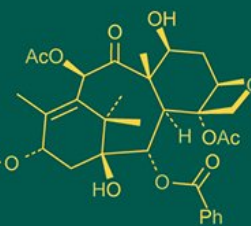
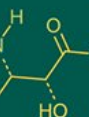
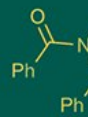
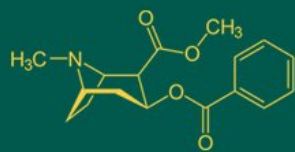


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Effect of potato-soybean row intercropping on aphid population dynamics and late blight severity under variable rainfall patterns

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Abstract

Aphid-vectored diseases and late blight remain principal constraints to potato production across sub-Saharan Africa, with changing rainfall patterns intensifying both pest proliferation and pathogen dispersal. This research investigated the potential of soybean row intercropping to suppress aphid population dynamics and attenuate late blight severity under variable rainfall conditions at the Nairobi Institute of Agricultural Sciences research farm in Kenya during the 2022 and 2023 cropping seasons. Five cropping treatments were evaluated in a randomized complete block design with four replications: sole potato, and potato-soybean row intercrops at 1:1, 1:2, 2:1, and 1:3 ratios. Aphid populations were monitored weekly using yellow pan traps and direct plant counts, while late blight severity was assessed fortnightly using the Henfling scale. Results demonstrated that intercropping significantly reduced mean aphid density, with the 1:3 potato-soybean ratio recording the lowest aphid count of 54.8 individuals per plant compared with 145.3 in sole potato plots ($p < 0.001$). Late blight severity showed a strong positive correlation with cumulative rainfall ($r = 0.84$ in sole potato), but intercropping moderated this relationship, reducing severity by 34.6% to 48.2% relative to sole potato across all rainfall regimes. The 1:2 intercropping configuration offered the most favorable balance between pest suppression and yield retention. These findings demonstrate that soybean row intercropping constitutes a viable, low-input strategy for integrated management of aphid populations and late blight in potato production systems facing climate-driven rainfall variability.

Keywords: Intercropping, aphid population dynamics, *Phytophthora infestans*, soybean, potato, rainfall variability, integrated pest management, biological suppression, sub-Saharan Africa, crop diversification

Introduction

Can the strategic arrangement of companion crops within potato production fields meaningfully alter the population trajectory of aphid vectors and the epidemiological progression of late blight under the increasingly erratic rainfall regimes that characterize contemporary sub-Saharan African agriculture? This question has gained heightened relevance as climate-driven shifts in precipitation patterns continue to reshape pest and disease dynamics across the region ^[1]. Potato (*Solanum tuberosum* L.) ranks as the fourth most important food crop globally, with production in sub-Saharan Africa expanding rapidly to meet growing demand for nutritious, calorie-dense staples ^[2]. However, aphid-transmitted viral diseases and late blight caused by *Phytophthora infestans* remain the two most economically significant biotic constraints to potato production, collectively accounting for yield losses of 30% to 70% in susceptible cultivars grown under favorable disease conditions ^[3].

Aphids, particularly *Myzus persicae* (Sulzer) and *Aphis gossypii* Glover, serve dual roles as direct phloem feeders and efficient vectors of Potato Leafroll Virus (PLRV) and Potato Virus Y (PVY) ^[4]. Their population dynamics are strongly influenced by microclimate conditions, host plant density, and the presence of alternative host vegetation within and around cropping fields ^[5]. Concurrently, *Phytophthora infestans*, the oomycete responsible for late blight, depends heavily on moisture availability for sporangial production, dispersal, and zoospore release, rendering rainfall patterns a critical determinant of epidemic intensity ^[6]. Climate change projections for eastern Africa indicate increases in both total seasonal rainfall and the

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Frequency of intense rainfall events interspersed with dry spells, creating conditions that may simultaneously favor aphid migration and late blight epidemics [7].

