GROWTH AND YIELD ANALYSES OF TEMPERATE
AND "TROPICALLY" ADAPTED
GRAIN SORGHUM

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CHAPTER I

INTRODUCTION

Tropically adapted sorghums are reported to have potential for extensive use in the next few years in sorghum breeding programs. Most sorghums are adapted in limited areas and produce their highest yield in those areas. These sorghums have been selected for the area in which they are growing and have limited genetic diversity. In contrast the tropically adapted grain sorghums have the genetic capacity to extend their range of adaptation, but they are still temperate sorghums because of their ability to remain relatively unaffected by photoperiods and temperature (33).

The temperate hybrids and lines mature faster in shorter latitudes, but they do not develop and do not yield as well as in longer latitudes (33). The higher night-time temperature is thought to be responsible for inadequate assimilate availability to support dark respiration (11). Severe yield reduction resulted when sorghums were subjected to a night-time temperature higher than optimal (13).

Precise, rapid determination of physiologic maturity is useful to sorghum research workers and sorghum producers. The dark layer formation in the placental region near the point of kernel attachment was considered as an indication of physiologic maturity in grain sorghum (15, 41). Data available to date were obtained only from a few hybrids of grain sorghum. In this experiment 16 hybrids and lines with different adaptation and maturity were examined to provide better information for this purpose.

The objectives of this study were:

1. Study the performance of temperate and tropically adapted grain sorghum in temperate, sub-tropical and tropical climates.
2. Study dry matter accumulation per day in tropically and temperate adapted hybrids and lines for grain and forage yield in grain sorghum.
3. Study at least two years to determine the climatic effect on the performance of these hybrids and lines.
4. Study the black layer formation in relation to maximum dry matter production to determine the time of physiologic maturity in grain sorghum.
5. Study the maximum dry matter accumulation in relation to moisture content of kernel during the black layer formation.

CHAPTER II

REVIEW OF LITERATURE

Tropically Adapted Grain Sorghum

Sorghums were introduced into the United States from tropical areas. Farmers made selections from these introductions of the early maturing and short types which can be grown and will mature in temperate areas (43).

Quinby and Karper (44) pointed out that the difference between tropical and temperate varieties is based on maturity genes only. Quinby (38) reported that genes at only four loci control maturity and that a recessive at any one of the four loci results in temperate adaptation. He also suggested that there may be several, or perhaps many, alleles at each of the four known maturity loci. Combinations of these loci and their multiple alleles along with photoperiod and temperature effects caused extreme variation in sorghum maturity.

Quinby and Karper (46) showed that heterosis in sorghum hybrids could be the result of heterozygosity at a single maturity locus. They produced hybrids which had greater yield than their parents by using isogenic inbred lines that differed by only one allele effecting maturity.

Quinby and Karper (45) indicated that sensitivity to day length was a completely dominant character. The F_1 of a cross between sensitive and insensitive lines was always sensitive, and hybrids which were insensitive to short day always had two relatively insensitive parents. Miller et al. (32) reported an experiment with known maturity genotypes of sorghum in temperate and tropical environments. They pointed out that all sorghum lines recessive at Ma_1 bloomed in about 50 days under short-day conditions and in about 60 days under long days. Miller et al. (31) reported that the maturity genes of dominant Ma_1 and Ma_2 showed a response to photoperiod in Puerto Rico. The lack of response from Ma_3 and Ma_4 indicated that they had a critical photoperiod greater than 13 hours in Puerto Rico.

A tropical variety can be converted into a temperate variety by substituting a recessive maturity allele for a dominant one (43). The conversion program which makes tropical germplasm easily available to plant breeders was described by several workers (39, 49, 53). Several hundred tropical varieties have been converted to temperate adaptations by the U.S. Department of Agriculture and Texas Agricultural Experiment Station personnel and at least by one seed company (43).

