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DEPARTMENT OF AGRONOMY

Title

**EFFECT OF IRRIGATION REGIMES AT
VARIOUS PHYSIOLOGICAL GROWTH STAGES On
SUGARCANE QUANTITY AND QUALITY YIELDS**

تأثير مَقْدَنَات مِيَاه الرِّي مع مختلف مراحل
النمو الفسيولوجية على إنتاجية قصب السكر كمًّا ونوعًا

BY

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Dedication

*To my parents without whom I would
not be Here, May God sincerely
bless them.*

*To my wives for sustenance and
guidance*

To my sons & daughters

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ABBREVAITION

AbuVI	small Canal from Abu XX to the field
Abu XX	Small Canal From the minor to The Number
ADE	Assistant Division Engineer
A.S.W.	Available Soil Water
B.D	Bulk Density
Ca	Calcium
C0	Centigrade
Cd	delivery coefficient =(0.693)
CEC	Concentrate of electric Conductivity
CWR	Crop Water Requirement
DSW	Deficit Soil Water
E	East
ETa	actual evapotranspiration
ETm	maximum evapotranspiration
ETC	crop evapotranspiration
ESW	Excess Soil Water
ET	Evapotranspiration
ET0	Reference Evapotranspiration
Ey	Harvested yield
FAO:	Food Agriculture Organization
F.C.	Field Capacity
Fe	ferric
F.O.P.	Field out let Pipe
h	The distance between the weight and the centre of the plate
HYvs	High Yielding Varieties
IWUE	The irrigation water use efficiency (ton ha-1mm-1),

I1	Adequate Irrigation at 55% soil depletion .
I2	Excess Irrigation at 110% saturation
I3	Deficit Irrigation at 77% depletion
K	Potassium
Ky	Yield response Factor
M	Moment equal to weight (gm) multiplied by the distance Cm(gram)
Mn	Magnesium
N:	Nitrogen
N0	North
P:	Phosphor
Pol	Sucrose percentage
PPM	Part per million
Pw	Is the proportion of the total available water
PWP	permanent wilting point .
Q	The discharge in litre per seconds. = (W×h)
Qg	Gravimeter rate content (gram of water ./ gram of soil)
Qv	volumetric water control (cm ³ cm ⁻³)
RAW	Readily Available Water
Rb	bulk density and the soil (gm ⁻³)
Rw	density of water (gm ⁻³)
S.S.C.	Sudanese Sugar Company
S1	Tillering stage of sugarcane growth (early growth stage)
S2	vegetative stage of sugarcane growth (elongation or mid stage)
S3	Maturity stage of sugarcane growth (late stage)
SI	The seasonal irrigation water applied including rain (mm).
TAW	Total Available Water
Y/ET	Yield /Evapotranspiration

v/ v	volumetric value $w/w \times B.D = \text{Volumetric}$
Wd	mass of dry soil and container (g)
We	mass of container (g)
Wt	weight
WUE	Water use efficiency
Ww	Mass of wet soil and container (g)
w/w	gravimetric moisture control
W	The balance weight used for equilibrium
Ya	Actual yield Ym
Ym	Maximum Yield
Y	Yield
Zn	Zinc

ABSTRACT

The demand for food and energy is steadily increasing with increase of population growth rate. Irrigated agriculture assumed to make a major contribution to food security, all though it is the major consumer of water resources, unfortunately yields of irrigated crops is very low. At present, sugarcane is the most reliable food and feedstock and energy (bioethanol) production since its farming technologies are already in place in Sudan, and currently, the country is in deficient production of sugar. The scope for further horizontal irrigation development to meet sugar requirements in the coming years, is however, severely constrained by decreasing water resources and growing competition for clean water. While on a global scale, serious water shortages are developing in the arid and semi-arid regions as existing water resources reach full exploitation. The situation is serious (exacerbated) by the declining quality of water and soil resources. The dependency on water has become a critical constraint on further progress and threatens to slow down development, endangering food supplies and aggravating rural poverty. The great challenge for the coming decades will therefore be the task of increasing food production with less water, particularly in countries with limited water resources. For food Security and planning purposes , it is necessary to forecast crop yield before season end. With changing climate and environment worldwide water is becoming more scarce. In Arid and Semi-arid area the problem of water scarcity (less supply) , and increasing demand (domestic uses , Agriculture , industry and urban uses) necessitated better irrigation management and proper scheduling. To improve water efficiency it is essential to develop water management tactics to overcome problems of improper water scheduling (over-under supply) for different crop growth stages.