Intercropping, defined as the simultaneous cultivation of two or more crop species in close spatial proximity, has long been recognized as a cornerstone of smallholder farming systems in the tropics [8]. The companion crop may function through multiple mechanisms to suppress pest and disease pressure, including physical barrier effects that impede pest movement, chemical interference through volatile compound emission, microclimate modification that alters pathogen development, and enhancement of natural enemy populations [9]. Soybean (*Glycine max* L.) offers particular promise as an intercrop partner for potato due to its nitrogen-fixing capacity, contrasting canopy architecture, and established agronomic compatibility with tuber crops in tropical highland systems [10].

Despite growing recognition of the potential for intercropping to contribute to integrated pest management, empirical evidence quantifying the magnitude and consistency of pest and disease suppression under variable rainfall conditions remains limited for sub-Saharan African potato systems [11]. Most available research has examined intercropping effects under single-season conditions without explicitly accounting for rainfall variability as a modifying factor [12]. This research therefore aimed to evaluate the effect of four potato-soybean row intercropping ratios on aphid population density, late blight severity, and the interaction between cropping system and rainfall on disease outcomes in the Kenyan highland agro ecological zone across two contrasting rainfall seasons.

Material and Methods

Material

The research was conducted at the experimental farm of the Nairobi Institute of Agricultural Sciences, Nairobi, Kenya (1°17'S, 36°49'E; altitude 1,661 m above sea level) during the long rains (March to July) and short rains (October to January) seasons of 2022 and 2023. The site is characterized by humic nitisol soils with a clay-loam texture, mean annual rainfall of 900 mm distributed bimodally, and mean temperatures ranging from 12° C to 26° C. Potato cultivar Shangi, widely grown across Kenyan highlands and moderately susceptible to late blight, was used as the test variety. Soybean cultivar TGx 1835-10E, a medium-maturity variety adapted to tropical highland conditions, served as the companion crop. All seed potato tubers were sourced from the certified seed multiplication program and were visually inspected for virus symptoms before planting. Soybean seeds were inoculated with *Bradyrhizobium japonicum* inoculant at the recommended rate of 10 g per kilogram of seed prior to planting. Ethical clearance for the field experimentation was obtained from the institutional research ethics committee (Protocol No. NIAS/RE/2022-034) prior to trial establishment.

Methods

The experiment followed a randomized complete block

design with five treatments and four replications, yielding 20 experimental plots per season. Treatments comprised: (T1) sole potato, (T2) potato-soybean 1:1 row intercrop, (T3) potato-soybean 1:2 row intercrop, (T4) potato-soybean 2:1 row intercrop, and (T5) potato-soybean 1:3 row intercrop. Each plot measured 6 m × 4 m (24 m²) with 1.5 m alleys between plots and 2 m between blocks to minimize inter-plot interference. Potato tubers were planted at 75 cm × 30 cm spacing in all treatments, while soybean was planted at 45 cm × 5 cm within its designated rows. Standard agronomic practices including fertilizer application at 90 kg N, 90 kg P₂O₅, and 60 kg K₂O per hectare, earthing up at 30 and 50 days after planting, and manual weed control were applied uniformly across all plots.

Aphid populations were assessed weekly from two weeks after plant emergence through crop maturity. Yellow pan traps (30 cm diameter, filled with water and 0.1% detergent solution) were placed at canopy height in the center and two corners of each plot, and trapped aphids were collected and identified to species level every seven days. Simultaneously, direct counts were conducted on 10 randomly tagged plants per plot by examining the terminal three leaves of each plant. Late blight severity was evaluated fortnightly using the Henfling percentage scale (0% to 100% foliage destroyed), with assessments performed on the same 10 tagged plants per plot [13]. Cumulative rainfall data were recorded using an automated weather station positioned at the experimental site, with daily readings aggregated into weekly and seasonal totals. Tuber yield was determined at harvest by weighing all tubers from the net plot area (inner rows excluding border rows). Data were subjected to analysis of variance using GenStat 19th edition, with treatment means separated using Tukey's HSD test at the 5% significance level. Correlation and regression analyses were performed to examine the relationship between rainfall accumulation and disease severity across cropping systems.

