Unique fertilizer response of sorghum on Plinthosols with thin effective soil depth

Increasing agricultural productivity is essential to meet the rapidly increasing demand for food in Sub-Saharan Africa (SSA). According to statistics from the FAO, while the population of the region tripled between 1980 and 2020, the productivity per unit area of sorghum, the main grain of semi-arid regions in SSA, increased by only 20% and remains stagnant. To address this problem, West Africa is currently redeveloping its cultivation guidelines, which take account of agro-ecological zones reflecting climate, but not soil type differences. However, a special soil type called Plinthosols, in which the effective soil depth (ESD) is less than 50 cm, is widely distributed in the semi-arid regions of West Africa. Because these soils have lower water-holding capacity than other soil types, the response of sorghum to fertilizer application may differ on the Plinthosols.

Therefore, this study aims to determine the differences in fertilizer response of sorghum on three dominant soil types in semi-arid West Africa: Lixisol (LX), which has a thick ESD of about 100 cm and high water-holding capacity; Plinthosol (PT), which has an ESD of about 50 cm; and Plinthosol (PX), which has an ESD of about 25 cm (Fig. 1).

In a year with 21% (1.3 times the standard deviation) less rainfall than the average year, yields are not reduced in LX, but are reduced in PT and PX (Table 1A). This indicates that lack of soil moisture can limit yield in any of the Plinthosols, suggesting that the optimal sorghum variety (e.g., earlier maturing) and sowing density (e.g., more sparsely planted) may be different in Plinthosols than in Lixisols. The optimal nitrogen (N) application rate for sorghum is 74 kgN ha^{-1} in LX and PT but 37 kgN ha^{-1} in PX. The reason for this probably is that the PX with 25-cm ESD has a very limited water-holding capacity and is unable to meet the increased water requirements that accompany the vigorous growth of sorghum with fertilizer application. Since the fertilizer response of sorghum varies greatly among LX, PT, and PX, it is necessary to distinguish between LX, PT, and PX and consider optimal fertilizer amounts, varieties, and seeding densities in the guidelines currently being redeveloped for cultivation in West Africa. This would pave the way for the development of tailor-made cultivation guidelines that will allow farmers to maximize fertilizer application efficiency. Finally, we would like to mention that soil types can be easily determined by ground-penetrating radar in semi-arid West Africa. (For more information, refer to Research Highlight A04 in FY 2018, "Ground-penetrating radar can predict the soil depth at which the petroplinthic horizon starts in the Sudan Savanna, West Africa").

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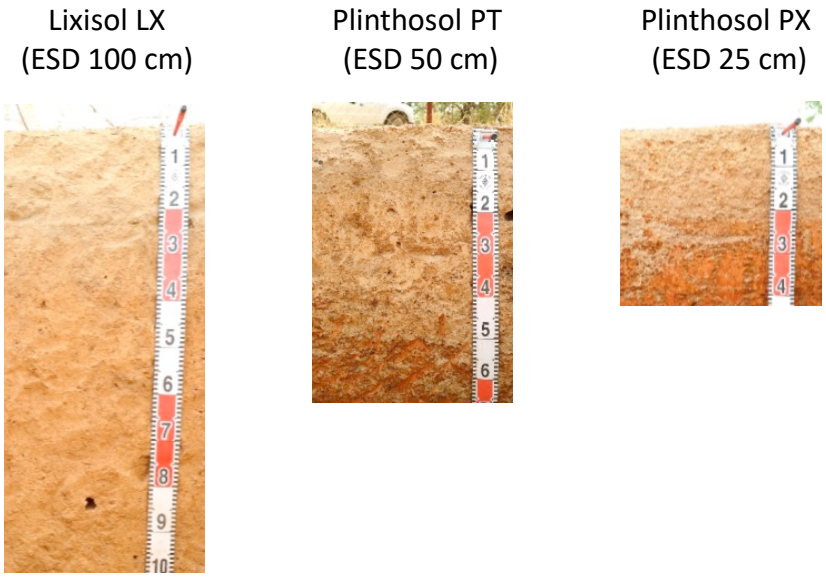

Fig. 1. Soil profiles of the three dominant soil types in the semi-arid West Africa
In PT and PX, an iron hardpan called petroplinthite, which does not allow crop roots to elongate, appears at a depth of about 50 cm and 25 cm, respectively, so the sorghum can only use the water in the soil layer above the iron hardpan.

Table 1. Effects of rainfall amount and fertilization on sorghum yield (kg/ha) in each soil type

	Soil Type		
	Lixisol LX (ESD[1)] 100 cm)	Plinthosol PT (ESD 50 cm)	Plinthosol PX (ESD 50 cm)
A: Rainfall amount	ns[2)]	*	**
B: Nitrogen application rate[3)]			
0 kg/ha	522 (52)c	325 (60)c	287 (71)b
37 kg/ha	1040 (121)b	520 (144)bc	800 (79)a
74 kg/ha	1534 (120)a	971 (107)a	808 (105)a
111 kg/ha	1596 (142)a	784 (101)ab	780 (116)a

Results of a 2-year experiment (average and low rainfall years) in central Burkina Faso, where the geology, topography, and soils are representative of semi-arid West Africa. [1)] Effective soil depth. [2)] Statistical analysis. ns: not significant ($p>0.05$), * $p<0.05$, ** $p<0.01$; Numbers in brackets are standard errors. Different alphabets indicate that sorghum yields differed significantly ($p<0.05$) among the same soil type with different nitrogen application rates. [3)] Nitrogen was simultaneously applied with phosphorus (23 kg P_2O_5/ha) and potassium (14 kg/ha).

References: Ikazaki et al. (2023) *Soil Science and Plant Nutrition* 70: 114–122. © The Author(s) 2023
Iseki et al. (2021) *Field Crop Research* 261: 108012. © The Author(s) 2020
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