Effects of Weed Tea Fertilizer, Moringa Leaf Extract, and Trellising on Combined Disease Incidence in Cucumber (Cucumis sativus L.) under Nigerian Savannah Conditions

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ABSTRACT

Cucumber (*Cucumis sativus* L.) production in the Nigerian savannah is constrained by diseases, and locally available plant-based inputs and cultural practices may offer low-cost management options. This study evaluated the effects of weed tea fertilizer (WF), moringa leaf extract (MLE), and trellising on combined disease incidence in cucumber during the 2023 and 2024 wet seasons at the Bayero University Kano (BUK) research farm and the Ahmadu Bello University (ABU) research farm, Samaru, Nigeria. Four diseases were identified: downy mildew, powdery mildew, angular leaf spot, and gummy stem blight, with downy mildew and powdery mildew ranking highest and angular leaf spot and gummy stem blight ranking lower. WF rate significantly affected combined disease incidence at BUK ($p = .006$) and ABU ($p = .005$). At BUK, incidence was 12.9%, 12.7%, 12.0%, and 11.4% at 0, 3,000, 6,000, and 9,000 L ha^{-1}, respectively, and at ABU it was 12.3%, 12.2%, 11.3%, and 11.1%; the 3,000 L ha^{-1} rate was close to the control, and the lowest mean was at 9,000 L ha^{-1}. MLE significantly affected combined disease incidence at both locations ($p < .001$): at BUK, incidence was 14.5%, 11.5%, and 10.7% at 0, 8.7, and 12.5 L ha^{-1}, respectively, and at ABU it was 13.9%, 11.0%, and 10.2%, so the highest rate recorded the lowest mean at both locations. Trellising also significantly reduced incidence ($p = .001$), from 15.3% to 9.1% at BUK and from 14.8% to 8.6% at ABU for non trellising and trellising respectively. All two-way and three-way interactions were non-significant ($p > .05$), so the effects of the three factors were independent. These results show that WF, MLE, and trellising were each associated with lower combined disease incidence.

Keywords: cucumber, disease incidence, weed tea fertilizer, moringa leaf extract, trellising

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an economically important vegetable crop cultivated in tropical and subtropical regions for fresh consumption and commercial sale. Its relatively short production cycle makes it attractive to smallholder farmers, while its fruits contribute water and dietary nutrients. However, cucumber production is constrained by several biotic and abiotic factors, including foliar diseases, soil fertility limitations, pests, and environmental stress. Diseases can reduce green leaf area, impair plant growth, and lower the quantity and quality of marketable fruits. The occurrence of cucumber diseases is influenced by host susceptibility, pathogen presence, environmental conditions, and crop-management practices (Agrios, 2005; Zitter *et al.*, 1996).

Disease incidence is a phytopathometric measure that describes the proportion of assessed plants or plant units affected by a disease. Clear definitions and consistent measurement procedures are essential for comparing treatments and interpreting disease-management experiments (Bock *et al.*, 2010). In the present study, the response variable was combined disease incidence, defined as the percentage of plants showing symptoms of at least one disease; a plant showing symptoms of more than one disease was counted once. Plant nutrition can influence host–pathogen interactions, but the direction and magnitude of the response vary with the nutrient,

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crop, pathogen, and environment. Adequate and balanced nutrition may support plant function and defence, whereas nutrient deficiencies or imbalances may alter susceptibility to disease. A review by Dordas (2008) showed that nutrients can influence plant disease resistance and tolerance, while also emphasising that effects are not uniform across pathosystems. Weed tea fertilizer, a liquid preparation made from plant biomass, may provide soluble nutrients, but its composition depends on the plant materials and preparation method. Its effect on disease incidence should therefore be assessed empirically rather than assumed.

