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Research Application Summary

Enhancing water use efficiency of cassava and sorghum based cropping systems in drylands

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Abstract

Soil moisture flow characteristics, infiltration and storage in the root zone determine the overall availability and use efficiency of water in crop production. This study is evaluating the effects of cropping systems and tillage management strategies on soil water flows in cassava and sorghum cropping systems in the drylands of eastern Uganda. The study site is in Uganda's Teso farming system on *Petroferric haplustox* soils. The experiment is set in a randomised complete block design laid out as split plot with treatments (sole cassava; sole sorghum; sole cowpea; cassava + sorghum; cassava + cowpea; sorghum + cowpea) replicated three times. Two tillage management practices (mouldboard; ripper ploughing) constitute the blocks. Main parameters measured are; leaf area index, precipitation, infiltration, soil moisture storage, evaporation and transpiration. The water balance equation, calculated from precipitation, changes in soil water storage within the profile, and the vertical water flux below the root zone, is used to estimate actual evapotranspiration (ETa). Water use efficiency (WUE) determined as a ratio of yield (Y) to actual evapotranspiration (ETa). The study is in the initial stages of data collection however, surface runoff is negligible in both mouldboard and ripper ploughing. This is augmented by the low slope gradient (0 - 3%) and the soil surface roughness observed. The trend in soil moisture storage is almost similar in the first 4 weeks after planting in all cropping treatments. Expected outputs of the research are: water distribution (flow and storage) in the different cropping systems and tillage management, water used in the different cropping systems quantified, cropping pattern with the best water use efficiency identified, and tillage management practices that reduce surface flow and increase green water flow in cassava and sorghum crops identified.

Key words: *Petroferric haplustox* soils, soil moisture flow, Teso, tillage practices

Résumé

Les caractéristiques d'écoulement d'humidité de sol, l'infiltration et le stockage dans la zone de racine déterminent la disponibilité globale et l'efficacité de l'emploi de l'eau dans la production végétale. Cette étude évalue les effets des systèmes de cultures et des stratégies de gestion de labourage sur des écoulements d'eau du sol dans des systèmes de culture de manioc et de sorgho dans les terres sèches de l'Ouganda oriental. Le milieu d'étude est dans les régions agraires de Teso en Ouganda sur des sols *Petroferric haplustox*. L'expérience est placée dans une conception de bloc complète randomisée présentée en tant que parcelle de terrain dédoublée avec des traitements (manioc unique ; sorgho unique ; dolique de Chine unique ; manioc + sorgho ; manioc + dolique de Chine ; sorgho + dolique de Chine) repetés trois fois. Les deux procédures de gestion de labourage (lame de labour, dents de labour) constituent les blocs. Les paramètres principaux mesurés sont : l'indice de la surface de la feuille, la précipitation, l'infiltration, le stockage d'humidité du sol, l'évaporation et la transpiration. L'équation d'équilibre de l'eau, calculée à partir de la précipitation, des changements dans le stockage de l'eau du sol dans le profil et le flux vertical de l'eau en-dessous de la zone de racine, est employée pour estimer l'évapotranspiration réelle (ETa). L'efficacité d'utilisation de l'eau (WUE) déterminée comme le rapport du rendement (y) à l'évapotranspiration réelle (ETa). L'étude est dans les phases initiales de la collecte de données cependant, les eaux de surface sont négligeables dans le labourage par lame et le labourage par dents. Ceci est favorisé par la faible inclinaison de la pente (0 - 3%) et la rugosité observée de la surface du sol. La tendance dans le stockage d'humidité du sol est presque semblable dans les 4 premières semaines après avoir planté dans tous les traitements de culture. Les résultats attendus de la recherche sont : la distribution de l'eau (écoulement et stockage) dans les différents systèmes de culture et de gestion de labourage, la quantité de l'eau utilisée dans les différents systèmes de culture, l'identification du modèle de culture avec la meilleure efficacité d'utilisation de l'eau et l'identification des procédures de gestion de labourage qui réduisent l'écoulement d'eau de surface et augmentent l'écoulement d'eau verte dans des cultures de manioc et de sorgho.

