

DEDICATION

I dedicated this work to these most important people in my life:

My Mother and Father

For investing in my education more than anything else and envisioning me at this position.

My Wife

For her participation in this project, and for taking care of me and our babies when I was busy working.

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Abstract

In the dry areas, water, not land, is the most limiting resource for improved agricultural production. Maximizing water productivity, and not yield per unit of land, is therefore a better strategy for dry farming systems. Under such conditions, more efficient water management techniques must be adopted. Water harvesting and conservation are highly efficient practices with great potential for increasing agricultural production and improving livelihoods in the dry rain fed areas. In the drier environments, most of the rainwater is lost by evaporation; therefore, the rainwater productivity is extremely low.

Sorghum productivity in rain fed areas of Sudan central clay plains is described as very low due to water scarcity and/or bad water distribution in space and time .This study documents the major research findings regarding improving water productivity in the dry rain fed regions of Sudan by adopting various water harvesting techniques. The study is directed to ascertain the hypothesis that: Productivity of water in rain fed agriculture improved through accelerated uptake and intensive use of rainwater harvesting and water conservation techniques. Hence, this study is directed to compare the performance of different planting geometry: planting on top of tied ridges (PTR), planting in the bottom of ridges (PBR), and flat (FLAT) and broadcasting on corrugations using the conventional wide level disc (WLD) as a conventional method for soil moisture conservation in dry land farming system. To compare the performance of different water conservation tillage: zero-tillage, chisel plow, and the wide level disk as a conventional method. To compare the performance of different In-situ rainwater harvesting and internal (Micro) catchment WHTs: contour ridge (CR), tied ridge (TR), ridge furrow (RF) and wide level disc (WLD) as a conventional method for soil moisture

conservation in dry land farming system. To develop, verify, apply and deliver a robust, fully-tested computer model to predict yield, WUE and runoff losses from rain fed farming techniques.

The work completed under this study follows on from previous water harvesting projects and research conducted in Twawa at Gedarief University and is linked with current water research. The specific researchable constraint addressed in all of the chapters of this study is the low productivity of water in rain-fed agriculture.

A twin-track approach was adopted, in which the fieldwork was linked to computer modeling. The outcome of the modeling effort was the development of the crop growth and water productivity prediction model. The model is a deterministic, process-based physical model with daily time-step cropping systems simulation model. The model can simulate the soil-plant water budget, crop canopy and root growth, and dry matter production for Sorghum crop.

The model simulates soil and plant water balance, vegetative growth, root growth and dry matter yield. Crop growth is simulated as a function of radiation intersected by the plant, available water and air temperature. The model considers the relationship between grain yield and seasonal stress index depending on the deficiency in relative evapo-transpiration and plant indexes. The model adds value to the field research in that it gives temporary prediction of the experiment results in a certain location. Also it gives tools that permit planners to make decisions about the best bet for the substitutes of water harvest innovations anywhere.

Keywords: Simulation model, Sorghum crop growth; planting geometry; conservation tillage; Rain fed agriculture; Rain water productivity; In-situ rainwater and Micro catchment Water harvesting Techniques.

الخلاصة

في المناطق الجافة المياه وليست الأرض هي المورد المحدد لتحسين الإنتاج الزراعي، وزيادة الإنتاجية بالنسبة لوحدة المياه وليس الإنتاج من وحدة المساحة هو الإستراتيجية الأفضل لأنظمة الزراعة الجافة، وتحت مثل هذه الظروف يجب أن تستخدم التقانات الفعالة في إدارة المياه. تقانات حصاد المياه والمحافظة عليها من الاستخدامات ذات الفعالية العالية كم أن لها إمكانية عالية على زيادة الإنتاج الزراعي وتحسين الظروف المعيشية في مناطق الزراعة المطرية الجافة. في البيئات الجافة يفقد معظم ماء المطر بالتبخر لذا فإن إنتاجيته تكون ضعيفة جدا.

