Project Narrative

Name of the Project: **Diallel Analyzes for Physiologic Traits Related to Water Use Efficiency in Sorghum**

Geographic Area of the Project: **Sorghum-growing regions of Texas and Semi-Arid Tropics**

Name of Principal Investigator(s): **Dr. William A. Payne and Dr. Maria Balota**

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(Other investigators' address, phone, fax, e-mail may be listed on an attached sheet of paper).

Amount of Funding Requested: **$ 8,000**

Project Need, Description and Expected Outcomes

Water is very important for Texas agriculture and the rural communities that depend upon it. Urban populations of Texas are continuously growing and therefore have increasing need of fresh water. In the central and southern parts of the state, water rationing has become a routine fact of life, while in the High Plains, rising energy cost, low commodity prices, and continued aquifer depletion threaten farm sustainability and therefore regional economy. These trends will accelerate conversion to dryland or deficit irrigation cropping systems. Although irrigation efficiencies have improved in recent decades, a relatively unexplored option is to develop more water-efficient cultivars. Such crops would produce more yield for each amount of water used, and increase farm profitability through both energy savings and higher yields.

Sorghum is an important crop in Texas. Recent genetic improvements in post-flowering drought tolerance of sorghum have been achieved through the stay-green trait. Pre-flowering adaptation to water-limited environments would also be advantageous, since it is during this period that stand, tiller number, number of heads, and especially number of seeds per head are determined (Squire, 1993), which are components of both yield and water-use efficiency (Easten at al., 1983; Evans, 1993).

Pre-flowering leaf photosynthetic rate of sorghum has been found to be correlated with biomass and grain production under both well-watered and water-limited conditions (Peng et al, 1992). The rate of CO_2 fixation (A) is highly correlated with stomatal conductance (g), but the ratio of A to g, and of biomass production to crop transpiration, are affected by both environment and genetics in C_4 plants, including sorghum (Kidambi et al., 1990; Payne et al., 1992; Onken and Wendt, 1989). Genetic differences for A/g were convincingly demonstrated by Kidambi et al. (1990), who concluded that genetic variation in intrinsic water-use efficiency could directly contribute to increased whole plant water use efficiency and productivity. Consistent with theory (Nobel, 1999), their preliminary work suggested that one could select for higher A without large increases in g. They also identified specific genotypes, such as Tx430, with enhanced rates of A. Despite these promising results, little has been done since to document genetic variability in intrinsic water-use efficiency of sorghum, to assess its heritability, or to further study its relationship to whole-plant water-use efficiency under different environments. New physiological traits of interest in sorghum, such as chlorophyll fluorescence and stay-green, and their relation to pre-flowering A and g rates have not been studied.

With funds provided by the Texas Water Resource Institute and the Texas Grain Sorghum Board this project has been started

in 2001. First, adequate instrumentation (LI-Cor 6400 infrared gas analyzer supplied with CO2 injector and Red/Blue Light source) was purchased ($29,222 from TGSB). In 2002-2003, TWRI contributed $15,000 for identification of parental lines and development of diallel crosses. Measurements of A and g were made on a large number of entries in irrigated and dryland sorghum nurseries of Dr. Darrell Rosenow, Professor of Sorghum Breeding, at Lubbock and Halfway as well as in the growth chamber at Bushland. Measurements were made with the most versatile infrared gas analyzer available to date, the LI-Cor 6400. Genotypes with superior A and A/g were identified From these, four contrasting parental lines were selected for genetic analysis: TX430, R1988, TX7078, and SC414 (Fig. 1). The lines TX430 and R1988 had high A/g slopes but TX430 had higher A (~40 to 65 μmol CO_2 m^{-2} s^{-1}) than R1988 (~30 to 50 μmol CO_2 m^{-2} s^{-1}). The enhanced A of TX430 is consistent with results of Kidambi et al. (1990). The lines TX7078 and SC414 has low A/g slopes, and SC414 had lower A than TX7078. In 2002 and 2003 15 diallel F1 generations, including reciprocal crosses, were developed by Dr. Rosenow at Lubbock and winter nursery at Costa Rica.

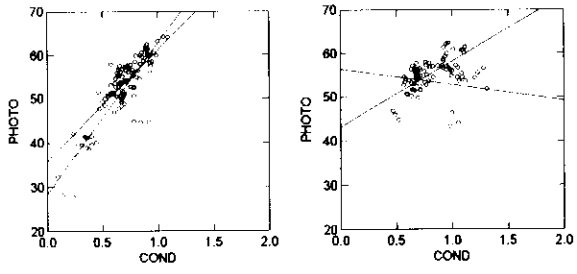

Figure 1. The relationship between A (PHOTO, in μmol CO_2 m^{-2} s^{-1}) and g (COND, in mmol H_2O m^{-2} s^{-1}) in four parental sorghum lines. Left: TX430 - red and R1988 - blue. Right:TX7087 - red and SC414 - blue.