Mots clés: Sols *Petroferric haplustox*, écoulement d'humidité du sol, Teso, pratiques de labourage

Background

Soil moisture flow characteristics are closely related to availability of water for crop production, especially in the dryland ecosystems of sub-Saharan Africa (SSA). Dryland ecosystems strongly depend on the water cycle for their functioning and present spheres over which rainfall is partitioned into ''green water'' and ''blue water'' (UNESCO-WWAP, 2003). In rain fed agricultural systems, soil water infiltration and storage in the root zone determine the overall availability and use efficiency of water in crop production (Hsiao *et al*., 2007). Therefore, planning agricultural systems that are efficient users of available water, as a pre-requisite for improving water productivity, requires a good understanding of crop water use vis-à-vis the water sources (water balance components). This on-going study is evaluating the effects of cropping systems and tillage management strategies on green and blue water flows in cassava and sorghum cropping systems in the drylands of eastern Uganda.

Literature Summary

Rain-fed agriculture is central to the food production process in sub-Saharan Africa (Cooper *et al.,* 2008), where up to 60% of cereals are produced under rain-fed systems in the region. The majority of farmers in the drylands are resource-poor, heavily depend on rain-fed crop production systems (Boko *et al*., 2007), and lack the incentive to improve water use efficiency in agricultural production (Abbate *et al*., 2004) including the motivation to conserve water (Hsiao *et al*., 2007). Improving agricultural production in the drylands of SSA will depend on efficient capture, management and use of the rainwater resources (Rockström *et al*., 2003).

Study Description

The study is being conducted in eastern Uganda (34^0 0' E and 1^0 40' N) in the Usuk sandy farm-grasslands agroecological zone (Wortman and Eledu, 1999). The dominant soil type in the area is *Petroferric haplustox*. Two studies are on-going: a) Effect of cropping systems on surface and sub-surface flows, infiltration, soil moisture storage, evaporation and evapotranspiration; and b) Effect of seedbed management practices on surface and sub-surface flows, infiltration, soil moisture storage, evaporation and evapotranspiration. The experimental design is a randomised complete block design laid out as split plot with treatments replicated three times. Seed bed preparation, i.e., mouldboard ploughing and ripping using ox-drawn equipment constitute the main plots while the subplots are allocated to cropping systems (treatments); i) sole cassava ii) sole sorghum iii) sole cowpea iv) cassava + sorghum v)

cassava + cowpea vi) sorghum + cowpea. Data will be collected for three seasons on parameters like; climate, leaf area index (LAI) as a measure of canopy cover as well as deriving evapotranspiration, water infiltration, hydraulic conductivity to calculate vertical water flux within the soil profile, and soil moisture content and plant available water at 0-10, 10-40, 40-60 cm. Actual evapotranspiration (*ETa*) will be derived from precipitation (*P*), changes in soil water storage within the profile ÄS, and the vertical water flux below the root zone V_2, following the expression by Moitra *et al*., 1996; $ETa = P + \Delta S \pm \int_{t_1}^{t_2} V_2 dt$. Then Water use efficiency (WUE) will be determined as a ratio of yield (Y, kg of crop ha^{-1}) to actual evapotranspiration (ETa, mm) $WUE = Y / ETa$. The GenStat 12.2 statistical software will be used for analysis of variance (two way ANOVA) to identify differences between treatments. To compare performance per season a three way ANOVA will be used.

Research Application

The study is still underway with only cowpea among the three crops about to be harvested. Surface runoff is drastically reduced in both mouldboard and ripper ploughing. This is augmented by the low slope gradient (0 - 3%) and soil surface roughness observed in the plots. The trend on soil moisture storage is almost similar for the first four weeks after planting in all cropping treatments. Treatments with cowpea were able to build a surface cover of about 40% by the four weeks after planting (WAP). By the end of the study the following outputs are expected;

- Water distribution (flow and storage) in the different cropping systems and tillage management practices will be quantified
- Water used in the different cropping systems will be quantified
- The cropping pattern with the best water use efficiency will be identified
- Tillage management practices that reduce surface flow and increase green water flow in cassava and sorghum crops will be identified

Recommendation

The study is in the initial stages of data collection, but there are indications that moisture distribution within the rooting zone can be manipulated by modifications of soil surface conditions through tillage and canopy cover. If this is true, cropping systems

that save more moisture in the rooting zone should be explored to enhance crop productivity in water-scarce environments.

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