Quinby (43) stated that the conversion of tropical varieties to temperate varieties not only contributed some obvious resistance to disease and insects, but some of them may be used directly to make agronomically suitable hybrids for temperate regions. He also indicated that because the difference between temperate and tropical adaptation is only one of the maturity genes, tropical sorghum can be made more useful to tropical plant breeders by using the conversion program and selecting the short stature parental lines with tropical maturity.

The tropically adapted varieties which have been used in this study came from the conversion program. They have tropical germplasm except that they have temperate maturity genes and short stature. Since they came from tropical regions they seem to be particularly well adapted in South and Central Texas (Quinby, J.R. Personal Communication).

Miller and Thomas (34) indicated that the tropically adapted sorghums have extra wide adaptability and genetic capacity to extend their range of adaptation further than temperate sorghums. They reported that the tropically adapted grain sorghums which have been produced and developed under the tropical growth conditions of South and Central Texas have the ability to produce a high stable yield under tropical growth conditions. They also pointed out that these sorghums have high levels of disease resistance, lodging resistance, more vigorous root systems, and higher test weights.

The dividing line between regions where a tropical and temperate environment exists in Texas is about Dallas, Wichita Falls, and San Angelo. North of this line is a temperate climate and south of this line is a tropical climate (Miller, F.R. Personal Communication).

The tropical environment may be defined as follows (33):

1 - Short days (generally between 11 and 13 hours)

2 - High mean temperature

3 - Low diurnal ranges in temperature

4 - Relatively high humidity

5 - Crops maturing with longer days

Miller and Thomas (33) indicated that the tropically adapted sorghums have a lower base temperature than temperate adapted sorghums.

The base temperature is the average time required for the sorghum seed to germinate 50% of maximum when grown on a temperature plate ranging from zero to 35°C. They reported that the tropically adapted grain sorghums produce more leaves and consequently more leaf area which remains green during the entire season. The tropically adapted grain sorghum hybrids produce more grain yield in the South Texas area than temperate hybrids. They pointed out that these two types of grain sorghum become very similar to each other in the temperate zone. The anthesis of tropically adapted hybrids in the South Texas area is 2-3 days later than poorer yielding temperate adapted hybrids, but the tropical hybrids reach harvesting at the same time or earlier than the temperately adapted types. The tropically adapted hybrids have a very rapid rate of grain fill and ensuing dry-down.

They (33) also indicated that the high night temperatures and short days which exist in South Texas and tropical areas have adverse effects on temperately adapted grain sorghums. The higher night temperatures and shorter day lengths interact to increase night respiration and alter the sink strength. Consequently yields are reduced by creating photosynthesis limiting growth conditions.

The effect of photoperiod and temperature on growth and development of sorghum will be discussed in the next section.

Photoperiod and Temperature

Sorghums are reported to be short-day plants and it has been shown that short days hasten maturity (21). Martin (29) reported that long days in the summer in longer latitudes prevent tropical varieties from maturing. In Florida the short days during the winter permitted the tropical varieties to mature.

Quinby and Karper (44) examined five pure lines of milos, which had different maturity genes, in 14-hour day-lengths and artificial 10-hour day-lengths. These varieties bloomed at almost the same time in 10-hour day-lengths but they differed greatly when they were subjected to 14-hour day-lengths. They indicated that the number of leaves and floral initiation also were controlled by photoperiod.

Quinby and Karper (45) also showed that different types of sorghum responded differently to photoperiod. Lemon Yellow exhibited complete response to day-length and initiated its head 43 days later and bloomed 55 days later in long days than in short days. Dwarf broomcorn did not respond to photoperiods. Other varieties responded differently in their growth periods when they were subjected to short- and long-day periods.

Coleman and Belcher (5) reported that the five sorgo varieties which were grown in Mississippi in spring and in Southern Florida in winter responded to day-length and flowered faster in the short days, but the temperature also had some effect on photoperiodism of sorgo varieties.

