Boosting cowpea grain yield in Plinthosols through fertilization and high plant density

Cowpea cultivation is widespread in the semi-arid regions of West Africa (Sudan Savanna) due to its drought tolerance. Cowpea serves as an important protein source for local farmers; however, due to low soil fertility, the yield per unit area is approximately one-fourth of that in Asia and the United States. The simplest way to increase yield in low-nutrient soils is through fertilization. However, due to high fertilizer costs and limited yield increase even with fertilization, most farmers in the region do not use much fertilizer for cowpea cultivation. Additionally, to compensate for low growth due to limited nutrients, increasing planting density is also considered, but the recommended planting density set over 50 years ago in the region remains unchanged.

Two dominant soil types play a significant role in agricultural productivity in the Sudan Savanna: Lixisols and Plinthosols. Lixisols are relatively fertile with high water retention, but they are prone to waterlogging after rainfall. Plinthosols have low fertility and water retention, with a higher risk of nutrient leaching after rainfall. The objective is to clarify the effects of fertilization and high plant density on these two different soil types to explore cultivation strategies to increase cowpea yields.

The effect of fertilization on yield was approximately 1.4 times higher in Plinthosols compared to Lixisols on average (Fig. 1). This difference is attributed to the high water retention in Lixisols, leading to a temporary decrease in soil oxygen levels and subsequent inhibition of root development due to elevated soil temperature (Fig. 2). Doubling the plant density from the recommended rate resulted in 1.5 times increase in yield in Plinthosols without fertilization, while the increase in yield was smaller in Lixisols (Fig. 1). Combining fertilization and high plant density resulted in higher yield increases than fertilization alone in both soil types (Fig. 1). Splitting fertilization into basal and top-dressing applications also yielded higher than applying all fertilizers at once as basal dressing (Fig. 1).

Soil types vary within a few hundred meters, allowing farmers to efficiently improve cowpea yields by adjusting fertilization rates and planting densities based on soil type within their fields. The ideal timing for top-dressing is around the 4th week after sowing during the maximum vegetative growth period. However, in the Sudan Savanna, this period coincides with the peak of the rainy season, posing a risk of nutrient leaching if heavy rainfall occurs shortly after top-dressing, especially in Plinthosols.

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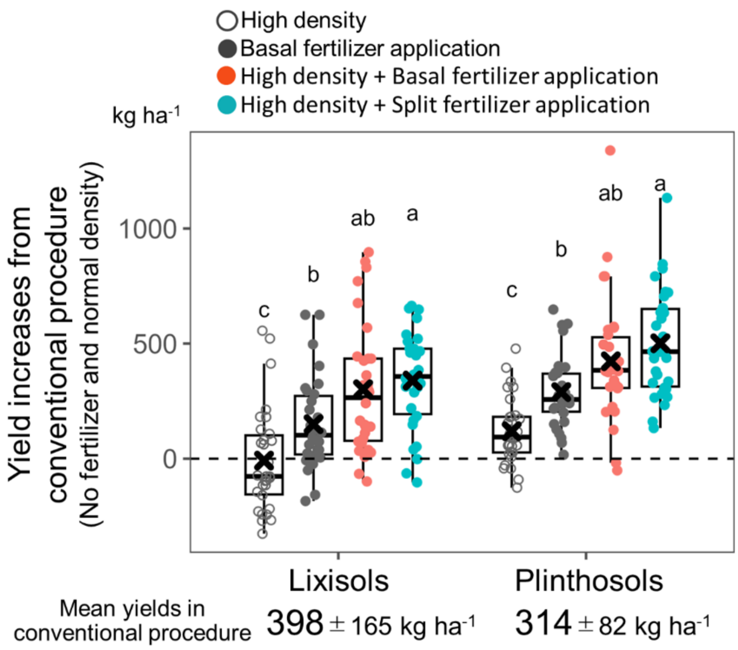

Fig. 1. Effects of fertilization and high plant density on cowpea yield in the dominant soil types of Sudan Savanna

Results of cultivating three cowpea varieties in the central region of Burkina Faso in 2018 and 2019. Each treatment shows variation over 2 years, with 3 varieties and 5 repetitions (n=30). Different letters indicate significant differences in means at P<0.05. The '×' symbol represents the mean value.

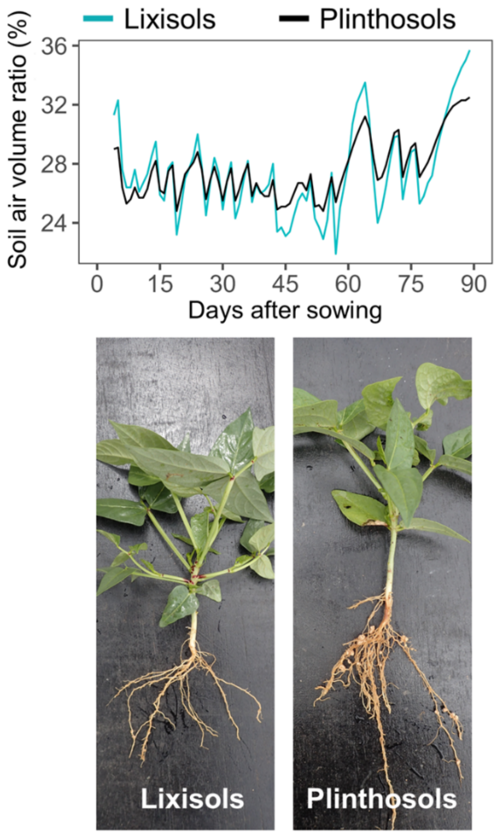

Fig. 2. Changes in soil air-volume ratio during the growth period (top) and appearance of cowpea root in each soil type (bottom)

Top: Lixisols are more prone to a decrease in soil air-volume ratio immediately after rainfall compared to Plinthosols, making them susceptible to waterlogging due to oxygen deficiency shortly after rainfall. Bottom: Cowpea grown in Lixisols showed minimal nodulation, and its root development was poorer compared to that in Plinthosols. The photos were taken in each soil type at four weeks after sowing.

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