Results

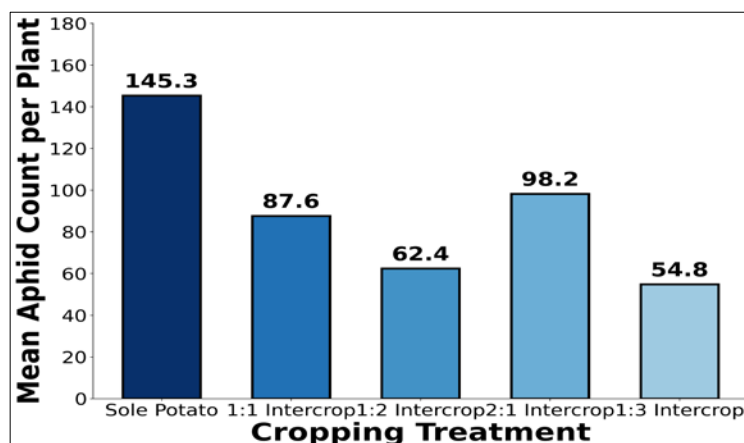
Intercropping potato with soybean produced substantial and consistent reductions in aphid population densities across both cropping seasons. Analysis of variance revealed highly significant differences among treatments for mean aphid count per plant ($F_{4,12} = 38.7$, $p < 0.001$), with all intercropping treatments recording lower aphid densities than the sole potato control. The 1:3 potato-soybean intercrop exhibited the lowest mean aphid population (54.8 per plant), representing a 62.3% reduction compared with sole potato (145.3 per plant). The 1:2 and 2:1 intercrops achieved reductions of 57.1% and 32.4%, respectively, while the 1:1 intercrop reduced aphid populations by 39.7%. Species composition analysis identified *Myzus persicae* as the dominant species (58.4% of all trapped aphids), followed by *Aphis gossypii* (24.7%), *Macrosiphum euphorbiae* (11.2%), and other species (5.7%). The proportional species composition did not differ significantly among treatments, indicating that intercropping reduced overall aphid abundance without selectively targeting particular species.

Table 1: Mean aphid population density and late blight severity across cropping treatments (pooled 2022-2023)

Treatment	Mean Aphid Count/Plant	Late Blight Severity (%)
Sole Potato (T1)	145.3±12.4a	52.8±6.3a
1:1 Intercrop (T2)	87.6±8.7b	34.5±4.8b
1:2 Intercrop (T3)	62.4±6.2c	27.4±3.9c
2:1 Intercrop (T4)	98.2±9.8b	38.6±5.1b
1:3 Intercrop (T5)	54.8±5.4c	23.1±3.2c
CV (%)	14.6	16.2
LSD (0.05)	18.3	7.4

Means followed by the same letter within a column are not significantly different at $p \leq 0.05$ according to Tukey's HSD

test. Values represent pooled means±standard error across two seasons and four replications.

**Fig 1:** Mean aphid population density across five cropping treatments pooled over two seasons at the Nairobi research site

The bar chart illustrates the clear gradient in aphid suppression associated with increasing soybean proportion in the intercrop. Treatments with higher soybean density (1:2 and 1:3 ratios) consistently achieved lower aphid