Miller et al. (31) planted temperate and tropical sorghums and different maturity genotype testers during each of the 12 consecutive months in Puerto Rico. They indicated that U.S. sorghums have different critical photoperiods than tropical sorghums. It was possible to bring all types into flower at about the same time in Puerto Rico by planting in mid-September through mid-November when day-lengths were below the critical level for varieties. They also indicated that photoperiod thresholds varied for different sorghums and they separated them into five general response classes.

Miller et al. (32) planted eight maturity genotypes within the milo group of varieties which have the same genetic background and F_2 populations of crosses between several genotypes which were different from each other at a single locus. The materials were grown in Puerto Rico during the winter and in Texas during the summer. They reported that the sorghums flowered at about the same time in short days, but not in long days. They also indicated that the maturity response of sorghum in the tropics was due to short days and not to quantitative inheritance.

Sen Gupta and Saha (50) demonstrated that [Sorghum Roxburghii var hians stapf (Jowar)] was a short-day plant. Ingle and Rogers (23) reported that Johnsongrass [Sorghum halepense (L.) Pers.], was a short-day plant, and the amount and duration of vegetative growth was proportional to day-length, and the photoperiod response of Johnsongrass was greater at higher temperature.

Lane (28) showed that four milo genotypes required 35 to 70 days for floral initiation under 14-hour days, but they required 19 days under 10-hour days. In long days floral development after initiation was retarded. The critical photoperiods were 12 to 13 hours for these genotypes. He also reported that the light wave length, light source, and interruption of light was very critical in photoperiodic responses of plants and different varieties showed different reactions to light quality.

Caddel and Weibel (2) planted three varieties, Early Hegari, 80-day Milo, and Wheatland, in a controlled environment chamber and subjected them to 27 and 32°C day temperature and 16 and 21°C night temperature with 10-, 12-, and 14-hour photoperiods. They reported that 10-hour days hastened the floral initiation and anthesis of each variety in all temperature combinations. Fourteen-hour days usually, but not always, delayed the maturity as compared to 10-hour days. Later Caddel and Weibel (3) reported an experiment with Early Hegari, 80-day Milo and Ryer Milo varieties of sorghum which were subjected at different ages to different treatments of 10-hour and 17-hour days in controlled-environment chambers. They indicated that photoperiodic sensitivity was attained at about 15 days of age. After sorghums reached this age, they became sensitive to short days and initiated floral tissue quickly following the stimulus. As the sorghum increased in age beyond 15 days, less time was required for floral initiation following short-day photoperiod treatment.

Kebede and Hume (24) subjected the three early maturing grain sorghum hybrids which had been developed for the Canadian climate to different day and night temperature regimes and photoperiods under controlled-environment conditions. They reported that all hybrids had fewer leaves, bloomed in fewer days, and had less total shoot dry weight when they were grown in 10-hour days as compared with 12-hour days. They indicated this type of response might be expected because these hybrids have been selected for earliness in northern latitudes and apparently exhibited longer critical photoperiod, as compared with tropical genotypes.

Vinall and Reed (55) indicated the optimum temperature for growth in sorghum is 33.5°C and that they could not thrive in regions of low temperatures. They reported that the best yields were obtained when the soil was warm during germination and emergence and the air temperature was moderate during flowering and grain filling periods. Martin (29) indicated that the highest yields could be obtained with the mean July temperature above 24°C, and a period of 120 to 160 frost-free days. Stoffer and Van Riper (54) showed that as the soil temperature increased from 9.5°C to 21°C sorghum plants grew faster, increased in grain yield and in carbohydrate content.

Quinby and Karper (46) indicated that all varieties of sorghum were short-day plants and those which were not hastened by short days had different thermal requirements. Therefore thermal requirement must be met before a variety can react to a given photoperiod. Quinby (40) reported that a difference of 2°C during the night was sufficient to hasten anthesis in some varieties but delayed this period in other varieties.