Moringa (*Moringa oleifera* Lam.) leaf extract has been investigated as a plant biostimulant because it contains nutrients and bioactive compounds that may influence plant growth and physiological performance. Reviews describe its potential to improve crop growth, quality, and tolerance to some abiotic stresses, although outcomes depend on extract preparation, concentration, crop species, and application method (Mashamaite *et al.*, 2022; Yuniati *et al.*, 2022; Zulfiqar *et al.*, 2020). These properties provide a rationale for evaluating moringa leaf extract in cucumber production, but improved plant performance does not automatically demonstrate a direct suppressive effect on pathogens.

Trellising supports cucumber vines above the soil surface and changes the spatial arrangement of the canopy. Depending on spacing, weather, and crop management, this may improve access for scouting and crop operations and may alter canopy airflow and leaf-wetness conditions. Because diseases differ in their epidemiology, the effect of trellising on overall disease incidence cannot be presumed to be identical for every disease. Measuring combined disease incidence can provide a broad assessment of crop health, but it does not identify which disease contributed most to the observed response.

Evidence from field experiments is needed to determine whether locally available plant-based inputs and trellising can reduce disease in cucumber under Nigerian savannah conditions. Accordingly, this study evaluated the effects of weed tea fertilizer, moringa leaf extract, and trellising on combined disease incidence in cucumber at Bayero University Kano (BUK) and Ahmadu Bello University, Samaru (ABU), during the 2023 and 2024 wet seasons. The specific objective was to determine the main effects of weed tea fertilizer rate, moringa leaf extract concentration, and trellising practice on combined disease incidence in cucumber.

MATERIALS AND METHODS

Experimental Locations and Seasons

The study was conducted at two locations during the 2023 and 2024 wet seasons: the Teaching and Research Farm, Faculty of Agriculture, Bayero University Kano (11°58′N, 8°24′E, 490.9 m above sea level), in the Sudan savannah agro-ecological zone, and the Institute for Agricultural Research farm, Ahmadu Bello University, Samaru, Zaria (11°11′N, 07°38′E, 686 m above sea level), in the northern Guinea savannah agro-ecological zone of Nigeria. Meteorological data were obtained from the meteorological stations of the two locations and are presented in Appendices 1 and 2. Soil samples were randomly collected from the experimental sites at a depth of 0–30 cm using a soil auger. The samples from each location were bulked, dried, ground, sieved, and subjected to physico-chemical analysis using the methods described by A.O.A.C. (2002).

Experimental Treatments and Design

The experiment comprised factorial combinations of four weed tea fertilizer rates (0, 3,000, 6,000, and 9,000 L ha^{-1}), three Moringa leaf extract (MLE) rates (0, 8.7, and 12.5 L ha^{-1}), and two trellising levels (trellised and non-trellised). The treatments were arranged in a split-plot design with four replications, in which weed tea and MLE were assigned to the main plots, while trellising was allocated to the sub-plots. Each main plot measured 6.0 m × 4.0 m (24 m^2), whereas each sub-plot measured 3.0 m × 4.0 m (12 m^2), giving a total experimental field area of 2,250 m^2

Crop Establishment and Management

Seeds of the cucumber variety Poinsett 76 were sown on 21st June at ABU and 1st July at BUK in both 2023 and 2024 at an intra-row spacing of 50 cm and an inter-row spacing of 60 cm. Fertilizer was applied uniformly to all plots at 50 kg N ha^{-1}, 38 kg P_2O_5 ha^{-1}, and 60 kg K_2O ha^{-1}. Insect pests (aphids, thrips, and leaf miners) were controlled weekly with Sherpa Plus EC (cypermethrin + dimethoate) at 1.15 kg a.i. ha^{-1} and neem oil (azadirachtin). Downy and powdery mildews were managed with weekly preventive and curative fungicide applications (mancozeb, Ridomil, and metalaxyl) at the rate of 2.5kg a.i ha^{-1} was applied to all plots including the controls.

