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Management of Crop Water Stress in the Tropics and Subtropics

Effects of water availability and water management on the performance of NERICA 4 under rainfed conditions in semi-arid areas, Tanzania

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Abstract

Rice is one of the most important staple crops. This crop is a rapidly growing food source and has become a commodity of strategic significance especially in Sub-Saharan Africa. In semi-arid areas in Africa soil degradation and droughts are increasingly productivity-reducing problems.

The idea of this thesis is to identify possibilities to grow upland rice in seasonal drought prone areas in Tanzania with minimal water management. The effects of minimal water management in case of modifying the soil surface to collect and save water; by adding a minimum amount of water or to decrease evaporation by an adapted weeding management, may help to grow a successful rice crop under local conditions.

Hereby the upland rice variety NERICA 4, which was developed to show resistance to African rice pests, diseases and water stress combined with high yield potentials, was used for investigating its performance under the management practices which were implemented in this study. This upland variety will be tested under rainfed conditions for the Dodoma region (592 mm, October - May), rainfed conditions with tied-ridging, tied-ridging combined with additional irrigation to keep soil moisture above the permanent wilting point of the soil (life saving irrigation), life saving irrigation without tied ridges and under fulfilled crop water requirements. Those options were combined with time based weeding strategies. Variation in soil moisture contents, leaf area, specific leaf area (SLA), biomasspartitioning, yield determining components like number of productive tillers and spikelets, grain yield, harvest index (HI), yield loss and water use efficiency (WUE) in response to the water management were investigated. Modification of the soil surface influenced soil moisture characteristics and is related to changed yield determining components. The weeding strategy did also lead to changed soil moisture values and microclimate within the canopy but is not responsible for significantly changed grain yields. The poor rainfall distribution in the growing season 2015 provoked total failure at the rainfed treatments and caused yield loss and thus low water use efficiencies for the treatments with life saving irrigation.

5 Conclusion

Rice cropping systems are often considered as water intensive and therefore not suited for seasonal drought prone areas. In rainfed systems precipitation often exceeds crop water requirements at a specific rain event. Additionally temporal distributions in terms of drought spells lead to suboptimal water supply. Managing water excess may improve water productivity during intervals between rain events with insufficient water supply from precipitation.
The main ideas of this study may help to grow successful NERICA 4 upland rice under local conditions in semi-arid areas like in Dodoma region. Therefore several water management practices like an adapted weeding management were implemented. Furthermore by adding a minimum amount of water, the soil moisture was kept above the permanent wilting point (life saving irrigation). Additionally the effects of minimal water management in case of modifying the soil surface to collect and save water, like tied ridges, were studied.

Time based weeding (farmer`s weeding) influenced the microclimate within the canopy in the treatment with full water supply (FI) in comparison to the clean weeded alternative. Soil moisture contents are significantly influenced by the weeding strategy, but soil drying after rain events was not affected. At all water management treatments the less weeded treatments showed a lower harvest index´ (HI) and yields. Hence one could conclude that the effects on the microclimate within the canopy led to decreased fertility and furthermore that water competitiveness by the water use of weeds influenced the water availability for the rice crop negatively. Although the negative impact of the weeds on yield determining components and finally on the grain yield was not significant.
Water availability influenced weed and crop density and their competitiveness for water and light. Rice cropping with the farmers´ weeding strategy reached leaf area index (LAI) values up to 4 for FI treatments (~2.5 LSI treatments). After removing the weeds, rice plants at irrigated treatment showed LAI values smaller than 0.5, which is still lower than LAI values for rice plants at their corresponding clean weeded treatments. The specific leaf area (SLA) was not affected by the weeding component.

Water-saving irrigation decreased yield as well as water productivity. In that context, it was not possible to produce more rice with less water. The rice cropping system with life saving irrigation showed a 40 % worse HI and a poor performance in terms of water use efficiencies (1 t/ha with 412 mm water use) in comparison with the rice plants grown under full water supply. Those plants reached a grain yield of 3 t/ha, which is acceptable for NERICA 4 varieties. Although life saving did not achieve the expected yields, repetitions with specific attendance at water sensitive stages to avoid especially White heads, maybe with better suiting upland varieties and/or higher germination rate in addition to a higher transplanting tolerance, could be an option to achieve better suitability for upland rice cropping systems in water limited areas in Dodoma region. Hereby the water competitiveness needs to be reduced by weed removal or weed suppression. Intercropping as well as total crop usage may also improve the productivity of the system.

Tied ridges as a rainwater conservation technique, is a combination of ridge furrows and earth ties forming micro-catchment basins in the field to decrease surface run-off and to improve grain yield. Thereby the precipitation distribution and the architecture of the tied ridges play a major role. In this study soil moisture contents were significantly influenced by tied-ridging but had no impact on soil drying after rainfalls. Although soil moisture contents at the LSI treatment with TR (FW) was improved, grain yield as well as weed biomass and density were lower than at treatments without tied-ridging.
The rainfed rice plants performed poorly (no grain yield recognizable). To conclude, that tied ridges improved water availability at the rainfed treatment could only be demonstrated in terms of the higher total biomass and the number of plants which survived. Although tied ridges may be an opportunity to decrease soil degradation in terms of reduced run-off and increasing organic matter content and may contribute to a sustainable rice cropping system.

In terms of changed climate conditions, the opportunity to mitigate extreme events such as droughts and floods needs to be provided through the choice of crops and the cropping calendar to ensure food and energy security (Asch and Huelsebusch, 2009). It is not reasonable to conclude out of this study, that upland rice cropping in Dodoma region is not advisable if water access and availability is limited. Nevertheless, the growing season 2015 is showing that the NERICA 4 variety does not ensure a secure and sustainable upland rice production for low-input systems in semi-arid areas in Tanzania.