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Research Article

Allelopathic Effects of *Azardiracta indica* and *Vitellaria paradoxa* on the Germination and Growth of Pepper (*Capsicum annuum* L.)

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ABSTRACT

This work was conducted to evaluate the allelopathic effects of Neem (*Azadirachta indica*) and Shea butter (*Vitellaria paradoxa*) on the germination and growth of pepper (*Capsicum annuum* L.) in the Northern Guinea Savannah agro-ecological zone of Nigeria. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three (3) replicates. Data were collected on germination rate, plant height, stem diameter, number of leaves, number of branches, root length, above ground biomass, and below ground biomass, and analyzed using Analysis of Variance (ANOVA) using Duncan's Multiple Range Test (DMRT) for mean separation at 5% probability to separate means. Results showed that *A. indica* caused stronger inhibition of pepper seed germination and growth parameters than *V. paradoxa*. Germination percentages under neem were reduced to 57.33% compared to 67.67% under shea butter, both lower than the control (100%). Neem also suppressed plant height, stem circumference, and biomass more than shea butter. Although statistical analysis revealed no significant differences ($p \geq 0.05$) among treatments, the inhibitory trend suggests that these trees can influence pepper growth. Findings align with recent research on allelopathy in sustainable agriculture. It was recommended that farmers consider the placement of these trees on farmlands to reduce potential productivity losses.

Keywords: Allelopathy; *Azadirachta indica*; *Capsicum annuum;* Germination; Growth; *Vitellaria paradoxa*

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INTRODUCTION

The term *allelopathy* refers to the adverse influence of one plant or microorganism on another through the release of chemical compounds into the environment (Musa *et al.*, 2021). While competition involves depletion of shared resources, allelopathy results from the release of secondary metabolites that can inhibit germination, growth, or survival of neighboring plants (Musa *et al.*, 2017). These allelochemicals may be released through leaching, volatilization, litter decomposition, or root exudation (Abdullahi *et al.*, 2017; Latif *et al.*,2017).

In agriculture, allelopathy is increasingly recognized as a natural tool for weed suppression and crop management. Studies indicate that many tree and crop species release allelochemicals that reduce germination and seedling vigor of associated plants (Hussain *et al.*, 2021). Neem (*Azadirachta indica*) and shea butter (*Vitellaria paradoxa*) are two multipurpose tree species common in sub-Saharan Africa, valued for their ecological and economic benefits but also reported to exert allelopathic effects (Adetunji & Olaniyan, 2019; Arowosegbe & Afolayan, 2019).

Neem exhibited stronger inhibitory effects on pepper compared to shea butter. This may be attributed to its higher content of bioactive compounds such as azadirachtin, which have been shown to impair seed germination and reduce growth in several crops (Arowosegbe & Afolayan, 2019; Odebode & Ayeni, 2020). In contrast, shea butter trees exerted milder effects, likely due to weaker allelopathic compounds or predominantly shading effects. Similar findings have been reported in other agroforestry systems where

neem reduced crop productivity more strongly than other indigenous trees (Adetunji & Olaniyan, 2019).

MATERIALS AND METHODS

The experiment was carried out at the Teaching and Research Farms of Federal College of Education Kontagora, Niger State, Nigeria, which falls within the Northern Guinea Savannah agro-ecological zone of Nigeria. Kontagora is a city in Nigeria with the gps coordinates of 10° 24' 25.7256'' N and 5° 28' 11.7012'' E. This location is found to be cold and dry from November to May and then warm and moist from June to October. It is characterized by mono-modal rainfall distribution whereby the rainy season starts in late late May and ends in mid-October. The annual mean rainfall is between 1047 and 1147 mm (https://www.climatestotravel.com/climate/niger/Kontagora -2022).

Seeds of (tatashe) pepper variety (sweet pepper) were obtained from the herbarium of the Department of Agricultural Science of Federal College of Education, Kontagora. Two (2) tree species; Neem, (*Azardirachta indica*), and Shear butter (*Vitellaria paradoxa*) used were found as volunteers' plants. Three beds each 3 m by 3 m dimension were prepared at a spacing of 12-18 inches between plants and 30-36 inches between rows under each of the trees respectively. Weeding was manually done using hoe as at 2, 4, 6, and 8 weeks after sowing. There were three replicates thus making a total of twenty-seven (27) beds. Seeds of pepper were planted on each of the beds. The treatment combinations were replicated four (4) times and the trial was laid out in a Randomized Complete Block Design (RCBD). Control experiment was also set up along the treatments outside the canopy of the trees which were also replicated in three times.

