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PHYSIOLOGICAL AND AGRONOMIC RESPONSES OF A GRAIN SORGHUM (SORGHUM BICOLOR (L.) MOENCH) HYBRID TO ELEVATED NIGHT TEMPERATURES

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PHYSIOLOGICAL AND AGRONOMIC RESPONSES OF A GRAIN SORGHUM [Sorghum bicolor (L.) Moench] HYBRID TO ELEVATED NIGHT TEMPERATURES

by

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TITLE

Physiological and agronomic responses of a grain sorghum

[*Sorghum bicolor* (L.) Moench] hybrid to elevated night temperatures

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INTRODUCTION

Temperature ranks as one of the most critical among the various climatic factors that are known to affect grain production. Grain yields of cereals are quite often limited by higher-than-optimum growth temperatures which occur quite commonly in the arid and semi-arid regions of the world. Some parts of Nigeria fall under such higher-than-optimum temperature category. Such higher temperatures also occur in the Southwestern and Great Plains regions of the United States, which produce most of its grain sorghum [Sorghum bicolor (L.) Moench]. This makes the use of adapted crop genotypes in such areas highly desirable, if not essential, as appropriate adaptation can mean the difference between reasonable yields and in some cases crop failures in unfavorable years. Consequently, adaptation and/or resistance to high temperature becomes an important trait to consider in developing new crop varieties for use in such areas.

Grain sorghum is one of the major grain crops of the United States, ranking second to corn as the most important feed grain. In total annual production, Nebraska ranks third after Kansas and Texas, respectively. Annual production in the U.S.A. is about 20 million metric tons. A preliminary estimate for 1977 gave Nebraska's grain sorghum production as about 4 million metric tons from a harvested area of about 852,000 hectares.[1] On a world-wide basis, grain sorghum serves as a staple for many developing nations.

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[1]USDA Agricultural Statistics, 1978. pp. 52-53, U.S. Government Printing Office, Washington, D.C.

The limiting effect of high temperature on crop yields can manifest itself through short-term, high-temperature periods during critical plant growth stages. Most previous work done in this area concerned high day temperatures and was done under controlled environments. Such artificial conditions do not represent the natural, dynamic field conditions. Therefore, the potential value of such studies for extrapolation to the field is questionable. Also, most such studies failed to consider the relations between high temperature and phenological stage of the plant.

The justification for the development of research in this area is evident from the fact that short- or long-term elevated night temperatures do occur during some growth stages of the crop which result in various degrees of yield reduction.

The investigations reported here consisted of two greenhouse and three field experiments conducted in 1977, 1978 and 1979 to (1) study some physiological and agronomic responses of a grain sorghum hybrid to elevated night temperatures and (2) to determine at which growth stages the plant is most sensitive to above normal or high temperatures.

Also, an attempt was made to determine the significance of heat-preconditioning ("hardening") on the response of grain sorghum to normal and elevated night temperatures under field conditions.

LITERATURE REVIEW

Effects of High Temperature on Crop Yield and Yield Components

The amount of information on effects of temperature extremes on crop yields in general is enormous, but relatively little is available on high night temperature effects in particular. Yield reductions occur from high temperatures in temperate crops and in tropical and semi-tropical crops in arid and semi-arid zones.

Various degrees of yield reduction in various crops resulting from high temperatures have been reported (Peters et al., 1971). In comparison with yields at moderate temperatures, United States grain sorghum cultivars grown under controlled high temperatures showed depressed yields (Downes, 1972). Results of a series of experiments indicated that when plants were grown under one of five day/night temperature regimes (from 21/16 C to 33/28 C), high temperature (33/28 C) between germination and panicle initiation resulted in low grain yield. Grain yield was greatest from plants grown at low night temperatures and progressively declined with higher night temperatures. Day temperature did not affect grain yield except when accompanied by high night temperatures (Downes, 1972). He suggested that low yields in tropical environments may reflect adverse effects of high temperatures.

Eastin (1976) imposed four day/night temperature regimes (29/17 C, 29/22 C, 29/27 C and 34/22 C) on five grain sorghum genotypes from panicle initiation through maturity in growth chambers. He reported an average of 25 to 33 percent yield reduction from a 5 C above-optimum

night temperature treatment, while 10 C temperature elevation reduced grain yields by about 50 percent. These yield reductions were generally paralleled by reductions in seed number.

Asana and Williams (1965) conducted some experiments in controlled environments to determine the effects of high temperature on grain development and yield of five wheat cultivars exposed to three day (25, 28, 31 C) and two night (9 and 12 C) temperatures during post-anthesis. They observed a 16 percent mean yield reduction for the 6 C rise in day temperature, but no significant differences among cultivars. Grain weight was not significantly affected by night temperatures in these studies. However, in a subsidiary experiment using three day/night temperature regimes (24/19, 27/22 and 30/25 C) highly significant but complex interactions between temperature regime and cultivar were established.

Comparing sorghum yields with daily maximum temperatures over a period in Queensland, Australia, Skerman (1956) found that when daily maximum temperatures exceeded 100 F for three or more consecutive days, there was an adverse effect on yields. The so-called "heat waves" were most deleterious during anthesis and during the first month of grain fill. His observations were confirmed by the fact that short-term periods of heat stress during critical growth stages in grain sorghum can have detrimental effects on grain yields (Sullivan et al., 1977a). Over a decade earlier, Pasternak and Wilson (1969) reported similar findings on the effects of heat waves on grain sorghum yields. They claimed that moist or dry heat stress could accelerate anthesis resulting in a reduced seed set and ultimately reduced yields. It was also

reported that heat stress at or soon after boot stage lowered yield and when this was accompanied by low humidity, 10 to 20 percent yield reductions can occur in the field.

In many instances, high night temperatures have been more detrimental to crop growth and yields than high day temperatures (Karr et al., 1959; Langridge and McWilliam, 1969; Owen, 1971; Palis, 1971; Peters et al, 1971; Downes, 1972; Campbell and McCloud, 1977). The data presented by Karr et al. (1959) on the effect of short periods of high day and night temperatures on pea (Pisum sativum L.) yields revealed that high night temperatures proved more critical than day temperatures, resulting in a 25 percent yield reduction as against about 8 percent for high day temperatures. Conflicting opinions have, however, been expressed by some other investigators. They contended that day temperatures, rather than night temperatures, were more influential on crop yields (Nel and Small, 1973).

Based on their findings from a field study designed to assess the effect of nighttime air temperatures on yields of corn, wheat and soybeans, Peters et al. (1971) surmised that the largest seasonal variant experienced by a plant community would be night leaf temperature. They conducted a series of experiments in which two night temperature treatments, hot and cool air, were artificially imposed on unreplicated plots. Results showed approximately 45, 40 and 10 percent yield reductions for wheat, corn and soybean, respectively, from about 10 C above-control night temperatures.