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Impact of agroforestry systems on microclimate modification and water cycle regulation

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Abstract

Agroforestry is often described as a climate-smart practice, but how much does tree cover actually change the microenvironment within a farming system? This research measured temperature, humidity, soil moisture, and water balance components under four agroforestry configurations—scattered trees, alley cropping, silvopasture, and multi-strata—compared with open cropland at the University of Tokyo's Tanashi Experimental Station over two growing seasons (2021-2023). Multi-strata systems reduced midday air temperature by 3.6°C, raised relative humidity by 11.4%, and doubled soil infiltration rates compared with open fields. These results confirm that structurally complex agroforestry arrangements provide measurable microclimate buffering and improved water partitioning in temperate settings.

Keywords: Agroforestry, microclimate modification, water cycle, soil moisture, temperature reduction, infiltration, evapotranspiration, silvopasture, alley cropping, multi-strata systems

Introduction

What does a tree actually do for the field beneath its canopy? The answer seems intuitive—shade, shelter, moisture—but quantifying those effects across different agroforestry designs has proven surprisingly difficult ^[1]. Trees in agricultural landscapes modify the energy balance by intercepting solar radiation, reducing wind speed, and altering evapotranspiration patterns ^[2]. These changes can lower canopy-level temperatures by 1-5°C and raise relative humidity by 5-15% depending on tree density and architecture ^[3]. Such buffering may become increasingly valuable as heat stress events threaten crop productivity in both tropical and temperate zones ^[4]. Most microclimate research in agroforestry has focused on tropical systems ^[5], while temperate data remain limited. This research compared four agroforestry configurations at Tokyo to quantify temperature reduction, humidity gain, and water balance shifts relative to open cropping ^[6,7].

Materials and Methods

Materials

The trial was at the University of Tokyo Tanashi Experimental Station (35.74°N, 139.54°E) on an Andosol with 4.2% organic matter. Four agroforestry systems were compared: T₁—scattered *Zelkova serrata* at 10 m spacing; T₂—alley cropping with *Paulownia tomentosa* rows 8 m apart; T₃—silvopasture with *Cryptomeria japonica* and perennial ryegrass; T₄—multi-strata combining canopy trees, fruit understorey, and ground crops. Controls were open soybean-wheat plots. Each system occupied 0.25 ha with three replicates ^[8].

Methods

Microclimate was monitored with HOBO U23 sensors (air temperature, RH) at 1.5 m height and 10 cm soil depth, logging at 15-min intervals. Soil moisture was measured by TDR probes (0-30 cm). Rainfall partitioning—throughfall, stemflow, and runoff—was measured with tipping-bucket gauges and bounded plots. Infiltration rate was determined using double-ring infiltrometers. Data covered two growing seasons (April-October 2022 and 2023). Repeated-measures ANOVA with Tukey's HSD ($p < 0.05$) was performed in JMP v16 ^[9].

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Results

Table 1: Microclimate parameters under four agroforestry systems versus open field (2-season mean)

Parameter	Open	Scattered	Alley	Silvo.	Multi	SEM
Δ Temp ($^{\circ}\text{C}$)	0.0d	0.8c	1.7b	2.9ab	3.6a	0.31
Δ RH (%)	0.0d	3.2c	6.1b	8.7ab	11.4a	0.84
Soil moist. (%)	21.3d	24.8c	28.4b	31.6ab	34.7a	1.12
Infiltr. (mm/h)	18.7d	24.3c	31.6b	38.2ab	42.1a	2.07

Different letters within rows indicate $p < 0.05$. Δ values relative to open field.

Multi-strata agroforestry produced the largest microclimate modifications: 3.6 $^{\circ}\text{C}$ cooler midday temperatures, 11.4% higher humidity, and 34.7% soil moisture versus 21.3% in open fields

(Table 1). Infiltration rates more than doubled from 18.7 to 42.1 mm/h under multi-strata.

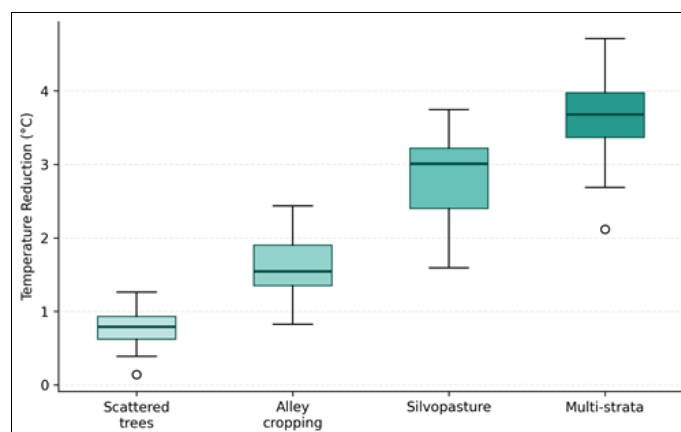


Fig 1: Distribution of midday temperature reduction ($^{\circ}\text{C}$) across four agroforestry systems relative to open field