Pauli et al. (37) indicated that in general early planting delayed floral initiation, lengthened the period from floral initiation to anthesis, and reduced the period from anthesis to physiological maturity. Fryer et al. (20) studied six varieties of grain sorghum under more than 100 different temperatures produced by 3 to 4 dates of planting at 8 locations in Kansas. They concluded that daytime temperatures above 21°C during the first 30 days following planting, and temperatures above 27 to 32°C thereafter, hasten maturity. Night-time temperatures between 16 to 21°C retarded maturity but night-time temperatures either below 16°C or above 21°C hastened maturity.

Caddel and Weibel (2) reported that floral initiation and anthesis under 12-hour photoperiods were highly dependent upon the day and night temperature. The warmer night and day temperatures often hastened sorghum development.

Downes (11) reported the results of several experiments by planting the sorghum in a controlled-environment glasshouse. He indicated the high day and night temperatures (33/28^{o}C) in the period between germination and initiation had an adverse effect on ultimate grain yield and total above ground dry matter as compared with day and night temperatures of 27/22^{o}C. The high temperature before initiation did not appear to reduce the number of florets developed in the early stages of panicle growth. Although high temperature delayed initiation while additional leaves were produced, the rate of development of the floral primordium was not retarded at 33/28^{o}C. The rate of panicle development and rate of leaf appearance was higher at 33/28 and 27/22 than at 21/16^{o}C. A temperature regime of 32/28^{o}C resulted in more branches being formed on the panicles than did one at 27/22^{o}C. After 15 leaves had appeared the panicle was much more sensitive to high temperature damage and development of many florets was discontinued at 33/28^{o}C. On the plants which grew at 33/28^{o}C until initiation and then were subjected to 27/22^{o}C the florets apparently reached maturity, but in many plants no mature grain was produced. He also reported that when the plants were subjected to various day and night temperatures in post-initiation phase of growth, the day temperature had little effect on grain production. These results were in agreement with Downes (10) that rate of photosynthesis in sorghum is not modified much by day temperatures between 25 and 35^{o}C. Grain yield was depressed by increased night temperatures. He stated that the adverse effect of high night temperature on grain yield is likely to be associated with inadequate assimilate availability to support dark respiration.

Eastin et al. (13) reported an experiment with temperate, intermediate and cool-tolerant varieties of sorghum which were grown in a growth room. The plants were grown in normal temperatures (27/22°C) up to the panicle initiation stage, and then they were subjected to day/night temperature combinations of 29/17, 29/22, 29/27 and 34/22°C. They indicated that a yield reduction of about 1/4 to 1/3 can be expected when hybrids are subjected to a night temperature 5°C higher than its optimal night temperature. The highest yield of temperate sorghum was obtained with 29/22°C while the cool-tolerant sorghum yielded best near 29/17°C. The day-time temperature influenced yield, but varied with different genotypes. They also pointed out that there was a steady decline in grain filling period and production of dry matter per day with increasing night-time temperature.

Norcio and Sullivan (36) measured the photosynthesis rate of sorghum and corn at 40 and 43°C to determine the thermal stability of the photosynthetic apparatus. At 43°C some sorghum entries showed a negative rate or a photo-oxidation process (photo respiration). The sorghum lines with more thermal stability were able to either maintain or increase their photosynthetic rate as temperature increased. They pointed out that the ability of the plants to photosynthesize at a higher rate when they were subjected to high temperatures may be an important characteristic when the plants are subjected to heat stress. The sorghum lines with heat tolerance also photosynthesized at a higher rate at high temperature.

Kebede and Hume (24) reported that grain yields were more reduced by increasing the day temperature (25 to 35°C) than increasing the night temperature (15 to 20^{o}C) in early morning sorghum hybrids with Canadian adaptation, but the grain filling period was reduced as the night-time temperature increased.

Physiologic Maturity

Development of the sorghum crop has been divided into simple and somewhat arbitrary categories (12). These stages are: growth stage 1 (GS1) or planting to panicle initiation, growth stage 2 (GS2) or panicle initiation to bloom, and growth stage 3 (GS3) or bloom to physiological maturity.