Preparation and Application of Treatments

Weed tea fertilizer was prepared from *Cosmos sulphureus* and *Andropogon gayanus* by uprooting, cutting, and cleaning the plants before mixing them with water at a ratio of 2 kg of weed material to 2 L of water. The mixture was fermented in airtight 3,000-L containers for two weeks and stirred weekly, following Ingham (2005). The fermented mixture was filtered through cheesecloth to obtain the liquid extract, and samples were analysed in the laboratory to determine their nutrient composition.

Fresh moringa leaves were crushed using a pestle and mortar at a ratio of 10 kg of fresh leaves to 1 L of water. The mixture was left overnight and filtered to obtain the aqueous extract, following Fuglie (2001). The resulting extract was analysed in the laboratory to determine its phytochemical and nutritional constituents, as described by Emonger (2012), Rady *et al.* (2013), and Howladar (2014).

Weed tea fertilizer was applied at 10 days after sowing at the rates of 0, 100, 200, and 300 mL $stand^{-1}$ (0, 3,000, 6,000, and 9,000 L ha^{-1}), administered in two split doses to minimize the effect of nutrient leaching. MLE was applied as a foliar spray to the cucumber plants using a knapsack sprayer according to the assigned treatment two times. The concentrated extract was diluted with water at 0% (0 mL extract per 96 mL water), 2% (2 mL extract per 96 mL water), and 3% (3 mL extract per 96 mL water) 0, 8.7, and 12.5 L ha^{-1} rates. The 0 mL $stand^{-1}$ weed tea plots received no weed tea, and the 0% MLE plots were sprayed with water only.

Trellising was established using wooden poles or bamboo stakes approximately 2.5 m tall and spaced 2 m apart. The poles were connected with binding wire after sowing, and cucumber plants were loosely tied to the support using twine. The plants were progressively trained as branching increased to support vertical growth and prevent leaves and fruits from contacting the soil.

Disease Identification and Assessment of Combined Disease Incidence

Diseases were identified visually from their characteristic symptoms on leaves and stems as presented in table 4. The combined disease incidence was determined as the percentage of plants showing symptoms of at least one disease. Ten plants were tagged from the net plot of each treatment and assessed visually for characteristic disease symptoms at 2-week intervals from sowing over three sampling periods (2, 4, and 6 weeks after sowing). The incidence analysed is the mean of the three assessments . A plant was recorded as diseased if it showed symptoms of one or more diseases, and a plant with symptoms of more than one disease was counted once. Combined disease incidence (CDI) was calculated for each plot as:

$$CDI(\%) = \frac{(\text{Number of Diseased Plants})}{10} \text{ x } 100$$

Statistical Analysis

The incidence data were subjected to analysis of variance (F-test) appropriate for a split-plot design using Genstat, 7th edition (2003) for each location and season and then combined across the two seasons. Treatment means were separated using the Student Newman Keuls (SNK) test at the 5% level of probability. In Table 1, "Combined" is the mean of the 2023 and 2024 seasons, p is the probability of the F-test, and SE is the standard error.

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RESULTS

Effect of Weed Tea Fertilizer

Weed tea fertilizer rate significantly affected combined disease incidence at both locations (BUK: p = .006; ABU: p = .005; Table 1). At BUK, the combined means were 12.9%, 12.7%, 12.0%, and 11.4% for 0, 3,000, 6,000, and 9,000 L ha^{-1}, respectively, which are relative reductions from the control of about 1.6%, 7.0%, and 11.6% for the three weed tea rates. At ABU, the corresponding means were 12.3%, 12.2%, 11.3%, and 11.1%, or reductions of about 0.8%, 8.1%, and 9.8%. The 3,000 L ha^{-1} rate was therefore close to the control at both locations, whereas the 6,000 and 9,000 L ha^{-1} rates recorded lower combined incidence, and the lowest mean was recorded at 9,000 L ha^{-1}. The same ordering of rates was seen in the individual seasons at BUK, where incidence in 2023 was 13.9%, 13.7%, 12.7%, and 12.3% and in 2024 was 11.8%, 11.6%, 11.3%, and 10.4% for the four rates.