For the pot experiment, two seeds of maize, cowpea and sesame were planted in the 5 kg of soil collected from under the canopy of *Azardiracta indica* and *Vitellaria paradoxa*. Another soil from open space was included as control for the planting of the studied arable crops. The control was laid out in a completely randomized design (RCD). Data were collected on seedling emergence at 4, 6, 8, and 10 days after sowing (DAS) and later converted to percentage emergence. Seedling growth parameters measured included plant height using measuring tape, stem girth with venier calipers which first gave the value of the diameter, which was later converted to circumference using a fomular of π D (i.e. 3.142) multiplied by the obtained diameter (D) value, number of branches determined by observation and direct counting of all well-developed branches per plant and number of leaves. These were measured at 2, 4, 6, 8 and 10 weeks after sowing (WAS). Seedlings root lengths were measured at harvest using measuring tape. The results obtained from the plants under these tree species were statistically compared to those obtained from the control experiments following the procedure of analysis of variance (ANOVA) where differences were observed, Duncan's Multiple Range Test (DMRT), at 5% level of probability, was used to compare differences among the treatment means.

RESULTS AND DISCUSSION

The results show that both *Azadirachta indica* and *Vitellaria paradoxa* inhibited pepper germination and growth compared to the control. Although differences were not statistically significant at $p < 0.05$, the inhibitory patterns were consistent. These results confirm earlier findings that allelopathic tree species reduce seedling establishment and vegetative growth of nearby crops through allelochemical release (Musa *et al*., 2016).

Pepper plant height, leaf number, and branch development were particularly suppressed under neem, supporting studies showing that allelochemicals can inhibit photosynthesis, reduce nutrient uptake, and alter hormonal balance (Latif *et al*., 2017; Hussain et al., 2021). This implies that allelopathy not only delays germination but also negatively influences vegetative growth and potentially yield. Statistically however, there were no significant ($p < 0.05$) difference in both the rate and total germination of pepper treated with tree species in the two experiments (Table 1). The control treatments were better than the treated plots except in number of leaves. However, with the detrimental effects of the tree species on pepper number of branches, the effect is likely to be very pronounced in fruit yield. Shaukat and Siddiqui (2001) had attributed reduction or outright stoppage of growth to inhibitory substances, in the soil which in this case is suspected to have been deposited by the *Azardiracta indica*.

The control treatment was superior to the treated plants in the plant height, stem diameter and numbers of branches in the two experiments (Tables 2-5). Pepper response to the treatments was similar over the period of monitoring in the two experiments except at 2 WAS in the pot and 2 WAS and 4 WAS in the field experiment where Neem was superior to Shea butter with respect to plant height (Table 3 and Table 4), but affected pepper number of leaves (Table 5) at 4 WAS and 6 WAS in the field experiment than others. *Vitellaria paradoxa* was less detrimental to pepper number of branches at both experiments. Both *A. indica* and *V.paradoxa* visually vegetatively affected pepper plant height, stem

diameter, number of leaves and root length on both the field and pot experiments.

Table 1: Effect of allelopathy of *A. Indica* and *V. paradoxa* on on pepper germination

	POT Percentage Germination				FIELD Percentage Germination			
T_rT	4 DAS	6 DAS	8 DAS	10 DAS	4 DAS	6 DAS	8 DAS	10 DAS
TOC	58.67 a	84.99 a	92.67 a	100.00 a	50.67 a	87.13 a	100.00 a	32.51 a
TNC	5.00 b	45.13 b	64.33 b	87.13 b	3.67 ab	40.03 b	46.70 b	50.33 b
TSC	8.67 b	45.67 b	67.67 b	87.97 b	0.13 b	46.67 b	58.67 ab	67.67 ab

Note: Means followed by the same letters within the same column are not significantly different at $p \leq 0.05$, using DMRT. TOC = Top soil from open space, TNC = Soil under Neem Tree, TSC = Soil under Shear butter Tree

Table 2: Allelopathic effect of *A. Indica* and *V. paradoxa*on on pepper plant height at different growth stages