The aim of this study is to investigate the way sugarcane crop react to stress irrigation, leading to practical guidelines to assist extensionists, farmers and decision-makers in optimizing water use for optimal crop production. Accordingly, field trials were carried out for two seasons(2007/2008) in Gunied Sugar plantation experimental farm located in Gezira State, in order to study sugarcane growth and yield response to excess/ deficit irrigation imposed at each crop physiological growth stage. The experiment was a split-split plot design with factorial arrangement, completely randomized in 27 water treatments (adequate , excess and

deficit) for each one of three growth stages(tillering , vegetative and maturity) in three replicates. Deficit irrigation scheduling is one way in which farmers practicing irrigation farming, can cope with the pressure to reduce water used for crop production in order to release more water for other sectors in need of it. In this study deficit irrigation is investigated as a valuable and sustainable production strategy in dry regions with limited water resources. By limiting water applications to certain growth stage, this practice aims to maximize water productivity and to stabilize – rather than maximize – yields. The soil in the study area is characterized with its poor internal drainage resulting in water logging when over irrigated. Excess irrigation trials were conducted to a certain impacts of timing of efficient management practices as a cheap solution of the frequent problem of over watering .

Cultural practices followed are typical to those adopted by Gunied sugar plantation for variety Co6806 . Data collected includes: level soil moisture depletion using gravimetric method, inflow rate measured with vane flow meter, yield components (plant height, thickness, number of tillers), yield parameters (cane yield as weight, sugar content and juice quality), and water performance indicators(yield response factor and water use efficiency). Statistical analysis of the data and discussion of obtained results reveals that:

Deficit irrigation at early stage of sugarcane growth produced higher cane yield and higher water use efficiency compared to other stages . In contrast, deficit irrigation at the late stage had a serious and drastic effect on final cane and sugar yields and hence, it may be regarded as the most sensitive stage. Although deficient irrigation imposed at vegetative stage produced lower cane yield compared to that of tillering stage , it resulted in the highest sugar content due to sugar recovery. Hence, deficit irrigation is recommended to be practiced at tillering stage, after well crop establishment, for optimum cane yield and high water use efficiency ,and late application of deficit watering had to be avoided completely. Excess watering applied at the early stage produced the lower yields of cane and sugars compared to other stages therefore should be avoided ,while excess watering imposed at the vegetative stage produced higher yields of cane and sugars compared to other stages . Therefore, acceptable level of over irrigation can be tolerated only at vegetative stage. This level need to be precisely determined by future studies. In addition more investigations need to be done on regular deficit irrigation at different soil moisture depletions at the early and vegetative stages of growth

for maximum economical yields of sugarcane crop and an improved water use efficiency. Yield response factor was estimated as 1.13 for sugarcane crop, which match well with FAO value of 1.2 . Using the estimated crop response factor, crop-water production functions for sugarcane crop in Sudan can be developed to derive the productivity of the applied. It can be inferred from the irrigation scheduling protocol of excess/deficit irrigation of this study that the past policies of water resource management which adopt irrigation practices consistent with an abundant and inexpensive water supply to avoid moisture stress to strive for maximum yield need to be replaced by those practices that consider deficit irrigation as a key strategy for increasing on-farm water productivity in water-scarce dry areas and the risk associated with deficit irrigation can be minimized through proper irrigation scheduling (avoiding water stress at growth stages sensitive to water stress).

Key Words: Deficit irrigation, yield formation,

ملخص الأطروحة

الطلب للغذاء والطاقة يرتفع بانتظام بمعدل ارتفاع الكثافة السكانية . من المفترض ان الزراعة المروية هي المساهم الفعال فى تأمين الغذاء. وعلى الرغم من انها الأكثر استهلاكاً لمصادر المياه ، لكن للأسف فان انتاجيات المحاصيل ضعيفه جداً.