Effect of Moringa Leaf Extract

Moringa leaf extract significantly affected combined disease incidence at both BUK and ABU ($p < .001$ at each location; Table 1). At BUK, the combined means were 14.5%, 11.5%, and 10.7% for 0, 8.7, and 12.5 L ha^{-1}, respectively. At ABU, the corresponding means were 13.9%, 11.0%, and 10.2%. Relative to the untreated control, the 8.7 L ha^{-1} rate represented a reduction of approximately 20.7% at BUK and 20.9% at ABU, and the 12.5 L ha^{-1} rate a reduction of approximately 26.2% at BUK and 26.6% at ABU. The 12.5 L ha^{-1} rate had the lowest combined incidence at both locations and differed significantly from the 8.7 L ha^{-1} rate in the combined analysis (Table 1).

Effect of Trellising

Trellising significantly affected combined disease incidence at both locations (p = .001 at each site). At BUK, incidence was 15.3% without trellising and 9.1% with trellising. At ABU, incidence was 14.8% without trellising and 8.6% with trellising. These means correspond to relative reductions of approximately 40.5% at BUK and 41.9% at ABU compared with non-trellised plants.

Interaction Effects

None of the interactions was statistically significant in the combined results. At BUK, the p values were .931 for WF × MLE, .300 for WF × trellising, .152 for MLE × trellising, and .369 for WF × MLE × trellising. At ABU, the corresponding p values were .951, .344, .187, and .323. All values exceeded .05, indicating that the effects of the three factors were independent of one another.

Table 1: Effect of Weed Tea Fertilizer, Moringa Leaf Extract, and Trellising on Cucumber Disease Incidence (%) at BUK and ABU During the 2023 and 2024 Wet Seasons

	BUK			ABU		
Treatment	2023	2024	Combined	2023	2024	Combined
Weed tea fertilizer (WF; L ha^{-1})						
0	13.9^{a}	11.8	12.9^{a}	11.8	12.8^{a}	12.3^{a}
3000	13.7^{ab}	11.6	12.7^{a}	11.6	12.7^{ab}	12.2^{a}
6000	12.7^{ab}	11.3	12.0^{b}	11.3	11.3^{b}	11.3^{ab}
9000	12.3^{b}	10.4	11.4^{ab}	10.4	11.8^{ab}	11.1^{b}
p	.022	.084	.006	.084	.031	.005
SE	0.416	0.406	0.328	0.406	0.416	0.318
Moringa leaf extract (MLE; L ha^{-1})						
0	15.5^{a}	13.4^{a}	14.5^{a}	13.4^{a}	14.5^{a}	13.9^{a}
8.7	12.5^{b}	10.5^{b}	11.5^{b}	10.5^{b}	11.5^{b}	11.0^{b}
12.5	11.5^{c}	9.9^{b}	10.7^{c}	9.9^{b}	10.5^{b}	10.2^{c}

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p	< .001	< .001	< .001	< .001	< .001	< .001
SE	0.360	0.352	0.284	0.352	0.360	0.275
Trellising (T)						
No trellising	16.3[a]	14.3[a]	15.3[a]	14.3[a]	15.3[a]	14.8[a]
Trellising	10.0[b]	8.2[b]	9.1[b]	8.2[b]	9.0[b]	8.6[b]
p	< .001	< .001	< .001	< .001	< .001	< .001
SE	0.294	0.287	0.232	0.287	0.294	0.225
Interaction (*p*)						
WF × MLE	.842	.998	.931	.998	.932	.951
WF × T	.359	.651	.300	.651	.491	.344
MLE × T	.206	.425	.152	.425	.315	.187
WF × MLE × T	.618	.663	.369	.663	.596	.323

Note. Means followed by the same letter within a column do not differ significantly at $p = .05$ according to the Student–Newman–Keuls (SNK) test. Combined = mean of the 2023 and 2024 seasons.

