

## Soil type-specific sorghum cultivation strategies for maximizing yield and net return in the Sudan Savanna

To meet the rapidly increasing food demand in Sub-Saharan Africa (SSA), improving agricultural productivity in the region is essential. In countries across the Sudan Savanna, the largest sorghum-producing region in SSA, agricultural recommendations are being revised. However, differences in soil types—which significantly influence sorghum yield—have not yet been taken into account.

Therefore, this study aims to identify optimal combinations of nitrogen (N) application rate, planting density, and variety (i.e., optimal cultivation practices) that maximize sorghum yield and net return from fertilization in three dominant soil types in the Sudan Savanna: Lixisols (LX), characterized by a deep effective soil depth (~100 cm); Plinthosols with medium effective depth (~50 cm; PT); and Plinthosols with shallow effective depth (~25 cm; PX).

The optimal cultivation practices identified through two years of field experiments were as follows (Table 1):

LX: 74 kg N ha<sup>-1</sup>, 5.6 plants m<sup>-2</sup>, Sariaso14

PT: 74 kg N ha<sup>-1</sup>, 8.3 plants m<sup>-2</sup>, Kapelga

PX: 37 kg N ha<sup>-1</sup>, 3.1 plants m<sup>-2</sup>, Kapelga

As expected, these practices differed depending on soil type. Current agricultural recommendations for sorghum in each country generally prescribe an N application rate of around 30 kg ha<sup>-1</sup> regardless of soil type. However, increasing the N application rate in LX and PT can improve both yield and net return. Based on fertilizer prices and farm-gate prices of sorghum in Burkina Faso from 2010 to 2022, a period during which prices fluctuated significantly, the net returns from fertilization under the optimal practices was calculated. The average net returns followed the order LX > PT > PX, reflecting differences in effective soil depth (Fig. 1). The economic robustness of the optimal cultivation practices also differed among soil types. In LX and PT, net returns from fertilization remained positive even under high fertilizer prices, whereas in PX, where the effective soil depth is shallow, net returns could become negative (Fig. 1).

These findings can be used to improve existing agricultural recommendations for sorghum in countries across the Sudan Savanna, making them more fertilizer-efficient. However, sorghum yields and net returns from fertilization in this study were obtained under fertilization practices recommended by INERA: a basal application immediately after sowing, followed by top-dressing at 4 and 6 weeks after sowing. Therefore, even with the same total N application rate, different application timings or frequencies may not yield the same results.

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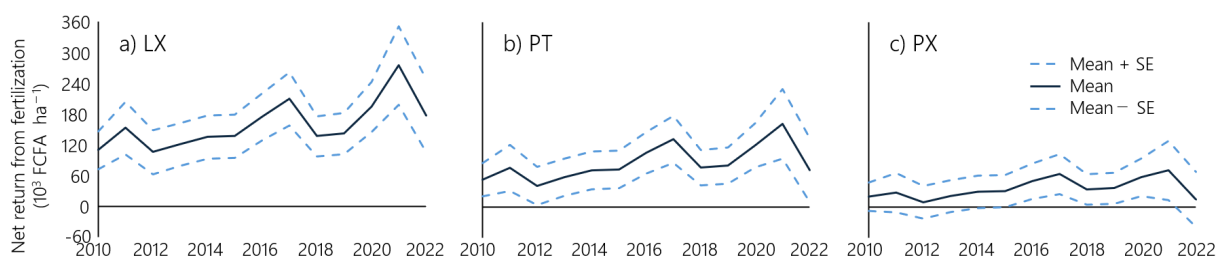
**Table 1. Effects of nitrogen application rate, planting density, and variety on sorghum yield and net returns from fertilization across soil types**

	Sorghum yield (kg ha <sup>-1</sup> )			Net return (10 <sup>3</sup> FCFA ha <sup>-1</sup> )		
	LX	PT	PX	LX	PT	PX
A: Nitrogen application rate <sup>1)</sup>						
37 kg ha <sup>-1</sup>	1098 a	619 a	691	55 a	3 a	25
74 kg ha <sup>-1</sup>	1660 b	1049 c	857	136 b	60 b	33
111 kg ha <sup>-1</sup>	1724 b	820 b	782	126 b	-4 a	-3
B: Planting density						
3.1 hills m <sup>-2</sup>	1332 a	696 a	784	80 a	-2 a	24
5.6 hills m <sup>-2</sup>	1661 b	828 ab	762	136 b	19 ab	17
8.3 hills m <sup>-2</sup>	1490 ab	975 b	774	101 ab	43 b	14
C: Variety <sup>2)</sup>						
Kapelga	1453	870	853 b	100	28	34 b
Sariaso14	1535	800	691 a	112	12	2 a

Results from a two-year field experiment (a normal rainfall year and a low rainfall year) conducted in central Burkina Faso, where representative geology, topography, and soils of the Sudan Savanna are distributed. LX denotes Lixisols with a deep effective soil depth (~100 cm); PT denotes Plinthosols with medium effective depth (~50 cm); and PX denotes Plinthosols with shallow effective depth (~25 cm). Values represent means for each treatment. Different letters indicate significant differences ( $p < 0.05$ ) in mean yield or net returns from fertilization within each soil type and factor (A, B, and C). Letters are omitted when differences are not significant. No interaction was observed among factors A, B, and C.

<sup>1)</sup> Phosphorus (23 kg ha<sup>-1</sup> as P<sub>2</sub>O<sub>5</sub>) and potassium (14 kg ha<sup>-1</sup> as K<sub>2</sub>O) were applied as basal fertilizer in all treatments. <sup>2)</sup> In LX, both yield and net returns from fertilization were significantly higher ( $p < 0.05$ ) for Sariaso14 than for Kapelga in the normal rainfall year, and because normal rainfall years occur more frequently than low rainfall years, Sariaso14 was selected as the optimal variety. In contrast, in PT, no significant differences in yield or net return from fertilization were observed between Sariaso14 and Kapelga; however, Kapelga was selected as the optimal variety because of its superior palatability and storability compared with Sariaso14.

1 FCFA = 0.28 JPY (December 2025).

**Fig. 1. Net returns from fertilization under optimal cultivation practices across soil types from 2010 to 2022**

LX, PT, and PX are defined as in Table 1. In LX and PT, even during the period from 2010 to 2022 when prices fluctuated substantially, the value of the mean minus one standard error (SE) remained consistently positive. In contrast, in PX, where the effective soil depth is shallow, the mean minus one SE became negative under high fertilizer prices, indicating the potential for economic loss due to fertilization.

Reference: Ikazaki et al. (2025) *Soil Sci. Plant Nutri.* 71: 724–735. © Authors 2025

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