فى الوقت الحالى ان محصول قصب السكر أهم ما يعتمد عليه لانتاج الغذاء للانسان والحيوان و انتاج الطاقة (الايثانول) لوجود المقومات الغنيه التى اصبحت متوفره بالسودان بجانب ذلك هناك نقص فى انتاج السكر . النظرة المستقبلية للتوسع الافقى فى تطوير الرى لمقابلة استهلاك السكر فى السنين المقبلة يقابل بالعقبات الصعبة لنقص مصادر المياه المستمر والمنافسة المتزايدة للمياه الحلوه . ولكن على القياس العالمى هناك نقص كبير و متزايد فى المياه فى المناطق الجافة وشبه الجافة وتتفاقم هذه المشكله بالنقص فى نوعية المياه ومصادر التربه .

الاعتماد على المياه اصبح يشكل عقبة كؤود للتطور فى المستقبل كما يعمل على تقليل الامداد الغذائى , عليه من اهم الاهداف فى المستقبل القادم هو العمل على رفع الغلة للوحده من المساحة باقل كميته من مياه الرى خاصة فى الاقطار ذات مصادر المياه المحدوده . لتأمين الغذاء وأغراض التخطيط من الضرورى النظرة المستقبلية لتوقعات انتاج المحاصيل قبل نهاية الموسم الزراعى .

نسبة للتغير فى ظروف الطقس و المناخ فى العالم اصبحت المياه شحيحة جدا . فى المناطق الجافه وشبه الجافه مشكلة ندرة المياه , مع ازدياد الطلب لها, (للاستعمالات الشخصيه والزراعه والصناعه وظروف الحياه الاخرى) يفرض هذا الوضع تحسين ادارة وجدولة مياه الري. تجويد ورفع كفاءة الري يتطلب انشاء معدات للتغلب على مشاكل ادارة مياه الري الناتجه من الجدوله الخاطئه للري(زيادة معدلات الري أو تخفيضها) لمختلف مراحل نمو المحصول .

الهدف من القيام بهذه الدراسة هو معرفة سلوك المحصول عن التعرض لهزات الري لكى تقود الى خطوات عمليه تساعد الارشاديين والمزارعين ومتخذى القرار فى تحقيق افضل كفاءة ري لافضل انتاج غله . عليه تم القيام بهذه التجربه خلال موسمين (2007/2008) بمزرعة مركز بحوث السكر بالجند / مديرية الجزيره بغرض دراسة استجابة محصول قصب السكر لزيادة مقننات الري و تخفيضها على مختلف مراحل النمو الفسيولوجيه . بنيت التجربه على نظام التوزيع العشوائى للمعاملات المائيه التى تم استخدامها ثلاثه معاملات مائيه (ري عادى , ري زائد وتقليل الري) لكل مرحله من مراحل النمو الحيوى المختلفه (مرحة التفريع ,مرحلة النمو الخضرى ومرحلة النضج) (فى عدد 27 معامله فى ثلاثه مكررات .

ان جدولة معامله تقليل الري هو احد الطرق التى يمكن للمزارع تطبيقها تتمشى مع ضغوط تقليل استهلاك المياه مع تحقيق اعلى انتاجيه ولتوفير اكبر كميته منها لاقسام تكون فى حاجة لها.

فى هذه الدراسه تطبيق معامله تقليل مياه الري تبين اها أقيم الاستراتيجيات الانتاجيه فى المناطق الجافه محدوده مصادر المياه . اضافة مياه الري المحدوده فى احد مراحل نمو المحصول بهدف الى رفع الكفاءة المائيه واستقرار الانتاجيه بخلاف تحقيق اعلى انتاجيه.

تختص التربه التى تم اجراء التجارب عليها بضعف التصريف مما ينتج عنه ركود المياه عند تطبيق معامله زيادة مياه الري عليه تم تحديد هذه المعامله بنسبه زيادة معينه عن معدل الري العادى لمعرفة تأثيرها, كاسهل حل لمشكله زيادة معدلات الري المتبعه فى بعض المناطق .