Table 2: Nutrient Composition of Weed Tea Fertilizer Prepared From *Cosmos sulphureus* and *Andropogon gayanus* Used in the 2023 and 2024 Wet Season Trials at BUK and ABU

	Concentration (ppm)	
Nutrient	2023	2024
Nitrogen	2100	2000
Phosphorus	137.79	134.3
Potassium	1695.22	1540.3
Calcium	1407.05	1334.5
Magnesium	166.3	170.1
Iron	332.52	336.1
Boron	6.51	5.8

Note. ppm = parts per million.

Table 3: Nutrient Composition of Moringa Leaf Extract Used in the 2023 and 2024 Wet Season Trials at BUK and ABU

Constituent	2023	2024
Vitamins (μg mL^{-1})		
Vitamin A	3814	4004.70
Vitamin B1	20.07	21.07
Vitamin B2	1.16	1.22
Vitamin C	199.52	209.50
Vitamin K	0.00208	0.00218
Phytochemicals (mg g^{-1})		
Phenolics	551.32	578.89
Alkaloids	499.33	524.30
Flavonoids	101.10	106.16
Tannins	185.80	195.09
Saponins	141.61	148.69
Phytonutrients (mg L^{-1})		
Nitrogen	22.15	23.26
Calcium	0.425	0.446
Magnesium	0.427	0.448
Sodium	0.069	0.072
Phosphorus	177.6	186.48

Manganese	0.427	0.448
Copper	0.020	0.021
Iron	1.873	1.967
Zinc	0.163	0.171

DISCUSSION

Four diseases were identified on cucumber at both locations in the 2023 and 2024 wet seasons: downy mildew, powdery mildew, angular leaf spot, and gummy stem blight (Table 4). Downy mildew and powdery mildew ranked highest, while angular leaf spot and gummy stem blight ranked lower, at both locations in both seasons.

Table 4: Ranking of the Diseases Identified on Cucumber From Lowest to Highest Incidence at BUK and ABU During the 2023 and 2024 Wet Seasons

Disease	**Probable causal organism**	**Characteristic symptoms**	**BUK 2023**	**BUK 2024**	**ABU 2023**	**ABU 2024**
Angular leaf spot	Pseudomonas syringae pv. lachrymans	Water-soaked angular leaf spots that dry and fall out, leaving a shot-hole appearance	1	1	1	1
Gummy stem blight	Didymella bryoniae	Brown leaf lesions and stem cankers exuding a gummy brown ooze	1	1	1	1
Downy mildew	Pseudoperonospora cubensis	Angular yellow leaf lesions bounded by veins, with purplish-grey sporulation on the underside	2	2	2	2
Powdery mildew	Podosphaera xanthii	White powdery fungal growth on leaf surfaces and stems	2	2	2	2

Note. Rating 1 = lowest incidence and Rating 2 = highest incidence. Diseases were rated by visual observation of their occurrence. Values are reported by site-season. Angular leaf spot and gummy stem blight, as well as downy mildew and powdery mildew, received equal values and therefore share a rating.

On the four diseases reported, angular leaf spot and gummy stem blight shared the lowest rating, while downy mildew and powdery mildew shared the highest (Table 4). These ranks describe the reported values only and do not imply statistical significance. Downy mildew is favoured by high relative humidity and prolonged leaf wetness from rain or dew (Zitter et al., 1996; Holmes et al., 2015), so frequent rainfall and a humid canopy can promote infection and symptom development. Powdery mildew requires a different interpretation. High relative humidity can favour infection, but free water and frequent rain may inhibit its development, while relatively dry conditions can favour colonisation and spore dispersal (Zitter et al., 1996; Pérez-García et al., 2009). Rainfall alone therefore cannot explain the powdery mildew rating. Relative humidity, leaf-wetness duration, temperature, canopy density, and disease timing should also be considered.