The GS1 is a completely vegetative period and the environmental conditions in this stage could have an effect on leaf area and the functional root system. The major event in GS2 is panicle initiation and expansion. This growth stage is critical since maximum potential seed number is set then and either expanded or partially aborted (12). Quinby and Schertz (47) indicated that unfavorable conditions in GS2 limit the meristematic growth which eventually affects yield.

Eastin et al. (17) pointed out that ultimate yield is a function of both grain filling period and metabolic or synthetic efficiency during that period if either seed number or potential size are not limiting. Therefore the rapid determination of physiologic maturity is of interest since it permits accurate measurement of the grain filling period or time factor of yield. Several methods have been used to determine physiologic maturity in corn and sorghum.

Corn

Aldrich (1) defined maturity as the point at which the maximum grain development is first attained. Shaw and Loomis (51) used the term of physiologic maturity for this stage of grain development.

Shaw and Thom (52) indicated that the determination of physiologic maturity by measuring dry matter accumulation in grain was difficult because of variation between sample weights. Also this approach was rather tedious and time-consuming.

Neal (35) reported that corn was mature when the moisture content of the kernels was approximately 30%, but Shaw and Thom (52) and Hallauer and Russell (22) indicated that the level of moisture at physiologic maturity varied in different varieties. So the moisture content of kernels is not a precise indication of physiologic maturity.

Kiesselbach and Walker (26) described the black layer formation in corn. They indicated that the tissue which grows in the placento-chalazal region of the kernel eventually turns into a black closing layer. Formation of this tissue starts after fertilization and grows completely across the placento-chalazal region of the kernel approximately 20 days after pollination and remains active until about 2 weeks before maturity. The black layer appears in cells several layers thick which are formed between the basal endosperm of the kernel and the vascular area of the pedicel. At the physiologic maturity stage these cells shrink, become dense, lose their moisture, and eventually become dark which can be seen by the naked eye when splitting the kernel in half. They pointed out at this time the translocation function to the kernel has ceased.

Daynard and Duncan (9) reported that the black layer formation in corn was a good indication of physiologic maturity. They found that initial visual occurrence of black layer formation was highly correlated with predicted dates of maximum dry matter.

Daynard (8) later reported that the moisture at black layer stage varied from 8 to 42%. This indicated that moisture is not a reliable measurement of physiologic maturity in corn which agreed with other reports (22, 52).

Rench and Shaw (48) indicated that visual pattern of black layer formation took place in five phases. At phase one, the milk line has almost reached the tip of the kernel. From phase one to phase two, the moist brown area dries and narrows into a brown layer. The visual development of black layer begins at phase 3. At phase 4 the brown line forms completely across the base of the kernel. At phase 5 the brown layer has darkened to black and shows a complete black layer development. They also reported that the maximum dry matter accumulation was coincident with initial occurrence of visual black layer, the phase 3. Moisture of the kernel continued to decrease during the black layer formation. Their conclusion was that black layer formation could be used to determine physiologic maturity in corn.

Sorghum

Several methods also have been used to measure or estimate physiologic maturity in grain sorghum. Maximum dry weight has been used to determine the physiologic maturity in sorghum by repeated sampling during GS3. Pauli et al. (37) used this method to measure physiologic maturity in their experiments. They tagged several heads within each plot and sampled grain at 2-day intervals from those heads. The date on which the kernel reached maximum dry weight was recorded on physiologic maturity. Collier (6), Wilkner and Atkins (58), and Kersting et al. (25) also used the same method for determination of physiologic maturity. This method was difficult and time-consuming as in corn and practically impossible for plant breeders to determine the physiologic maturity for thousands of entries in their sorghum breeding programs.

Pauli et al. (37) indicated that the number of days required by a variety to attain each of its stages of development (GS1, GS2, and GS3) is almost identical. It is possible to estimate physiologic maturity by this method but it is necessary to determine floral initiation which is not a quick and easy method.

