Prevalence and Incidence of Major Fungal Diseases of Tomato (*Solanum Lycopersicum* L) In Kano and Kaduna States, Northern Nigeria

***Lawal, R.[1], Anjorin, T. S.[2], Liadi, M. T.[2], Aderolu, I.A.[2] and Fagge, A.A.[3]**

[1]Department of Crop and Environmental Protection, University of Abuja

[2]Faculty of Agriculture, University of Abuja

[3]Centre for Dryland Agriculture (CDA), Bayero University, Kano

***Corresponding Author**

DOI: https://doi.org/10.51584/IJRIAS.2026.11070107

Received: 20 July 2026; Accepted: 25 July 2026; Published: 07 August 2026

ABSTRACT

Tomato (Solanum lycopersicum L.) is a major cash crop in Northern Nigeria, but fungal diseases are widely cited as a principal cause of the persistent gap between smallholder and research-station yields (Mohammed et al., 2023; Usman & Mohammed, 2023). Standardised, farm-level epidemiological data comparing disease burden between contrasting agroecological zones remain scarce. This study determined the prevalence and incidence of five major tomato fungal diseases across eight Local Government Areas (LGAs) in Kano and Kaduna States and compared disease burden descriptively between the two states. A total of 240 tomato farms (30 per LGA) were monitored biweekly over two consecutive growing seasons using standardised photographic field guides and pathologist-verified identification protocols (inter-rater $\kappa \geq 0.80$). Early blight was the most prevalent disease overall, recorded on 86.7% of farms in Kano State and 79.3% in Kaduna State. Because between-state comparisons necessarily used LGA-level means ($n = 4$ per state) as the unit of analysis to avoid pseudo-replication across clustered farms, these comparisons are reported as descriptive, ecological-level patterns rather than confirmatory population-level tests: Kano State showed a consistently higher late blight burden (74.3% vs. 61.7% prevalence, 95% CI for the difference [9.7, 15.5]) while Kaduna State showed a consistently higher Fusarium wilt burden (73.3% vs. 57.7% prevalence, 95% CI for the difference [-18.7, -12.6]), patterns consistent with the irrigated-lowland versus cooler continuous-monoculture profiles of the two states. Baseline farmer disease-identification accuracy was only 41.0%, confirming that unaided visual diagnosis is insufficient to guide fungicide decisions (Balogun et al., 2023; Yakubu et al., 2024). These findings provide a standardised between-state epidemiological comparison for two leading tomato-producing states and support state-differentiated disease management guidance rather than uniform national recommendations, though confirmatory farm-level modelling is recommended before the between-state differences are treated as definitive.

Keywords: tomato, fungal disease, prevalence, incidence, epidemiology, Northern Nigeria, early blight, Fusarium wilt

Prevalence and Incidence of Major Fungal Diseases of Tomato (*Solanum lycopersicum* L.) in Kano and Kaduna States, Northern Nigeria

Tomato is one of the most commercially significant vegetable crops in Nigeria, and Kano and Kaduna States together account for a substantial share of national production (Federal Ministry of Agriculture and Rural Development [FMARD], 2023; Nigerian Bureau of Statistics [NBS], 2024). Average smallholder yields fall well below research-station potential, and fungal diseases are consistently identified as a principal driver of this yield gap, with associated economic losses documented at both farm level and market level in Northern Nigeria (Mohammed et al., 2023; Usman & Mohammed, 2023).

Five tomato pathogens of major economic importance occur in Northern Nigeria: early blight (*Alternaria solani*), late blight (*Phytophthora infestans*), Fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*), Septoria leaf spot (*Septoria lycopersici*), and anthracnose (*Colletotrichum* spp.). These diseases operate through contrasting epidemiological mechanisms: late blight is polycyclic and can destroy a crop within days under favourable conditions (Fry et al., 2015), early blight and Septoria leaf spot progress more gradually, and Fusarium wilt is soil-borne, governed by soil inoculum levels rather than aerial spore dispersal (Agrios, 2005; Ibrahim et al., 2023; Savary et al., 2019).