Angular leaf spot and gummy stem blight rated lower but are also moisture-associated. Angular leaf spot is favoured by humid conditions and prolonged leaf wetness, and the bacterium can be spread by splashing rain. Gummy stem blight is promoted by high humidity and sustained leaf moisture, and its spores can also be spread by rain splash (Zitter et al., 1996). Their lower rank should therefore not be taken as evidence that wet

conditions suppress them. Disease expression also depends on inoculum availability, cultivar susceptibility, crop stage, field sanitation, temperature, and the timing and duration of wet periods.

At ABU, the ratings in Table 4 were the same in both seasons: downy mildew and powdery mildew received the higher rating and angular leaf spot and gummy stem blight the lower rating in 2023 and in 2024. The ratings did not change between years, but disease levels did: all four diseases were recorded at higher levels in 2024 than in 2023 (Table 1). Yet the meteorological records (Appendix 2) did not show higher rainfall or relative humidity in 2024. Rainfall entries from June to October summed to 94.60 mm in 2023 and 83.25 mm in 2024. Mean relative humidity across the 15 observation periods was about 76.3% at 10 a.m. and 66.5% at 4 p.m. in 2023, compared with 73.9% and 62.9% in 2024; these are simple averages of the ten-day observations, not daily or hourly means. The largest ten-day rainfall entry was 13.88 mm (1–10 July) in 2023 and 15.10 mm (21–31 August) in 2024, showing that the distribution of rainfall differed between years. In both years, 10 a.m. relative humidity was highest in July and August (about 79–87% in 2023 and 73–87% in 2024), and the higher rating of the two mildews is consistent with their known preference for humid conditions, although the data do not allow this to be tested. Seasonal rainfall totals and period-average humidity therefore explain neither the stable ratings nor the rise in all four diseases in 2024; the timing of rainfall, leaf-wetness duration, temperature, inoculum pressure, cultivar response, crop stage, and field management may also have contributed.

At BUK, the ratings were likewise the same in both seasons, with downy mildew and powdery mildew rated higher and angular leaf spot and gummy stem blight rated lower, but disease levels were higher in 2023 than in 2024 for all four diseases (Table 1). This agrees with the rainfall records (Appendix 1), which were higher in 2023: the ten-day rainfall entries from June to October summed to 95.0 mm in 2023 and 66.7 mm in 2024, and the largest entry was 27.5 mm (21–31 July) in 2023 compared with 11.0 mm (1–10 July) in 2024. Relative humidity was not recorded at BUK, so the contribution of humidity to the BUK pattern could not be assessed. Taken together, the BUK results are consistent with the higher rainfall of 2023, whereas the ABU results are not, which indicates that rainfall and relative humidity alone do not account for the differences in disease between seasons.

The results show that weed tea fertilizer, moringa leaf extract, and trellising were each associated with significantly lower combined disease incidence at both sites. Weed tea fertilizer at 6,000 and 9,000 L ha^{-1} recorded lower incidence than the control, whereas the 3,000 L ha^{-1} rate was only slightly lower than the control. This pattern may be related to nutrient supply, because the weed tea contained nitrogen, phosphorus, potassium, calcium, magnesium, iron, and boron (Table 2), and balanced plant nutrition can influence host susceptibility to disease (Dordas, 2008). Similar associations between organic amendments and lower disease levels have been reported (Abbasi *et al.*, 2002; BioCycle, 2004; Kumar *et al.*, 2021; Ali *et al.*, 2024), and foliar compost extracts have been investigated as a way of improving the utilization of compost (Meshref *et al.*, 2010). However, plant nutrient status, microbial populations, and defence-related compounds were not measured in this study, so the mechanisms behind the lower incidence remain untested. The difference between 6,000 and 9,000 L ha^{-1} was small (0.6 percentage points at BUK and 0.2 at ABU), so the lower rate may be preferable in practice if it costs less, which should be tested in further trials.