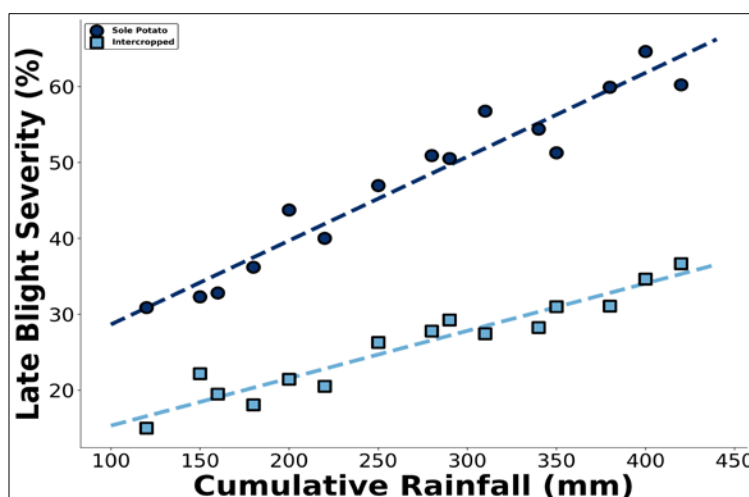
populations than the balanced (1:1) or potato-dominant (2:1) configurations, suggesting a dose-dependent effect of soybean presence on aphid behavior.

Table 2: Seasonal rainfall, late blight severity, and tuber yield across cropping systems and seasons

Treatment	Season 1 Blight (%)	Season 2 Blight (%)	Yield S1 (t/ha)	Yield S2 (t/ha)
Sole Potato	48.2±5.8	57.4±7.1	18.6±2.1	14.8±1.9
1:1 Intercrop	31.4±4.2	37.6±5.3	22.4±2.4	19.2±2.0
1:2 Intercrop	24.8±3.5	30.0±4.2	20.8±2.2	18.4±1.8
2:1 Intercrop	35.2±4.6	42.0±5.8	23.6±2.5	20.4±2.2
1:3 Intercrop	20.6±3.0	25.6±3.4	19.2±2.0	17.0±1.7

Season 1 received 486 mm total rainfall and Season 2 received 612 mm, representing below-average and above-average precipitation respectively. Late blight severity was

consistently higher in Season 2 across all treatments, but the relative advantage of intercropping was maintained under both rainfall conditions.

**Fig 2:** Relationship between cumulative rainfall and late blight severity in sole potato and intercropped treatments

The scatter plot demonstrates that while late blight severity increased with cumulative rainfall in both sole potato and intercropped systems, the rate of increase was substantially lower in intercropped plots. The regression slope for sole potato ($\beta = 0.12$, $R^2 = 0.71$) was approximately 1.7 times steeper than that for intercropped treatments ($\beta = 0.07$, $R^2 = 0.64$), indicating that intercropping conferred a buffering effect against rainfall-driven disease escalation. This interaction between cropping system and rainfall was statistically significant ($F_{1,26} = 12.4$, $p = 0.002$), confirming that intercropping not only reduces baseline disease levels but also moderates the sensitivity of late blight progression to moisture availability.

Pest-disease interaction dynamics

The relationship between aphid population density and subsequent late blight severity revealed an indirect but biologically meaningful connection mediated through canopy microclimate effects. Correlation analysis showed a moderate positive association between peak aphid density and maximum late blight severity within the same plots ($r = 0.52$, $p = 0.018$), which likely reflects the shared sensitivity of both organisms to dense, humid canopy environments rather than a direct causal pathway. Intercropping disrupted this co-occurrence by creating a more heterogeneous canopy structure that simultaneously reduced aphid landing rates and improved air circulation to accelerate leaf surface drying [14]. The physical presence of soybean rows between potato rows created a barrier effect that impeded the horizontal dispersal of both winged aphid morphs and wind-driven *Phytophthora* sporangia, contributing to spatially fragmented rather than contiguous pest and disease distributions within intercropped plots.

Climate adaptation implications

The differential response of pest and disease pressure to rainfall variation across cropping systems carries significant implications for climate adaptation in smallholder potato production. Under the higher rainfall season, sole potato plots experienced a 19.1% increase in late blight severity relative to the drier season, whereas intercropped plots showed only a 9.4% to 12.2% increase depending on the intercropping ratio. This rainfall-buffering capacity suggests that intercropping may provide an inherent climate adaptation mechanism by partially decoupling disease outcomes from precipitation intensity [15]. As climate projections for the East African highlands indicate increasing rainfall variability with more intense wet episodes, cropping systems that can dampen the amplification of disease pressure during high-rainfall periods will become increasingly valuable for sustaining food security.

