Project Narrative

Name of the Project: **Genetic Variability 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**

Mailing Address(es): **Texas Agricultural Experiment Station**

6500 Amarillo Blvd. West, Amarillo, TX, 79106

Phone: **(806) 354-5801** Fax: **(806) 354-5829** E-mail: m-balota@tamu.edu; w-payne@tamu.edu

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

Amount of Funding Requested: **$ 15,000**

Project Need, Description and Expected Outcomes

Recurrent drought and declining aquifer levels have reinforced the reality that water is the lifeblood of Texas agriculture and the rural communities that depend upon it. Urban populations in Texas are also affected by the economic status of agriculture, and 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 Texas crop known worldwide for its drought and heat tolerance. Recent genetic improvements in sorghum have been achieved through the stay-green trait, which is associated mostly with tolerance to post-flowering drought. 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 (Eastin, 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, 1991). The rate of CO_2 fixation (A) is highly correlated with stomatal conductance, but the ratio of A to g, and of biomass production to crop transpiration, have been shown to be 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 differences in variation in intrinsic water-use efficiency could directly contribute to increased whole plant water

use efficiency and productivity. Their measurements suggest that A is more sensitive to water stress than g, which is consistent with theory (Nobel, 1999). Their preliminary work suggested that one could select for higher A without large increases in g, and 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.

Preliminary measurements were taken this year in irrigated and dryland sorghum nurseries of Dr. Darrell Rosenow, Professor of Sorghum Breeding, at Lubbock and Halfway using a new LiCor 6400 portable gas exchange system purchased with a grant from the Texas Grain Sorghum Board. Results confirm the wide genetic variability documented by Kidambi et al. (1990), as well as the enhanced rate of A of Tx430. Several populations from this parent now exist, although crosses were not made specifically for looking at inheritance of A or intrinsic water-use efficiency. Many crosses exist with materials that possess the stay-green trait. Dr. Rosenow also has other verified sources(cultivars) of excellent pre-flowering drought tolerance from various countries of the world growing in hie drought screening nurseries, as well as several diverse sources with post-flowering drought tolerance(stay green). Additionally, our laboratory has recently acquired a chlorophyll fluorescence meter. Thus, there exists the ingredients to begin more formally testing some of the ideas put forth by Kidambi et al. (1990), Payne et al. (1992), and others for selecting for increased water-use efficiency in sorghum.

The objectives of the proposed research will be 1) to further assess genetic variability in sorghum for A and g under both irrigated and dryland conditions, using modern breeding material, and 2) to assess the relation of the more recent physiological traits chlorophyll fluorescence and stay-green, which vary genetically, to pre-flowering A and A/g. Sorghum genotypes identified for high A and A/g would be used in existing or subsequent crosses a view towards further examining heritability for these traits. Our long-term goal is to identify genes associated with high A and A/g, and to develop molecular diagnostic tools for more efficient incorporation of these traits into sorghum hybrids targeted for water-limited cropping systems.

Methods

Measurements of *A* and g will be made on a large number of entries that include both hybrids and converted lines of the Sorghum Breeding Program of Dr. Rosenow at TAES-Lubbock to more formally identify genotypes with superior A and A/g. Measurements will be made with the Li-Cor 6400 under irrigated and non-irrigated field conditions at Halfway, Texas, as well as under controlled condition in the growth chamber at Bushland. Chlorophyll fluorescence will be measured at 720 nm wavelength using a PAM 2001 fluorescence sensor (Walz, Germany). as a potential indirect measure of both A/g.

References

Eastin, J.D., T.E. Dickinson, D.R. Krieg, and A. B. Maunder. 1983. Crop physiology in dryland agriculture. p 334-364 in Dryland Agriculture (H.E. Dregne and W.O. Willis, Eds.). Dryland Agriculture (ASA Monograph 23). American Society of Agronomy, Madison, Wisconsin.

Evans, L.T. 1993. Crop evolution, adaptation, and yield. Cambridge University Press, London, U.K.

Kidambi, S.P., Dl. R. Krieg, and D.T. Rosenow. 1990. Genetic variation for gas exchange rates in grain sorghum. Plant Physiol. 92:1211-1214.

Nobel, P.S. 1999. Physicochemical & Environmental Plant Physiology. Second edition. Academic Press, San Diego.

Onken, A.B., and C.W. Wendt. 1989. Soil fertility management and water relationships. In Soil, crop and water management systems for rainfed agriculture in the Sudano-Sahelian zone. Proceedings of an International workshop, 7-11 Jan. 1987. ICRISAT Sahelian Center, Niamey, Niger. ICRISAT, Patancheru, Andhra Pradesh, 502 324, India.

Payne, W.A., M.C. Drew, L.R. Hossner, R.J. Lascano, A.B. Onken, and C.W. Wendt. 1992. Soil phosphorus availability and pearl millet water-use efficiency. Crop Sci. 32:1010-1015.

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 a 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 other field sites.

Submitted by_____
(P.I. signature)

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

Submitted by_____
(Co-P.I. signature)

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

Approved for submission _____
(Unit Head signature)

John M. Sweeten, Ph.D. P.E.
Professor and Resident Director
Texas A&M University
Agricultural Research & Extension Center
6500 Amarillo Blvd., West,
Amarillo, TX 79106-1796
Phone (806) 359-5401 Fax (806) 358-9718