Moringa leaf extract at 12.5 L ha^{-1} recorded lower combined disease incidence than the untreated control at both locations. Previous reviews describe MLE as a source of nutrients and bioactive compounds that can affect plant growth and physiological performance (Mashamaite *et al.*, 2022; Yuniati *et al.*, 2022; Zulfiqar *et al.*, 2020). These studies provide a plausible basis for investigating MLE in crop management, but they do not establish that MLE directly suppresses the particular pathogens present in this experiment. The present results support an association between MLE treatment and lower combined incidence; pathogen-specific effects and physiological mechanisms require further assessment.

Trellising produced the largest relative reduction in combined disease incidence among the main effects. A more open canopy and reduced contact between plant parts and the soil are plausible explanations, because vertical training of the vines may improve air movement and light penetration and shorten leaf-wetness periods, conditions that are less favourable to pathogen development. However, canopy humidity, leaf-wetness

duration, disease identity, and disease severity were not measured in this study, so this explanation remains untested. Staking has also been reported to benefit cucumber crop performance (Nweke *et al.*, 2013).

CONCLUSION

Under the conditions of these trials at BUK and ABU in the 2023 and 2024 wet seasons, weed tea fertilizer, moringa leaf extract, and trellising were each associated with significantly lower combined disease incidence. No interaction was significant, so their effects were independent and the data do not show a combined benefit beyond the sum of the individual effects. Weed tea fertilizer at 6,000 and 9,000 L ha^{-1} recorded lower incidence than the control, with the lowest mean at 9,000 L ha^{-1}; 12.5 L ha^{-1} moringa leaf extract recorded the lowest mean among MLE rates; and trellising was associated with relative reductions of approximately 40.5% at BUK and 41.9% at ABU compared with non-trellised plants. Downy mildew and powdery mildew ranked highest among the four diseases identified, while angular leaf spot and gummy stem blight ranked lower. Because disease-specific incidence and severity, canopy microclimate, and plant nutrient status were not measured, the mechanisms behind these effects cannot be concluded. Further studies on disease-specific responses, weed tea rates between 6,000 and 9,000 L ha^{-1}, and crop yield are recommended.

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APPENDIX 1: Meteorological observations of BUK location during the 2023 and 2024 rainy seasons

Month	Date	2023				2024			
		Rain	Temperature		SRAD	Rain	Temperature		SRAD
			Tmax	Tmin			Tmax	Tmin	
June	1st–10th	2.8	26	21.2	37.1	4.6	30.3	22.3	18.1
	11th–20th	0.9	24.9	19.5	36.1	1.5	29.4	20.9	17.1
	21st–30th	0.5	25.3	20.5	37.2	8.1	29.5	20.9	14
July	1st–10th	6.2	24.5	17.9	34.8	11	29.1	20.5	17.8
	11th–20th	20	23.4	19.1	33.3	2.4	30	20.9	18.9
	21st–31st	27.5	22	16.9	28.9	3.8	28.8	20.7	16.5
August	1st–10th	8.9	21.6	16.1	29.1	3.9	27.4	20.8	14.5
	11th–20th	6	21.7	13	28.4	3.2	27.9	20.3	16.4
	21st–31st	3.3	21.6	15.7	29	4.6	28.4	21.1	16.6
September	1st–10th	9.6	21.4	15.3	28.9	9	27.5	20.4	18.7
	11th–20th	4.5	22.2	20.6	29.4	3.6	27.4	20.9	18
	21st–30th	2.8	21.6	19.8	33.2	3.5	28.9	20.5	18.1
October	1st–10th	1.7	21.8	21.6	31.8	4.8	29	21.2	14.9
	11th–20th	0.3	21.8	22.6	28.6	2.2	29	21.1	18.9
	21st–31st	0	20.3	21.9	31.6	0.5	31	20.6	21.2
November	1st–10th	0	14.3	22.6	30.2	1.3	30.9	20.9	18.9
	11th–20th	0	13.7	21.7	28.5	1.6	30.9	20.6	18.7
	21st–30th	0	11.1	21.5	30.3	0.8	31.3	19.3	20.6

