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Performance of Four Rice Cultivars Transplanted Monthly over Full Year under Irrigated Conditions in Tanzania

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Abstract: In Tanzania, the phenology and seasonal variations of the yields of different rice cultivars have rarely been studied, especially under fully-irrigated conditions. A trial was conducted to identify the most suitable calendar for rice production in Tanzania under fully-irrigated conditions. Four popular rice cultivars, NERICA1, Wahiwahi, IR64 and TXD306, were transplanted monthly from January to December 2011. The four cultivars recorded similarly higher or lower yields than the annual means when transplanted in July (0.50–0.57 kg/m^2) and April (0.07–0.31 kg/m^2). A yield-ranking analysis showed that plants transplanted in July was the most productive while those transplanted in April was the least productive, and also revealed a yield-seasonality for irrigated rice in Tanzania, a low-yield season (April–May), a high-yield season (June–August), and an unstable-yield season (September–March). These yield seasons would appear to be closely linked to seasonal temperature variations. When transplanted in April–May, plants were exposed to very low temperatures between panicle initiation and flowering, apparently reducing yield through cold-induced sterility. Those transplanted in June–August prolonged their growth under relatively low temperatures and increased yield through increasing biomass production. In September–March, yield levels varied greatly due to the shortened phenological growth durations at higher temperatures. We conclude that under fully-irrigated conditions in Tanzania, rice should be transplanted in July to ensure the maximum production and yield stability. The yield-seasonality suggests that implementing measures to protect plants from low and high temperature stress at critical phenological stages may allow year-round rice production under fully-irrigated conditions in Tanzania.

Key words: irrigated rice; local variety; phenological response; temperature; yield component; yield performance

Rice (*Oryza sativa* L.) is the second largest grain crop after maize in Tanzania (MAFC, 2009; USDA, 2013). Because rice consumption exceeds domestic production, import usually supplements supply. The national production deficit is expected to increase over the next decade as urbanization shifts consumer preference from traditional staples to rice (Sekiya et al, 2013). Thus, Tanzania should increase local rice production to conserve foreign exchange as well as to ensure food security.

Only a limited area of rice in Tanzania is irrigated (literature estimates of the proportion vary from 6% to 30%), so the balance is fully dependent on rainfall (Kanyeka et al, 1995; MAFC, 2009). Because the yield of irrigated rice is reported to be two- to four-folds higher than that of rain-fed rice (MAFC, 2009), expansion of irrigated rice is considered to be the most effective way to increase production. Thus, the

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government is making efforts to expand the area of irrigated rice (Kadigi et al, 2004; MAFC, 2009).

Traditionally, rice production in Tanzania has been timed to coincide with the rainy seasons. In the unimodal system, it coincides with the 'long-rains' from December to April and in the bimodal system with the 'long-rains' from March to May (Meertens et al, 1999; Raes et al, 2007; Sekiya et al, 2013). Even under irrigated conditions, most rice farmers follow their traditional cropping calendars because the inadequate water reservoirs are unable to supply sufficient water for rice cropping during the dry seasons (Kadigi et al, 2004; Mdemu et al, 2004; Mwakalila, 2005). However, if a sufficiently-abundant year-round water supply was to be established based on a modern irrigation infrastructure, the optimal timing of rice cropping can well differ from this pattern. Unfortunately, little information is available on the seasonal variation of rice performance in Tanzania on which a best-cropping calendar can be based, except one preliminary trial conducted from 1996 to 1998 at the Kilimanjaro Agricultural Training Centre (KATC) in Moshi, Tanzania.

The results of the preliminary trial suggested that IR54 (a popular rice cultivar in the 1980s and 1990s) produces high yields (7.90 ± 0.87 t/hm^2, mean ± *SD*) when transplanted from June to July, low ones (2.49 ± 0.92 t/hm^2) when transplanted from April to May, and unstable ones (4.66 ± 1.38 t/hm^2) when transplanted in the remaining months. However, no further study such as analysis of yield components was conducted to account for the yield variation. At present, different rice cultivars other than IR54 are widely grown by farmers in Tanzania. In addition, the climate change such as the increased variability of annual rainfall and the steady increase of temperature has been recorded in this region during the last decade (Rowhani et al, 2011). Thus, it is unclear whether the results of the KATC trial during 1996–1998 are applicable under the present rice cropping environment.

In this study, therefore, we evaluate the performance of rice growing in Tanzania throughout the year. Four rice cultivars (NERICA1, Wahiwahi, IR64 and TXD306) were sown and transplanted monthly from January to December 2011 and otherwise grown under uniform cultivation practices. The 12 months were then ranked based on yields of each cultivar. The specific objectives of this study were to evaluate the consistency of ranking among the four cultivars and to identify the most and the least productive months. The number of growing days, accumulated temperatures, and biomass yields were also measured pre- and post-flowering, and their relationships with yield and yield components were analyzed.

MATERIALS AND METHODS

Trial site

The trial was conducted in a field (100 m × 30 m) from January 2011 to March 2012 at the KATC in Moshi, Tanzania (3º27′7″ S, 37º23′49″ E, 720–730 m above mean sea level). The field was split into two sections (each 100 m × 12.5 m) by an earth corridor (2.2 m wide and 0.3 m above the soil surface). Each section was split into eight plots (each 12.5 m × 12.5 m) by concrete walls (0.1 m wide, and reaching 0.3 m above and below the soil surface), which created a total of 16 plots in the whole field. A steel net (30 mm mesh) screen house (100 m × 30 m × 3 m) was constructed over the field to protect the plants from birds. The field was irrigated with groundwater stored in a reservoir at KATC. The water was delivered to the research area by a main canal from the pond, and by a secondary canal along the central earth corridor to supply each plot. This arrangement allowed full and independent control of the water level in each plot. The local soil had a relatively high pH 7.8 (H_2O) and 6.2 (KCl) and a low electrical conductivity value of 0.13 dS/m. Total nitrogen (N) and P_2O_5, determined using the Kjeldahl method (Bremner, 1996) and the Bray-1 method (Bray and Kurtz, 1945), were low at 47.9 and 0.29 mg/g, respectively. In contrast, CaO, MgO and K_2O, determined using ammonium acetate extraction (Suarez, 1996), were high at 469, 133 and 54.4 mg/100g, respectively. Prior to our trial, the plot had been planted with rice for about 15 years, during which period each of the two plots had been planted and fallowed alternately.

Rice cultivars

Four rice cultivars, NERICA1, Wahiwahi, IR64 and TXD306, were transplanted monthly from January to December 2011. NERICA1 is an interspecific hybrid between *Oryza sativa* and *Oryza glaberrima* (AfricaRice, 2008). Since its release in 2009, its cultivation has spread across Tanzania through a governmental dissemination campaign. Wahiwahi is a popular, early-maturing and local cultivar with high yield-potential. IR64 was introduced from the International Rice Research Institute, the Philippines