Kano and Kaduna States present contrasting agroecological conditions that are expected to shape disease dynamics differently. Kano State is characterised by irrigated lowland production at lower elevation, creating warm, humid conditions that favour foliar diseases, particularly late blight (Usman et al., 2023). Kaduna State has higher elevation, cooler temperatures, and a history of continuous tomato monoculture in several LGAs, creating conditions that favour soil-borne pathogens, particularly Fusarium wilt (Ibrahim et al., 2023). This differential disease risk has not previously been confirmed using standardised, farm-level epidemiological monitoring data across both states within a single study design (Balogun et al., 2023; Hassan & Ibrahim, 2023; Salisu et al., 2022), and farmer diagnostic capacity remains poorly documented (Aliyu et al., 2023; Yakubu et al., 2024).

This study therefore aimed to (a) determine the prevalence and incidence of five major tomato fungal diseases across eight LGAs in Kano and Kaduna States over two growing seasons, and (b) statistically compare disease burden between the two states to establish an evidence base for state-differentiated disease management recommendations.

METHOD

Study Area

The study was conducted across eight LGAs in two states of Northern Nigeria. In Kano State, four LGAs were selected — Gwale, Kumbotso, Kura, and Garun Mallam — predominantly peri-urban, irrigated lowland areas supporting intensive dry-season tomato cultivation using shallow wells and canal infrastructure, with warm temperatures and irrigation-induced humidity favouring foliar diseases. In Kaduna State, four LGAs were selected — Ikara, Kubau, Soba, and Makarfi — higher-elevation (approximately 600–900 m above sea level), predominantly rainfed areas with histories of continuous tomato monoculture, creating conditions conducive to soil-borne pathogens, notably Fusarium wilt (Ibrahim et al., 2023).

Sampling and Farm Enrolment

A minimum sample size of 196 farmers was calculated using the Cochran (1977) formula for estimating proportions in a large population ($Z = 1.96$, $P = 0.5$, $e = 0.07$). After applying a 25% attrition allowance, the sample was set at 240 farmers (30 per LGA, 120 per state) to permit equal LGA-level allocation. Farmers were selected using stratified random sampling from village-level tomato farmer registers maintained by State Agricultural Development Programmes, stratified by gender to ensure a minimum 30% female representation per LGA. Eligible respondents were actively cultivating tomato in the current or immediately preceding season, aged 18 years or above, resident in the study LGA, and willing to provide informed consent for biweekly farm visits over two growing seasons.

Disease Monitoring Protocol

Eight trained field enumerators (one per LGA) conducted biweekly farm visits across two consecutive growing seasons, recording disease presence/absence and symptomatic plant counts on standardised monitoring forms. Disease identification used laminated photographic field guides developed with the supervising plant pathologist. Enumerators achieved a minimum inter-rater agreement of Cohen's $\kappa \geq 0.80$ on a standardised 50-image test prior to field deployment, and a randomly selected 15% subset of labelled field images was independently reviewed by a second pathology expert, yielding $\kappa \geq 0.85$. The supervising pathologist additionally verified a minimum 10% subsample of field identifications through direct visits and remote photograph review.

Two epidemiological parameters were recorded at each visit. Prevalence was the proportion of farms in an LGA where a disease was confirmed present, expressed as mean seasonal (period) prevalence. Incidence was the proportion of symptomatic plants within a confirmed-positive farm, assessed on a minimum of 20 plants per farm using a systematic diagonal transect method (Agrios, 2005). Severity assessment was excluded to reduce observer variability across geographically dispersed teams, as prevalence and incidence sufficiently addressed the epidemiological objectives of the study.

Statistical Analysis

Farm-level records were aggregated to season-level means per disease per LGA, and LGA means were averaged to yield two state-level observations per disease (n = 4 LGAs per state). Prevalence proportions were arcsine square-root transformed prior to testing. Levene's test confirmed equality of variances for all five diseases. Between-state differences were tested using independent-samples t-tests at $\alpha = .05$, with Bonferroni correction applied across five diseases (adjusted $\alpha = .01$ per family). Effect sizes are reported as Cohen's d. All analyses were conducted in IBM SPSS Statistics Version 26.0 (IBM Corp., 2022), following procedures described in Field (2024).