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APPENDIX 2: Meteorological observations of ABU location during the 2023 and 2024 rainy seasons

(mm)											
(mm)											
Month	**Date**	**2023**					**2024**				
		% Rel. humidity		**Air temp.**		**Rainfall**	**% Rel. humidity**		**Air temp.**		**Rainfall**
		10 a.m.	**4 p.m.**	**Max °C**	**Min °C**		**10 a.m.**	**4 p.m.**	**Max °C**	**Min °C**	
June											
1st–10th	**69.4**	**61.3**	**31.4**	**23.7**	**3.92**	**78.8**	**71.5**	**30.2**	**21.6**	**6.68**	
	11th–20th	**73.3**	**62.7**	**31.1**	**35.5**	**2.47**	**70.6**	**62.9**	**29.8**	**23.5**	**3.61**
	21st–30th	**77.6**	**66.1**	**30.3**	**33.3**	**8.56**	**84**	**64.4**	**30.3**	**22.6**	**7.7**
July	**1st–10th**	**78.5**	**67.3**	**29.2**	**23.1**	**13.88**	**72.9**	**66.7**	**30**	**22.7**	**6.03**
	11th–20th	**81.4**	**72.1**	**28.5**	**23.4**	**12.1**	**74.5**	**64.1**	**30.2**	**22.4**	**2.64**
	21st–31st	**84.5**	**70.2**	**28.2**	**23.5**	**6.7**	**78.8**	**69.7**	**29.8**	**23.4**	**2.3**
August	**1st–10th**	**80.8**	**73.9**	**28**	**23.6**	**0.93**	**87.2**	**78.9**	**27.5**	**22.8**	**8.85**
	11th–20th	**86.6**	**77.6**	**27.2**	**23**	**12.57**	**80**	**66.3**	**29.4**	**22.2**	**6.68**
	21st–31st	**82.5**	**76.5**	**26.9**	**23.5**	**8.5**	**79.7**	**66.2**	**30.3**	**22.5**	**15.1**
September	**1st–10th**	**76.3**	**67.6**	**29**	**23.1**	**10.64**	**78**	**65**	**30.1**	**23**	**7.01**
	11th–20th	**75.2**	**68.6**	**30.4**	**22.1**	**7.45**	**76.5**	**66.6**	**30**	**23.4**	**8.71**
	21st–30th	**77.9**	**66.6**	**29.8**	**22.5**	**2.4**	**71.9**	**71.3**	**31.4**	**23.3**	**7.18**
October	**1st–10th**	**77.9**	**66.6**	**29.8**	**23.3**	**2.4**	**65.9**	**61.5**	**30**	**23.5**	**0.26**
	11th–20th	**71.2**	**60.1**	**31.2**	**22.9**	**2.08**	**68.3**	**43.1**	**31.9**	**22.6**	**0.5**
	21st–31st	**51.3**	**40.7**	**31.6**	**20.1**	**0**	**41.3**	**24.9**	**33**	**19.7**	**0**
November	**1st–10th**	**28.5**	**29.5**	**30.5**	**17.3**	**0**	**29.9**	**26.1**	**33.7**	**19.2**	**0**
	11th–20th	**23.4**	**22.2**	**30.7**	**17.3**	**0**	**28.7**	**25.7**	**32.1**	**20**	**0**
	21st–30th	**17**	**18.5**	**28.8**	**16.5**	**0**	**28**	**25.5**	**33.3**	**20.1**	**0.56**