إنتاجية الذرة في المناطق المطرية في السهول الوسطى في السودان يمكن وصفها بأنها منخفضة جدا بسبب قلة المياه و/أو سوء توزيعها مكانيا وزمانيا، وهذه الدراسة توثق لمعظم نتائج البحوث التي تهتم بإنتاجية المياه في مناطق الزراعة المطرية الجافة في السودان باتخاذ شتى تقانات حصاد المياه. هذه الدراسة موجهة للتحقق من فرضية أن إنتاجية المياه في الزراعة المطرية تتحسن خلال تعجيل الاستخدام المكثف لتقانات حصاد المياه وتقانات المحافظة على المياه. لهذا فهي موجهة لمقارنة أداء مختلف الأشكال الهندسية لتوزيع البذور: البذر على قمة السرايات المربوطة، داخل بحر السراية، على أرض مستوية السطح والنثر على سطور باستخدام الآلة التقليدية المحراث القرصي العريض باعتباره الطريقة التقليدية في نظام الزراعة المطرية للأراضي الجافة، لمقارنة أداء تقانات حراثة مختلفة لصيانة المياه: الزراعة الصفرية، المحراث الحفار والتقنية التقليدية المحراث القرصي العريض، لمقارنة أداء تقانات حصاد مياه الأمطار المكانية وأحواض التجميع المصغرة: السراب الكنتوري، السرايات المربوطة، بحر السرايات والطريقة التقليدية المحراث القرصي العريض ولتطوير، تأكيد، تطبيق وتوزيع نموذج حاسوبي قوي ومختبر للتنبؤ ب: نمو المحصول، الانتاجية، كفاءة استخدام المياه والفاقد بالجريان السطحي من تقانات الزراعة المطرية.

العمل الذي تم في هذه الدراسة يتبع خطة بحوث حصاد المياه التي أجريت في توابا بجامعة القصارف ومرتبطة ببحوث المياه الجارية حاليا، أيضا فإن المقيد المحدد للبحث الذي ينصب على جميع أبوابها هو الانتاجية المنخفضة للمياه في

الزراعة المطرية، والسبب الخاص الداعي إلى البحث في هذه المواضيع والذي ذكر في كل أبواب هذه الدراسة هو انخفاض إنتاجية الزراعة المطرية.

لقد أتخذ الطريق المتوائم الذي يقرب الارتباط بين العمل الحقلي والنماذج الحاسوبية، حيث أن الحصيلة من النمذجة هي تطوير نموذج حاسوبي للتنبؤ بنمو المصول والإنتاجية، وإنتاجية المياه، وهو نموذج حتمي وأساسه العمليات الحيوية ويومي في نظام محاكاته، ويمكنه محاكاة المزيانية المائية للنبات والتربة والنمو الخضري والجذري وإنتاجية المادة الجافة لمحصول الذرة الرفيعة، وهو قد صمم اعتماداً على الأساس الفيزيائي الذي يحاكي العمليات البيوفيزيائية المفتاحية التي تؤثر في أداء نظم حصاد مياه الأمطار، وقد استفاد في تأسيسه الأولي من نموذج محاكاة إنتاجية القمح الشتوي تحت ظروف الزراعة الجافة والمروية الذي قام بتطويره زياي وسباسخ العام 2002 م.

النموذج يحاكي الموازنة المائية للنبات والتربة، النمو الخضري والجذري للمحصول وإنتاج المادة الجافة، والنمو المحصولي تتم محاكاته ككل كدالة في الإشعاع الشمسي الذي يتم اعتراضه بواسطة النباتات، المياه المتاحة ودرجة حرارة الهواء الجوي، والنموذج يبحث العلاقة بين إنتاج حبوب الذرة الرفيعة باعتبار طبقتين للتربة دليل الاجهاد المائي الموسمي المعتمد على النقص في التخزين النسبي ودلائل الطيف النباتي، وهو يضيف قيمة للبحث الحقلي في أنه يعطي استقراء مؤقت لنتائج التجارب في الحيز المعين، وكذلك يزود بأدوات تسمح للمخططين لعمل قرارات عن معرفة حول أفضل رهان لبدائل ابتكارات حصاد مياه الأمطار عند أي موقع معين.

الكلمات المفتاحية:

نموذج محاكاة؛ نمو محصول الذرة؛ الأشكال الهندسية لتوزيع البذور؛ الحراثة المحافظة؛ الزراعة المطرية؛ إنتاجية مياه الأمطار؛ تقانات حصاد المياه المكانية والمستجمعات الصغيرة.