Moisture content as a measure of maturity and time for harvest is only useful to the producer. This method does not give physiologic maturity. Kersting et al. (25) reported that Combine Kafir-60 grain sorghum reached maximum dry matter accumulation at 45 days after pollination with 23% moisture in one year and at 33 days with 30% moisture in the next year. Their data showed that moisture content cannot be used to determine the physiological maturity. The moisture in the grain and stem is affected by humidity and rainfall during the grain filling period (30, 59).

Warnes (56) studied the relationship between percentage of grain moisture in ripening grain sorghum hybrids and days from planting to one-half bloom. He reported that climatic conditions had a major effect on the loss of grain and head-stem moisture. Grain moisture content and average days to one-half bloom were highly correlated, but the correlations were lower at successive sampling dates as the crop approached maturity. He suggested that hybrids of single maturity groups had different drying and filling rates. Days from planting to one-half bloom give a general indication of relative maturity of sorghum hybrids, but differential drying and filling rate of hybrids must also be considered for accurately comparing the relative maturity at harvest.

Because bloom date could be determined very easily and quickly sorghum research workers have used bloom date to obtain relative maturity in grain sorghum (15).

Quinby (41) considered the use of black layer formation as a possible indicator of physiologic maturity in sorghum. Eastin et al. (15) studied the dark closing layer in the placenta region near the sorghum kernel point of attachment in relation to cutoff of assimilate translocation to the kernel. They indicated that sorghum pollinates from the tip to the base of the head and consequently, matures in the same direction. They fed $C^{14}O_2$ in the flag leaves when the upper portion of the panicle branches in the middle of the head showed black layer. Twenty-four hours later eight samples were taken from tip to bottom of the panicle and were tested for radioactivity. They reported that there was little or no translocation of C^{14} into the kernel in which the black layer had appeared, but the highest amount of C^{14} was found in kernels which did not show black layer at the time of the experiment. They pointed out that there was no interaction between sampling (treatment) and genotype so it can be safely used as an indicator of physiologic maturity. There appeared to be an excellent correlation between an external judgment on black layer appearance and the time translocation was cut off to the kernel.

Weibel (57) used a group of hybrids and lines in Puerto Rico to study the relationship of black layer formation with maximum dry weight and moisture content. Black layer formation and maximum dry weight occurred together or within two days in most cases. Moisture content of the kernels at black layer formation, however, varied with hybrids and lines.

The amount of grain harvested from a field depends on two general factors if neither seed number nor potential seed size are limiting (15). The first is the length of the grain filling period and the second is the rate of grain production or metabolic efficiency of the plant. Quinby (42) studied the length of grain filling period for 12 hybrids and their parents by measuring maximum dry weight of kernels at physiologic maturity. He reported that all entries reached maximum kernel weight between 30 and 40 days after flowering. There were no significant differences in length of grain filling period between parents and hybrids.

Eastin et al. (17) reported that hybrids had a greater grain filling period than their parents. They used black layer for determination of physiologic maturity. They also indicated that hybrids are more efficient than their parents in grain production per unit of time. Therefore, it is of interest to express metabolic efficiency of the genotype for that period by dividing grain yield by grain filling period.

Dalton (7) indicated that under favorable growing conditions, there is a positive correlation between yield and days to half bloom. Eastin et al. (17) reported the correlation between yield and GS1, GS2, GS3, and the total season. The correlation between yield and grain filling period was significant. They suggested that two-thirds of the variability in yield can be predicted by variability in length of grain filling period.

Eastin et al. (14) conducted an experiment to determine the range of days for grain filling period in adapted sorghum genetic material by using the black layer for physiologic maturity. They have shown that duration of the grain filling period was normally distributed in a random mating population of grain sorghum. Duration of grain filling period ranged from 31 to 53 days indicating that the potential for selection for this characteristic was good.

Castleberry et al. (4) reported that the duration of the grain filling period was not significantly affected by the plant population. They pointed out the variation in population density should not be a problem in selecting for duration of the filling period in random mating populations. Eastin and Sullivan (16) showed the average length of grain filling period for 15 sorghum hybrids on dryland was 19.5% shorter than irrigated land and the average grain yield on dryland was 23.5% below irrigated land. The suggested that despite the severe drought during the experiment the metabolic efficiency in grain sorghum during grain filling period remained relatively high.

