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Growth and yield responses of rice varieties to various soil water deficit conditions under different soil types

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Abstract

To avoid drought stress under rainfed upland conditions, it is important for rice to efficiently utilize water at shallow soil layers supplied by rainfall, and access to water retained in deer soil layers. The root developmental characteristics of rice, which play important role in the adaptability to drought conditions, vary depending on the variety. Moreover, water availability for plant differs depending on the soil types that have different physical properties such as water holding capacity, permeability, capillary force, penetration resistance, etc. In this study, we evaluated growth and yield responses of rice varieties to various soil water deficit conditions under three different soil types. The experiment was conducted in a plastic greenhouse at the Kenya Agricultural and Livestock Research Organization-Mwea from October 2016 to January 2017. Two upland varieties (NERICA 1 and 4) and one lowland variety (Komboka) were grown in handmade PVC pots (15.2 cm diameter and 85.0 cm height) filled with three different types of soil collected from major rice-growing areas of the country, namely black cotton (BC), red clay (RC), and sandy clay (SC). Three watering methods, 1) supplying water only from the soil surface (W1), 2) supplying water only from the bottom of the pots (W2), and 3) supplying water both from the soil surface and the bottom of pots (W3), were imposed from 40 days after sowing to maturity. Soil water content (SWC) at 20, 40, and 60 cm depths was measured regularly. At the harvesting stage, aboveground and root samples were collected to determine total dry weight (TDW), grain yield, and root length at 0–20, 20–40, 40–60, and 60–80 cm soil layers. Irrespective of the watering methods, the greatest root development was obtained in RC, while that in BC was less than other two soils. In BC, the degree of yield reduction under W1 was less than that in RC and SC, which could be attributed to the higher water holding capacity of BC. In RC, the growth and yield reduction observed in all varieties under W1 was attributed to the severe drought stress. On the other hand, under W2, SWC at the shallow soil depth in RC was maintained because of its higher capillary force compared with BC and SC. As the result, growths and yields in RC were not suppressed under W2. In SC, deep root development was not promoted by W2 irrespective of the varieties, which resulted in significant yield losses. Under W1, the rice growth and yield in SC was decreased although shallow root development was enhanced, and the stomatal conductance was maintained higher than RC. It was suspected that W1 caused nutrients leaching in SC because of its higher permeability. Under rainfed conditions, growth and yield of rice can be strongly affected by soil types because dynamics of soil water conditions change according to soil physical properties.

Keywords: drought, rice, root growth, soil type, watering method, yield response

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