Sustainable intensification of smallholder crop-livestock farming systems in northern Ghana: Optimizing groundnut plant density for grain and fodder

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Introduction

- There is limited literature on the assessment of the sustainability of integrated crop-livestock technologies at smallholder farm scale.
- Two on-farm trials (Agronomic trial and Livestock feeding trial) were conducted to identify optimal groundnut plant density for sustainable intensification of crop-livestock farming system.

Photo 1. Groundnut planted at 22 plants/m^2.

Materials and Methods

Experimental design and treatment

Agronomic trial: Four groundnut plant densities (22, 15, 11 and 9 (farmer practice) plants/m^2) laid in RCBD with eight replications per treatment conducted for 2 years (2017/2018).

Livestock feeding trial: Same four plant densities as treatments laid in RCBD with three replications per treatment conducted for 70 days during 2018. The feed composition was 60% groundnut fodder and 40% corn bran. A sheep (19 ± 2.0 kg) was offered 500 g of feed per day from 6:30-9:30 am and kept in a semi-intensive system.

Sustainable Intensification assessment

We applied the Sustainable Intensification Assessment Framework (SIAF) to compare the sustainability of the above treatments (Fig. 1).

Fig. 1. Application process of SIAF and sustainability

Step 1 — Measured selected indicators from the five SIAF domains which were useful to answering research question (Table 1).

Step 2 — Transformed measured data (Table 1) into sore and find mean score under each of the SIAF domain to generate data for Fig. 2 and 3.

(Abdul Rahman et al. 2024)

Step 3 — calculated sustainability index using geometric rules for calculating the area of a pentagon (Fig. 3).

Results

Table 1. The effect of groundnut plant on SIAF indicators

		Plant density (plants/m^2)					
Domain by indicator	**Metric**	**22**	**15**	**11**	**9**	**s.e.m**	**P-value**
Productivity							
Crop Productivity	Grain yield (kg/ha)	1189.9a	858.7b	641.9c	536.0c	42.81	<.0001
	Fodder yield (kg/ha)	4357.2a	2779.3b	1961.7c	1435.1c	167.17	<.0001
	Weed biomass (g/m^2)	245.4b	434.6b	662.5a	880.2a	42.60	<.0002
Animal productivity	Live body weight gain (kg)	23.4a	22.2b	22.1b	21.8b	0.31	0.008
Economic							
Profitability	Net income Gnut grain (GHS/ha)	882.6a	348.2b	335.3b	48.9c	96.56	<.0001
	Gross margin livestock (GHS/ head, n=5)	1470.2	1392.9	1387.8	1366.1	22.74	-
Environment							
Vegetative cover	Vegetative cover at harvest (%)	98.2a	91.0b	88.6b	83.2c	1.68	0.0011
Soil quality	Biological nitrogen fixation (%/ha)	62.3a	55.3ab	36.4b	39.8b	5.93	0.0381
Disease incidence	Incidence of leaf spot disease (%)	35.1a	34.9a	36.2a	33.6a	1.34	0.9162
Manure quality	Manure N content (g/kg)	21.0a	19.8ab	17.7c	18.7bc	0.4	0.001
Human							
Food security	Calorie grain (kc/ha, 10^4)	675.0a	487.0b	364.0c	304.0c	24.27	<.0001
	Calorie Livestock (kc/ha, 10^4)	6.6a	6.3b	6.2b	6.1b	0.1	0.008
Nutrition	Protein grain (g/ha, 10^3)	307.0a	221.6b	165.6c	138.3c	11.05	<.0001
	Protein livestock (g/ha, 10^3)	3.9a	3.7b	3.7b	3.6b	0.06	0.008
Social							
Gender equity	Tech. rating (number of farmers)						
	Men (n= 150)	65	36	26	23	9.58	
	Women (n= 110)	49	30	18	13	8.01	

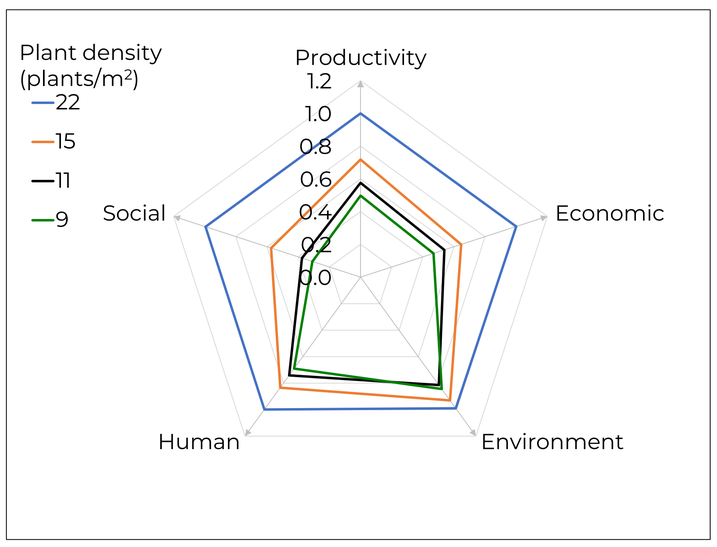

Fig. 2. Groundnut plant density effect on SIAF domains

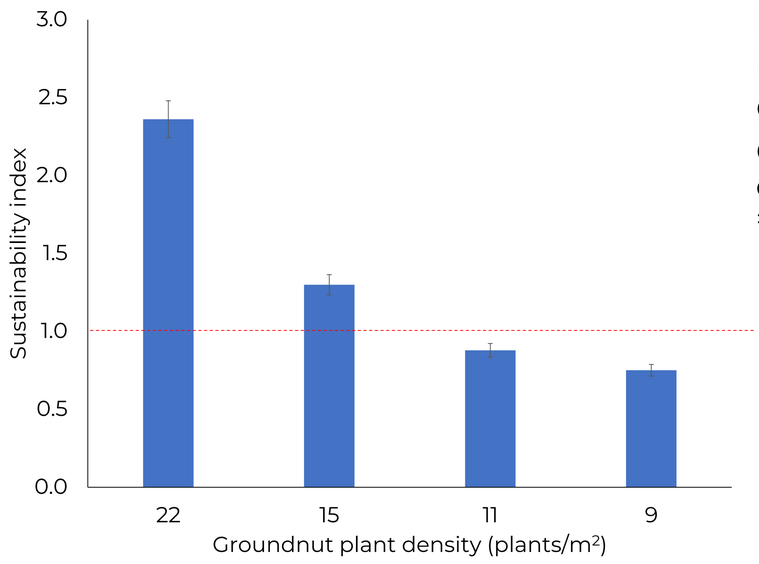

Fig. 3. Sustainability index as affected by groundnut plant density. Bars = standard error and Broken red line = sustainability threshold

Conclusion

- Groundnut plant density at 22 plants/m^2 recorded higher scores across the SIAF domains and sustainability index relative to the others.
- We recommend that planting groundnut at a density of 22 plants/m^2 will enhance the sustainability of smallholder crop-livestock farming system in northern Ghana and similar agro-ecologies through its effect on productivity, income, food security, nutrition, and gender equity.

Reference

Abdul Rahman, N., Larbi, A., Kizito, F., Kotu, B. H., & Hoeschle-Zeledon, I. (2024). Sustainable intensification of smallholder maize production in northern Ghana: The case of cowpea living mulch technology. Agronomy Journal, 1–14. https://doi.org/10.1002/agj2.21600