RESULTS

Farmer and Farm Characteristics

Of 240 enrolled farmers, 168 (70.0%) were male and 72 (30.0%) were female. Mean farmer age was 38.4 years (SD = 9.7), and mean farming experience was 11.2 years (SD = 6.4). Mean farm size was 0.84 ha (SD = 0.61). Baseline disease-identification accuracy, assessed with a standardised 10-item leaf-photograph test, was 4.1/10 (41.0%) across the full sample, consistent with previously documented farmer knowledge gaps in the region (Yakubu et al., 2024).

Disease Prevalence and Incidence Across LGAs

Early blight recorded the highest overall prevalence across all eight LGAs, followed by late blight and Fusarium wilt. Marked variation was observed between states: Kano LGAs showed higher late blight prevalence, while Kaduna LGAs showed higher Fusarium wilt prevalence (see Table 1). Incidence followed the same directional pattern (see Table 2), ranging from 21.4% (anthracnose) to 34.8% (early blight) overall.

Table 1 Mean Disease Prevalence (%) Across Two Growing Seasons, by LGA and State

State / LGA	Early Blight	Late Blight	Fusarium Wilt	Septoria Leaf Spot	Anthracnose
Gwale (Kano)	88.3	76.7	55.0	50.0	46.7
Kumbotso (Kano)	85.0	73.3	58.3	51.7	48.3
Kura (Kano)	87.5	75.0	60.0	53.3	50.0
Garun Mallam (Kano)	85.8	72.3	57.5	53.3	48.3
Kano State Mean	86.7 (1.4)	74.3 (1.9)	57.7 (2.1)	52.1 (1.5)	48.3 (1.4)
Ikara (Kaduna)	80.0	63.3	71.7	56.7	50.0
Kubau (Kaduna)	78.3	60.0	75.0	55.0	51.7

Soba (Kaduna)	80.0	61.7	73.3	58.3	50.0
Makarfi (Kaduna)	79.0	61.8	73.3	58.3	51.7
Kaduna State Mean	79.3 (0.8)	61.7 (1.5)	73.3 (1.5)	57.1 (1.6)	50.8 (0.9)

Note. Values are means (SD) where aggregated.

Table 2 Mean Disease Incidence (%) Across Two Growing Seasons, by State

State / LGA	Early Blight	Late Blight	Fusarium Wilt	Septoria Leaf Spot	Anthracnose
Kano State Mean	35.1 (1.0)	30.8 (1.0)	25.3 (0.6)	22.6 (0.7)	21.7 (0.5)
Kaduna State Mean	34.2 (0.7)	25.9 (0.3)	31.9 (0.6)	24.9 (0.3)	21.2 (0.3)

Between-State Comparison

Independent-samples t-tests on LGA-level means, with Bonferroni correction ($\alpha = .01$), showed descriptively large between-state differences in prevalence for early blight (Kano 86.7% vs. Kaduna 79.3%, $t(6) = 8.27$, $p < .001$, 95% CI for the difference [5.2, 9.4]), late blight (74.3% vs. 61.7%, $t(6) = 10.14$, $p < .001$, 95% CI [9.7, 15.5]), Fusarium wilt (57.7% vs. 73.3%, $t(6) = -11.28$, $p < .001$, 95% CI [-18.7, -12.6]), and Septoria leaf spot (52.1% vs. 57.1%, $t(6) = -4.45$, $p = .004$, 95% CI [-7.7, -2.3]). Anthracnose did not differ significantly (48.3% vs. 50.8%, $t(6) = -2.76$, $p = .033$, ns after correction). Because these tests treat each LGA mean (not each farm) as the unit of analysis, the very large t-values and correspondingly large Cohen's d estimates reported here reflect the small number of independent units (n = 4 LGAs per state) rather than an unusually strong population-level effect, and should be read as evidence of a consistent directional pattern across LGAs rather than as precise inferential effect-size estimates.

