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Assessment of N_2 Fixation and Water-Use Efficiency in a Soybean-Sorghum Rotation System

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Abstract : Industrial-based nitrogen (N) fertilizers are justifiably credited for the current state of food production across the globe, but their continued use is not sustainable and has an adverse effect on the environment. The search for greener and sustainable technologies has led to an increase in exploiting biological systems such as legumes and organic amendments for plant growth promotion in cropping systems. Although the benefits of legume rotation with cereal crops have been documented, the full benefits of soybean-sorghum rotation systems have not been properly evaluated in Africa. This study explored the benefits of soybean-sorghum rotation through assessing N_2 fixation and water-use efficiency of soybean in rotation with sorghum with and without organic and inorganic amendments. The field trials were conducted from 2017 to 2020. Sorghum was grown on plots previously cultivated to soybean and vice versa. The succeeding sorghum crop received fertilizer amendments [organic fertilizer (5 tons/ha as poultry litter, OF); inorganic fertilizer (80N-60P-60K) IF; organic + inorganic fertilizer (OF+IF); half organic + inorganic fertilizer (HIF+OF); organic + half inorganic fertilizer (OF+HIF); half organic + half inorganic (HOF+HIF) and control] and was arranged in a randomized complete block design. The soybean crop succeeding fertilized sorghum received a blanket application of triple superphosphate at 26 kg P ha^{-1}. Nitrogen fixation and water-use efficiency were respectively assessed at the flowering stage using the ^{15}N and ^{13}C natural abundance techniques. The results showed that the shoot dry matter of soybean plants supplied with HOF+HIF was much higher (43.20 g plant-1), followed by OF+HIF (36.45 g $plant^{-1}$), and HOF+IF (33.50 g $plant^{-1}$). Shoot N concentration ranged from 1.60 to 1.66%, and total N content from 339 to 691 mg N $plant^{-1}$. The $\delta^{15}N$ values of soybean shoots ranged from -1.17‰ to -0.64‰, with plants growing on plots previously treated to HOF+HIF exhibiting much higher $\delta^{15}N$ values, and hence lower percent N derived from N_2 fixation (%Ndfa). Shoot %Ndfa values varied from 70 to 82%. The high %Ndfa values obtained in this study suggest that the previous year's organic and inorganic fertilizer amendments to sorghum did not inhibit N_2 fixation in the following soybean crop. The amount of N-fixed by soybean ranged from 106 to 197 kg N ha^{-1}. The treatments showed marked variations in carbon (C) content, with HOF+HIF treatment recording the highest C content. Although water-use efficiency varied from -29.32‰ to -27.85‰, shoot water-use efficiency, C concentration, and C:N ratio were not altered by previous fertilizer application to sorghum. This study provides strong evidence that previous HOF+HIF sorghum residues can enhance N nutrition and water-use efficiency in nodulated soybean.

Keywords : ^{13}C and ^{15}N natural abundance, N-fixed, organic and inorganic fertilizer amendments, shoot %Ndfa
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