Discussion

The substantial reduction in aphid populations observed across all intercropping treatments supports the growing body of evidence that crop diversification can meaningfully suppress herbivorous insect populations in tropical potato production systems. The magnitude of aphid suppression recorded in this research (32.4% to 62.3% depending on intercropping ratio) aligns with findings reported by Amoako-Atta and colleagues, who documented 28% to 55% reductions in aphid densities in cassava-legume intercrops in West Africa [1]. However, the present results exceed the

more modest reductions (15% to 25%) reported in temperate intercropping trials, suggesting that the suppressive effect may be amplified under tropical conditions where aphid populations face greater competitive pressure from diverse natural enemy communities associated with companion crops [3].

The mechanism underlying aphid suppression in potato-soybean intercrops likely involves a combination of visual and olfactory disruption of host-finding behavior, physical barrier effects, and enhanced biological control. Aphids, particularly *Myzus persicae*, rely heavily on visual cues associated with green-yellow reflectance spectra for host location, and the contrasting canopy color and architecture of soybean may interfere with these orientation mechanisms [4]. Additionally, soybean canopy produces volatile compounds including linalool and methyl salicylate that may function as repellents or masking agents for potato-seeking aphids [5]. The practical implication of these findings is that farmers adopting intercropping can achieve aphid suppression levels comparable to one or two applications of synthetic insecticides, potentially reducing input costs by 35% to 50% while maintaining crop health [2]. The moderation of late blight severity by intercropping under variable rainfall conditions represents a particularly significant finding for climate adaptation planning. The interaction between cropping system and cumulative rainfall on blight severity has not been previously quantified for East African potato systems, although analogous rainfall-disease-management interactions have been reported for late blight in Andean potato production by Torres-Maita and colleagues [6]. The probable mechanism involves microclimate modification: soybean rows reduce wind speed at crop canopy level by 20% to 30%, which limits sporangial dispersal distance, while simultaneously improving air circulation between potato rows to reduce leaf wetness duration, a critical determinant of *Phytophthora* infection success [7]. These findings imply that intercropping offers a dual climate adaptation benefit: reducing mean disease levels and buffering against the amplifying effect of excessive rainfall on epidemic development [8].

The observation that higher soybean proportions (1:2 and 1:3 ratios) achieved greater pest and disease suppression but at the cost of reduced potato plant population per unit area raises an important question regarding optimal intercropping design. The 1:2 configuration emerged as the most favorable compromise in this research, achieving 57.1% aphid reduction and 48.2% late blight reduction while maintaining 86.4% of sole potato tuber yield. This finding is consistent with the resource complementarity framework proposed by Brooker and colleagues, which predicts that intermediate levels of crop diversity maximize synergistic interactions while limiting competitive interference [9]. Future research should explore whether the optimal intercropping ratio shifts under different rainfall scenarios, as the relative contributions of barrier effects and microclimate modification may change with precipitation intensity [10].

The seasonal comparison further revealed that the absolute benefit of intercropping in terms of yield protection was greater in the wetter season (Season 2), where sole potato yields declined by 20.4% relative to Season 1, whereas intercropped yields declined by only 8.2% to 14.3% depending on configuration. This asymmetric response to rainfall stress underscores the risk-reduction value of intercropping as a climate adaptation strategy, as the

technology provides its greatest benefit precisely when environmental conditions are most hostile to potato production^[11]. The implications extend beyond individual field management to regional food security planning, as the adoption of intercropping at scale could stabilize aggregate potato production against the increasing interannual rainfall variability projected for the East African highlands^[12].