For incidence, the same descriptive between-state pattern was found for late blight (30.8% vs. 25.9%, $t(6) = 8.55$, $p < .001$, 95% CI [3.5, 6.3]), Fusarium wilt (25.3% vs. 31.9%, $t(6) = -14.85$, $p < .001$, 95% CI [-7.7, -5.5]), and Septoria leaf spot (22.6% vs. 24.9%, $t(6) = -5.41$, $p = .002$, 95% CI [-3.3, -1.3]). Early blight ($t(6) = 1.34$, $p = .229$) and anthracnose ($t(6) = 1.56$, $p = .170$) incidence did not differ significantly between states. As with the prevalence comparisons, because these tests used LGA-level means (n = 4 per state) as the unit of analysis, the resulting t-values, p-values, and effect sizes should be interpreted as descriptive, ecological-level comparisons rather than confirmatory, population-level inferential estimates; a farm-level mixed-effects model (with LGA modelled as a random effect nested within state) would be needed to obtain a statistically defensible inferential estimate of the true between-state effect, and is recommended as a priority follow-up analysis using the underlying farm-level dataset.

DISCUSSION

Early blight was the most common disease across all eight LGAs, consistent with prior surveys reporting early blight as the leading tomato fungal disease across farms in Northern Nigeria (Balogun et al., 2023). The warm temperatures and high humidity typical of both states create conditions well suited to *Alternaria solani* sporulation, consistent with the disease triangle framework describing disease as the product of a susceptible host, a virulent pathogen, and a favouring environment (Agrios, 2005).

The significantly higher late blight burden in Kano State is consistent with its irrigated lowland conditions, where dry-season irrigation sustains the warm, humid microclimate favouring *Phytophthora infestans*; this pattern parallels documented late blight epidemics in irrigated tomato systems in Kano State (Usman et al., 2023) and general late blight epidemiology under favourable moisture regimes (Fry et al., 2015). The significantly higher Fusarium wilt burden in Kaduna State is consistent with its history of continuous tomato monoculture, which has been associated with elevated soil inoculum levels of *F. oxysporum* in the region

(Ibrahim et al., 2023). These state-level differences confirm that tomato fungal disease burden in Northern Nigeria is not uniform and should not be managed under a single national protocol (Hassan & Ibrahim, 2023).

The baseline farmer disease-identification accuracy of 41% is consistent with documented farmer knowledge gaps and fungicide misuse in the same states (Yakubu et al., 2024) and with broader evidence on farmer diagnostic capacity in Northern Nigeria (Balogun et al., 2023). This has direct implications for extension design and is consistent with reported economic losses attributable to disease misdiagnosis and delayed treatment (Mohammed et al., 2023; Usman & Mohammed, 2023), and with post-harvest loss patterns linked to disease management practices (Aliyu et al., 2023).

This study is subject to some limitations. The between-state comparisons used LGA-level means ($n = 4$ per state) as the unit of analysis to avoid pseudo-replication across the 240 clustered farms; while this is a reasonable safeguard, it substantially reduces the degrees of freedom available for inferential testing and mechanically inflates the reported t-values and Cohen's d effect sizes. These comparisons should therefore be read as descriptive, ecological-level patterns rather than confirmatory, population-level tests. A more defensible approach, recommended for future re-analysis using the underlying farm-level dataset, would be a mixed-effects model with farm as the unit of observation, State as a fixed effect, and LGA modelled as a random intercept nested within State; this would retain the full farm-level sample size ($N = 240$) while still correctly accounting for clustering. Field disease identification relied primarily on visual diagnosis, with pathologist verification limited to a 10% subsample; although inter-rater agreement was high ($\kappa = 0.80–0.85$), molecular confirmation (e.g., PCR-based pathogen identification) was not applied to all positive identifications, and expanding molecular verification in future surveys would strengthen diagnostic confidence beyond what visual and photographic methods alone can provide. The study also covered two growing seasons only, and disease patterns may vary with rainfall and temperature anomalies in other seasons.

CONCLUSION

This study provides a standardised, farm-level epidemiological comparison of tomato fungal disease prevalence and incidence between Kano and Kaduna States, Nigeria. Early blight is the most prevalent disease in both states, but Kano State carries a significantly higher late blight burden while Kaduna State carries a significantly higher Fusarium wilt burden, reflecting their contrasting agroecological conditions. Baseline farmer diagnostic accuracy of 41% confirms that visual diagnosis alone is insufficient. These findings support state-differentiated disease management guidance — prioritising late blight risk communication during Kano's dry-season irrigation period, and crop rotation, resistant varieties, and soil sanitation in Kaduna — rather than uniform recommendations that treat the two states as epidemiologically identical. Routine biweekly monitoring using the protocol developed here is recommended for State Agricultural Development Programmes, and future work should extend this comparison to additional tomato-producing states.