The objectives of the proposed research will be 1) to examine the heritability for A and A/g and 2) to assess the relation of chlorophyll fluorescence and stay-green, two relatively easier measurable physiological traits, to pre-flowering A and A/g, and to further assess genetic variability in sorghum for A and g. Our long-term goal is to identify genes associated with high A and A/g, and to develop molecular and physiological diagnostic tools for more efficient incorporation of these traits into sorghum hybrids targeted for water-limited cropping systems.

Methods

All F1's, reciprocal F1's and their parental lines will be planted at TAES Amarillo under 80 and 40% soil moisture in pots in a green house. At key vegetative stages for yield formation, pots will be moved to a growth chamber for precise environmental control and evaluation of A and g. Chlorophyll fluorescence will be measured as well at 720 nm wavelength using a PAM 2001 fluorescence sensor (Walz, Germany) as a potential indirect physiological diagnostic tool of both A and g. Griffing's Model 1 (Method 1) (Griffing, 1956) will be employed to estimate general and specific combining abilities for A, g, A/g, and WUE. Half of F1's will be advanced to F2 generation (some of the F2 seed has already been produced), which will be then used to estimate variance components and heritability for these traits. We will compare A measurements made with the infrared gas analyzer and chlorophyll fluorescence for speed, precision and ease of operation.

References

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Specific Issues Addressed

Relative to the needs of current water and/or conservation projects (listed in Section III, or others), what concern(s) is/are addressed by this project?

This proposal addresses the need for water conservation and drought mitigation to maintain agricultural productivity. These are of course important issues for agriculture and rural communities, but also for urban communities in Texas, who depend indirectly on the economic well being of the agricultural sector, and who increasingly compete with agriculture for water. The development of sorghum hybrids with improved A/g will contribute to further increases in irrigation efficiency and groundwater conservation. There would be beneficial spill-over effects as well to developing countries in the semi-arid tropics who are dependent upon sorghum as a staple food.

Collaboration

What agencies, groups, organizations, or additional TAES/TAEX disciplines are included in this project? List all collaborators and their function in the project.

TAES – Amarillo, Crop physiology and Sorghum Breeding Program from TAES - Lubbock.

Dr. William Payne is responsible for the overall execution and quality of the study. He has worked internationally with sorghum and millet for 10 years, including six years as Principle Crop Physiologist with ICRISAT. Dr. Maria Balota is responsible for the day-to-day research activities and data quality of field and laboratory measurements. She has also worked internationally as a crop physiologist, and first came to the US as a Fulbright Scholar. Most of the requested funds are to support Dr. Balota's salary. Dr. Darrell Rosenow is distinguished and internationally recognized sorghum breeder with TAES - Lubbock. He will provide seeds for the sorghum entries studied, and maintain the nurseries at Halfway and any field sites.

Submitted by _____
(P.I. signature)

William A. Payne, Ph.D.
Associate Professor Crop Physiology

Submitted by _____
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Maria Balota, Ph.D.
Postdoc-Research Associate Stress Crop Physiology

Approved for submission see attached
(Unit Head signature)

John M. Sweeten, Ph.D. P.E.
Professor and Resident Director
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5. Nobel, P.S. 1999. Physicochemical & Environmental Plant Physiology. Second edition. Academic Press, San Diego.5.
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Submitted by_____ William A. Payne, Ph.D.
(P.I. signature) Associate Professor Crop Physiology

Submitted by_____ Maria Balota, Ph.D.
(Co-P.I. signature) Postdoc-Research Associate Stress Crop Physiology

Approved for submission _____ John M. Sweeten, Ph.D. P.E.
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TAES/TWRI
Water Conservation and Soil Management
Project Budget Form

Expenditure Description	Amount Requested	Other Sources	Total
Staffing Requirements:			
1) Co- PI	0	5,350 (20% salary)	5,350
2) Undergraduate student	5,120	0	5,120
3)			
4)			
Fringe	0	2,295 (20% fringe)	2,295
Total Staff Costs			
Materials and Supplies	1,420	0	1,420
Travel	960	500	1,460
Equipment	0	46,200	46,200
Printing and Publications	500	0	500
Services			
Evaluation			
Other (describe in detail) 1. Stress detection glasses 2. Anemometer 3. Quantum meter	0		
Total Project Costs	$ 8,000	$ 54,345	$ 62,345

Name and addresses of the other investigators involved:

1. **Darrell Rosenow, Ph. D.**
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