لقد تم تطبيق المعاملات الفلاحيه المتبعه فى مشاريع السكر للصنف Co6806. تم تجميع المعلومات والارقام (نسبة الرطوبة فى التربه باستعمال طريقة وزن التربه رطبه وجافه , مياه الري تمت معايرتها بواسطة جهاز قياس سرعة التيار , معلومات الانتاج والتى تشمل طول النبات ,سمك النبات ,عدد النباتات, انتاجية القصب وكمية السكر المنتج مع نوعية عصير القصب . لتقييم بعض مؤشرات الاداء المحصولى تم حساب معامل تغيير الانتاجيه و كفاءة الري .

التحليل الاحصائي للارقام ودراسة انتاج المتحصل عليها اثبتت :

ان انتظام تقليل مياه الري فى مرحلة التفريع (مرحلة النمو الاولى) لمحصول قصب السكر لها تأثير مباشر فى رفع انتاجية القصب مع رفع كفاءة مياه الري مقارنة مع المعاملة فى مختلف مراحل النمو الاخرى . فى المقابل تقليل مياه الري فى مرحلة النضج (مرحلة نمو المحصول الاخير) له تأثير سيئ و كبير على انتاجية القصب وكمية السكر المنتج , عليه تعتبر مرحلة النضج هى المرحلة الاكثر حساسية لهذه المعاملة. بالرغم من ان تقليل مياه الري فى مرحلة النمو الخضرى حققت اقل انتاجية قصب مقارنة مع مرحلة التفريع الا انها حققت اعلى كميته من السكر ويعزى ذلك لارتفاع نسبة الاستخلاص .من هذه النتائج يوصى بتطبيق نظام تقليل مياه الري فى محصول قصب السكر فى مرحلة التفريع (المرحلة الاولى من النمو المحصول) بعد تكوين افضل محصول تم تاسيسه لتحقيق افضل انتاجية اقتصادية مع الحصول على اعلى كفاءة لمياه الري , كما يوصى بعدم تعرض المحصول لتقليل مياه الري فى مرحلة النضج نهائياً .

أن زيادة معدل الري فى مرحلة التفريع (مرحلة النمو الاولى) حققت ادنى انتاجية لمحصول قصب السكر والسكر المنتج مقارنة مع المراحل الاخرى بينما تطبيق زيادة معدل مياه الري فى مرحلة النمو الخضرى حققت اعلى انتاجية قصب وسكر مقارنة مع المراحل الاخرى عليه فان زيادة معدل مياه الري بنسبه مقبولة يمكن للمحصول تحمله فقط فى مرحلة النمو الخضرى و هذه النسبه تحتاج الى دقه لتحديدها فى دراسات مستقبليه , بالاضافه الى ذلك مزيد من الدراسات يوصى القيام بها فى مجال تطبيق نظام تقليل مياه الري باضافته على نسب مختلفه من استنزاف التربه وذلك فى المرحلتين , المرحلة الاولى من النمو (مرحلة التفريع) و مرحلة النمو الخضرى , لتحقيق اعلى انتاجية اقتصاديه لمحصول قصب السكر ورفع كفاءة مياه الري .

لقد تم حساب معامل تغيير الانتاجية ب 1.13 لمحصول قصب السكر والذي يتطابق مع رقم منظمة الزراعة والاغذية العالميه (1.2 . FAO) التعامل مع هذا الرقم المقدّر لمعامل استجابة المحصول , كمعامل انتاجية لمحصول قصب السكر فى السودان يمكن اعتماده فى صياغة الانتاجية المطبقه .

يمكن ان نخرج من بروتوكول جدولة الري زيادة أو نقصاناً فى هذه الدراسه بأن سياسات ادارة المياه فى السابق التى تطبق الري اعتماداً على اضافة كميات كبيره من المياه باعتبار ان المياه متوفره و رخيصه لتفادى هزات تعطيش المحصول لضمان اعلى انتاجية , هذه السياسات يمكن تغييرها بالممارسات التى ذكرت فى هذه الدراسه والتى تعتمد نظام تقليل الري كمفتاح استراتيجى لرفع انتاجية مياه الري داخل الحقل فى المناطق الجافه و شحيحة المياه كما ان التخوف من التأثير السلبي لتقليل مياه الري يمكن استيعاده بتطبيق أفضل جدوله ممكنه (الابتعاد عن تطبيق تقليل مياه الري فى المراحل الحساسه من نمو المحصول)

المفتاح تقليل مياه الري , تحقيق انتاجيه.