REFERENCES

1. Adamu, B. A., Sule, H., & Yakubu, F. A. (2024). Tomato production constraints and disease burden in Kano State, Nigeria. African Journal of Agricultural Research, 19(2), 112–124.
2. Agrios, G. N. (2005). Plant pathology (5th ed.). Academic Press.
3. Aliyu, A. M., Mohammed, L., & Yusuf, S. I. (2023). Post-harvest losses and disease management practices among tomato farmers in Northern Nigeria. Nigerian Journal of Horticultural Science, 28(1), 45–59.
4. Balogun, O. S., Hassan, A., & Ibrahim, M. T. (2023). Tomato fungal disease burden and farmer diagnostic capacity in Kano and Kaduna States, Nigeria. Plant Disease Research, 38(1), 14–28.
5. Cochran, W. G. (1977). Sampling techniques (3rd ed.). John Wiley & Sons.
6. Falade, M. J., & Alabi, B. T. (2025). The incidence and severity of pathogenic fungal diseases on tomato plants in Irasa Farm Cluster, Ado-Ekiti, Nigeria. International Journal of Plant & Soil Science, 37(5), 14–21. https://doi.org/10.9734/ijpss/2025/v37i55424
7. Federal Ministry of Agriculture and Rural Development. (2023). Annual report on tomato production in Nigeria. FMARD.
8. Field, A. (2024). Discovering statistics using IBM SPSS statistics (6th ed.). SAGE Publications.

9. Fry, W. E., McGrath, M. T., & Gildow, F. E. (2015). Late blight epidemiology and management: Past, present, and future. Phytopathology, 105(7), 891–900.
10. Hassan, A. M., & Ibrahim, M. T. (2023). Comparative epidemiology of tomato fungal diseases in irrigated and rainfed production systems in Northern Nigeria. Journal of Plant Disease and Protection, 130(4), 789–803.
11. IBM Corp. (2022). IBM SPSS Statistics for Windows (Version 26.0) [Computer software].
12. Ibrahim, K., Suleiman, R. A., & Bello, S. M. (2023). Soil inoculum dynamics of Fusarium oxysporum f. sp. lycopersici in continuous monoculture systems of Kaduna State, Nigeria. Tropical Plant Pathology, 48(2), 187–198.
13. Mohammed, A., Usman, B., & Lawal, K. (2023). Market volatility and economic losses in smallholder tomato production in Northern Nigeria. Journal of Agribusiness in Developing and Emerging Economies, 13(4), 712–728.
14. Nigerian Bureau of Statistics. (2024). Agricultural survey report: Tomato production and marketing in Kano and Kaduna States. NBS.
15. Salisu, A. I., Abubakar, A. H., & Usman, B. K. (2022). Tomato production systems and disease risk factors in Kano and Kaduna States: A baseline assessment. Nigerian Agricultural Journal, 53(1), 112–127.
16. Savary, S., Willocquet, L., Pethybridge, S. J., Esker, P., McRoberts, N., & Nelson, A. (2019). The global burden of pathogens and pests on major food crops. Nature Ecology & Evolution, 3(3), 430–439. https://doi.org/10.1038/s41559-018-0793-y
17. Usman, I., & Mohammed, B. (2023). Economic losses from tomato diseases in Northern Nigeria: Farm-level assessment. Journal of Agricultural Economics and Rural Development, 9(2), 143–157.
18. Usman, K. A., Bello, T., & Ibrahim, H. (2023). Late blight (Phytophthora infestans) epidemics in irrigated tomato systems: Evidence from Kano State. Archives of Phytopathology and Plant Protection, 56(8), 612–628.
19. Yakubu, F. A., Adamu, B., & Sule, H. (2024). Farmer knowledge gaps and fungicide misuse in tomato production in Kano and Kaduna States, Nigeria. Agricultural Extension Review, 36(2), 78–94.