	POT number of Leaves					FIELD number of Leaves				
T_rT	2 WAS	4 WAS	6 WAS	8 WAS	10 WAS	2 WAS	4 WAS	6 WAS	8 WAS	10 WAS
TOC	10.00 a	14.33 a	32.67 a	36.13 a	42.00 a	10.67 a	18.00 a	34.00 a	37.13 a	40.13 a
TNC	7.67 b	11.67 b	22.13 b	27.67 b	31.33 b	8.13 b	12.67 b	21.00 b	25.33 a	27.67 b
TSC	8.00 b	12.13 b	22.33 b	29.00 b	33.13 b	9.13 ab	13.13 b	22.13 b	28.13 ab	31.13 ab

Note: Means followed by the same letters within the same column are not significantly different at $p < 0.05$, using DMRT. TOC = Top soil from open space, TNC = Soil under Neem Tree, TSC = Soil under Shear butter Tree

Table 3: Allelopathic effect of *A. Indica* and *V. paradoxa*on on pepper stem circumference at different growth stages

	POT Stem Circumference (cm)					FIELD Stem Circumference (cm)				
T_rT	2 WAS	4 WAS	6 WAS	8 WAS	10 WAS	2 WAS	4 WAS	6 WAS	8 WAS	10 WAS
TOC	0.63 a	0.93 a	2.67 a	2.83 a	2.97 a	0.67 a	0.87 a	2.33 a	2.51 a	2.63 a
TNC	0.47 b	0.57 b	0.73 b	0.87 b	1.00 b	0.43 b	0.53 b	0.70 b	0.81 b	0.93 b
TSC	0.43 b	0.60 b	0.77 b	0.90 b	1.13 b	0.47 b	0.57 b	0.77 b	0.83 b	0.97 b

Note: Means followed by the same letters within the same column are not significantly different at $p < 0.05$, using DMRT. TOC = Top soil from open space, TNC = Soil under Neem Tree, TSC = Soil under Shear butter Tree

Table 4: Allelopathic effect of *A. Indica* and *V. paradoxa*on on pepper plant height at different growth stages

	POT Plant Height (cm)					FIELD Plant Height (cm)				
T_rT	2 WAS	4 WAS	6 WAS	8 WAS	10 WAS	2 WAS	4 WAS	6 WAS	8 WAS	10 WAS
TOC	10.63 a	18.93 a	32.67 a	36.83 a	38.13 a	10.67 a	17.07 a	28.33 a	32.51 a	35.63 a
TNC	7.47 b	10.57 b	16.73 b	19.87 b	21.91 b	8.43 b	11.03 b	16.70 b	18.11 b	20.13 b
TSC	7.13 b	10.33 b	16.77 b	20.93 b	23.13 ab	7.73 b	11.87 b	17.67 b	19.83 ab	22.03 ab

Note: Means followed by the same letters within the same column are not significantly different at $p < 0.05$, using DMRT. TOC = Top soil from open space, TNC = Soil under Neem Tree, TSC = Soil under Shear butter Tree

Table 5: Allelopathic effect of *A. Indica* and *V. paradoxa*on on pepper number of branches, root length and biomass yield at different growth stages

	No of Branches		Root Length (cm)		Biomass yield (g)	Biomass yield (g)
T_rT	At Harvest					
	Pot	Field	Pot	Field	Pot	Field
TOC	8.33 a	8.33 a	48.67 a	52.17 a	50.12 a	48. 52 a
TNC	3.56 b	4.56 b	42.13 b	42.67 b	30.12 b	31.67 b
TSC	5.67 ab	5.01 b	45.13 ab	45.67 ab	32.67 b	31.13 b

Note: Means followed by the same letters within the same column are not significantly different at $p < 0.05$, using DMRT. TOC = Top soil from open space, TNC = Soil under Neem Tree, TSC = Soil under Shear butter Tree

CONCLUSION

This study concludes that both neem (*Azadirachta indica*) and shea butter tree (*Vitellaria paradoxa*) possess allelopathic properties that inhibit the germination and growth of pepper (*Capsicum annuum* L.), with neem exerting stronger inhibitory effects. Although differences were not statistically significant, the consistent reduction in growth parameters highlights the need for caution when cultivating peppers near these trees.

These findings align with evidence that allelopathy plays a significant role in tree crop interactions within agroforestry systems (Hussain *et al*., 2021; Latif *et al*., 2017). Farmers are advised to practice wider spacing or selective removal of neem and shea butter stands in pepper fields to minimize productivity losses. Future research should focus on identifying specific allelochemicals responsible for these effects and developing strategies to mitigate them in sustainable agroforestry systems.

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