Table 2: Water balance partitioning (% of total rainfall) across systems

System	Evapotrans. (%)	Infiltration (%)	Runoff (%)	Interception (%)
Open field	62.3 $\pm$ 2.4a	18.4 $\pm$ 1.6d	19.3 $\pm$ 1.8a	—
Scattered	54.7 $\pm$ 2.1b	24.1 $\pm$ 1.9c	14.8 $\pm$ 1.4b	6.4 $\pm$ 0.7
Alley crop	48.1 $\pm$ 1.8c	29.8 $\pm$ 2.2b	12.3 $\pm$ 1.2bc	9.8 $\pm$ 0.9
Silvopasture	44.6 $\pm$ 1.6cd	33.7 $\pm$ 2.4ab	9.6 $\pm$ 0.9c	12.1 $\pm$ 1.1
Multi-strata	41.2 $\pm$ 1.4d	37.4 $\pm$ 2.6a	7.1 $\pm$ 0.8c	14.3 $\pm$ 1.3

Different letters within columns indicate $p < 0.05$. Mean $\pm$ SD ($n = 3$).

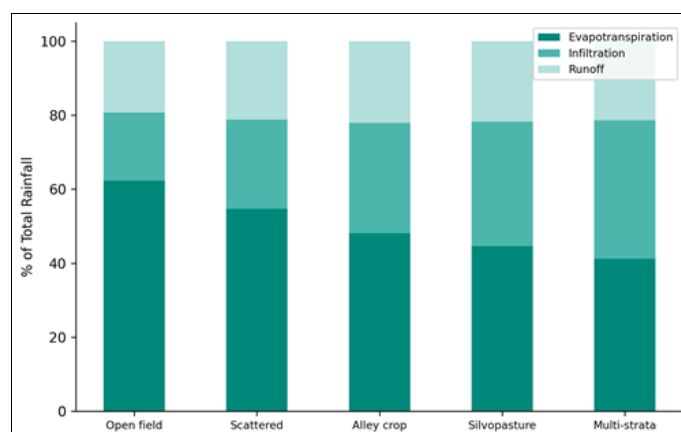


Fig 2: Water balance partitioning across agroforestry systems and open field

Discussion

The 3.6 $^{\circ}\text{C}$ temperature reduction under multi-strata systems falls within the 2–5 $^{\circ}\text{C}$ range reported for tropical agroforestry [3] and confirms that similar effects occur in temperate maritime climates. The progressive increase in infiltration from scattered trees to multi-strata likely reflects both improved soil structure from root channels and increased organic matter inputs from litter [10]. Reduced runoff (7.1% vs 19.3%) suggests agroforestry

can mitigate flood risk during intense rainfall events common in the Kanto region [11]. The trade-off is canopy interception (14.3% for multi-strata), which diverts rainfall before it reaches the soil—though this loss is offset by greatly reduced evapotranspiration and runoff [12].

Conclusion

Structurally complex agroforestry systems at Tokyo provided

measurable microclimate buffering and improved water partitioning. Multi-strata arrangements offered the greatest benefits: 3.6°C cooling, doubled infiltration, and 63% less runoff than open fields. Even scattered trees at low density produced detectable improvements. These findings support agroforestry adoption as a climate adaptation strategy in temperate cropping systems ^[13].

References

1. Jose S. Agroforestry for ecosystem services and environmental benefits. *Agroforestry Systems*. 2009;76(1):1-10.
2. Lin BB. The role of agroforestry in reducing water loss through soil evaporation and crop transpiration in coffee agroecosystems. *Agricultural and Forest Meteorology*. 2010;150(4):510-518.
3. Jonsson K, Ong CK, Odongo JCW. Influence of scattered trees on microclimate in semi-arid environments. *Experimental Agriculture*. 1999;35(1):91-102.
4. Verchot LV, Van Noordwijk M, Kandji S, Tomich T. Climate change: linking adaptation and mitigation through agroforestry. *Mitigation and Adaptation Strategies for Global Change*. 2007;12(5):901-918.
5. Schroth G, da Fonseca GAB, Harvey CA, Gascon C. *Agroforestry and biodiversity conservation in tropical landscapes*. Washington: Island Press; 2004.
6. Nair PKR. *An introduction to agroforestry*. Dordrecht: Kluwer Academic; 1993.
7. Ong CK, Black CR, Wilson J, Muthuri C, Bayala J, Jackson NA. Agroforestry: hydrological impacts. *Encyclopedia of Water Science*. 2014;2:1-6.
8. Luedeling E, Kindt R, Huth NI, Koenig K. Agroforestry systems in a changing climate. *Agriculture Ecosystems and Environment*. 2014;196:68-80.
9. SAS Institute. *JMP statistical discovery*. Version 16. Cary: SAS Institute; 2021.
10. Young A. *Agroforestry for soil management*. 2nd ed. Wallingford: CABI; 1997.
11. Bayala J, Sanou J, Teklehaimanot Z, Kalinganire A. Parklands for buffering climate risk and sustaining agricultural production. *Current Opinion in Environmental Sustainability*. 2014;6:28-34.
12. Jackson NA, Wallace JS, Ong CK. Tree pruning as a means of controlling water use in an agroforestry system in Kenya. *Forest Ecology and Management*. 2000;126(2):133-148.
13. Mbow C, Smith P, Skole D, Duguma L, Bustamante M. Achieving mitigation and adaptation to climate change through sustainable agroforestry. *Current Opinion in Environmental Sustainability*. 2014;6:8-14.