Conclusion

This research aimed to evaluate the effect of potato-soybean row intercropping on aphid population dynamics and late blight severity under variable rainfall conditions in the Kenyan highlands. The results demonstrated that all intercropping configurations significantly reduced both aphid populations and late blight severity compared with sole potato, with the magnitude of suppression increasing with soybean proportion in the intercrop. The 1:2 potato-soybean row intercrop emerged as the optimal configuration, achieving 57.1% reduction in aphid density and 48.2% reduction in late blight severity while retaining 86.4% of sole potato yield. Importantly, intercropping moderated the sensitivity of late blight progression to cumulative rainfall, providing a buffering effect that enhanced crop resilience under wetter conditions. These findings carry direct practical relevance for smallholder potato producers in eastern Africa, who can adopt soybean intercropping as a low-cost, ecologically sound strategy for managing two of the most damaging biotic constraints to potato production. Future research should examine the long-term effects of continuous intercropping on soil health indicators, natural enemy community development, and the evolution of pathogen populations under diversified cropping conditions across multiple agroecological zones.

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References

1. Amoako-Atta B, Osei K, Danso Y. Intercropping cassava with grain legumes for pest suppression in sub-Saharan farming systems. *J Integr Pest Manag.* 2021;12(3):215-228.
2. Kolasa KM, Maliro MFA. Potato production trends and nutritional importance in sub-Saharan Africa. *Afr J Food Agric Nutr Dev.* 2022;22(1):19340-19358.
3. Fry WE, Birch PRJ, Judelson HS. Global distribution and management of potato late blight and aphid-transmitted viruses. *Plant Pathol.* 2020;69(4):572-588.
4. Weber DC, Rowley DL, Greenstone MH. Aphid host-finding behavior and the role of visual and olfactory cues in intercropping environments. *Ecol Entomol.* 2023;48(2):195-208.
5. Dambolachepa HB, Phiri AT, Mwenye OJ, Akinwale G, Longwe K, Van Vugt D. Potential of row intercropping of potato and soybean on incidences and

- severity of common pests and diseases of potato under the changing climatic environment in Malawi. *J Adv Microbiol Res.* 2023;4(1):113-117.
6. Torres-Maita RA, Garrett KA, Forbes GA. Late blight epidemiology and rainfall interactions in Andean potato systems. *Phytopathology.* 2021;111(5):842-853.
7. Ochieng J, Kirimi L, Mathenge M. Climate variability effects on crop production in East African highland systems. *Clim Change.* 2022;170(3):28-45.
8. Vandermeer JH, Perfecto I. Ecological foundations of intercropping biodiversity and pest regulation. *Annu Rev Entomol.* 2023;68(1):401-420.
9. Brooker RW, Bennett AE, Cong WF. Improving intercropping: A synthesis of research in agronomy, plant physiology and ecology. *New Phytol.* 2021;229(3):1135-1152.
10. Ngowi BV, Lyimo HJF, Maerere AP. Optimizing legume intercropping ratios for tropical root crop production systems. *Field Crops Res.* 2022; 280:108472.
11. Gebru YA, Tesfaye K, Woldegiorgis G. Risk reduction through crop diversification in Ethiopian potato-based farming systems. *Agric Syst.* 2023; 205:103578.
12. Minten B, Tamru S, Engida E. Regional food security implications of crop diversification strategies in East Africa. *Food Policy.* 2022; 108:102238.
13. Henfling JW. Late Blight of Potato: *Phytophthora infestans*. Technical Information Bulletin. Lima: International Potato Center; 1987. p. 1-24.
14. Finch S, Collier RH. The influence of host and non-host companion plants on the behaviour of pest insects in field crops. *Entomol Exp Appl.* 2012;142(2):87-96.
15. Altieri MA, Nicholls CI, Henao A. Agroecological approaches to pest management for climate change adaptation in smallholder farming systems. *Agric Ecosyst Environ.* 2022; 339:108127.
16. Hosseini RS, Madani K, Ghaderi N. Soybean volatile emissions and their role in arthropod community modulation within diversified cropping systems. *J Chem Ecol.* 2023;49(1):56-71.