Kumar (27) studied the dry matter accumulation in grain sorghum at four different locations in Oklahoma. The formation of black layer was used to determine physiologic maturity. He reported that on the dryland locations the rate of dry matter production per day for periods from planting to black layer, planting to mid-bloom, and mid-bloom to black layer increased from early to medium to late maturity groups. The same trend was found on the irrigated location for dry matter accumulated per day for the period of planting to mid-bloom. Dry matter accumulation per day for the period from planting to black layer was similar for the three maturity groups. A reverse situation appeared in the case of dry matter accumulated per day for the period of mid-bloom to black layer.

CHAPTER III

MATERIAL AND METHODS

Materials

The varieties selected for the study are listed in Table I, and the pedigree and source of seeds is listed in Table XXVII of the Appendix. Sixteen and 20 different grain sorghum hybrids and lines were selected for study in 1977 and 1978, respectively. These entries were selected on the basis of maturity and adaptation to tropical or temperate climates. Two early maturing hybrids with temperate adaptation were selected. No early maturing hybrids with tropical adaptation were available. In the medium maturing groups four hybrids with temperate and three hybrids with tropical adaptation were selected. In the late maturing category two temperate and four tropically adapted hybrids or lines were chosen. In 1978 two late and two medium tropically adapted hybrids or lines were added to the experiment.

Methods

Performance Test

The experiment was conducted at Perkins and Goodwell in Oklahoma and at Isabela, Puerto Rico, in 1977. In 1978, it was grown at College Station, Texas, in addition to the other three locations. Information

TABLE I

SORGHUM ENTRIES USED FOR TEST

Entry	Seed Color
Early Temperate	
NB 505	Red
DeKalb B 35	Red
Medium Temperate	
RS 610 A	Red
A 399 x TAM 2567	Red
RS 671	Red
NB 691	Red
Late Temperate[1]	
TAM 618[2]	White
B Redlan[2]	Red
Medium Tropical[1]	
TAM 670	White
TAM 680	Red
TX 618 x TAM 430[3]	White
Redlan x TAM 430[3]	Red
Funks[4] HW 1761	
Late Tropical[1]	
Funks[4] G 722 DR	Red
Funks[4] HW 1760	Red
TX 622 x TAM 430	White
TX 623 x TAM 428[3]	White
TX 623[2,3]	White
TAM 428[2]	White
TAM 430[2]	White

[1]Some entries varied from this maturity grouping from location to location.

[2]Sorghum lines, remaining entries are hybrids.

[3]Not used for test in 1977.

[4]Personal communication from Dr. N. B. Wilson indicated one tropical parent.

concerning the locations and the test conditions may be found in Table II.

The experiment was arranged in a randomized complete block design with five replications. Single rows constituted experimental units. To reduce the possibility of interplot competition due to maturity and/or height differences, OK 612 (a medium maturing hybrid) was planted in every other row. One exception occurred at College Station in 1978 due to space limitations.

The climatological data for 1977 are listed in Tables XXVIII, XXIX, and XXX for Perkins, Goodwell, Isabela locations, respectively, and for 1978 in Tables XXXI, XXXII, XXXIII, and XXXIV for Perkins, Goodwell, Isabela, and College Station locations, respectively. The approximate number of hours per day with a light intensity of 5 ft.-C. was reported by Francis (18). Since critical intensities have not been reported for sorghum, the light intensity (5 ft.-C.) to which the photoperiod mechanism in corn (19) is sensitive was used to estimate the effective day length.

At Perkins, Oklahoma, in 1978 rainfall during the summer was far below normal and its distribution was such that the crop was in severe stress during the period of normal heavy water usage. In such conditions some of the late entries did not exsert their panicles at all and were eliminated from the experiment.

At Goodwell, Oklahoma, in 1977 there was some hail injury and severe infestation of crabgrass in part of the experimental plots. In 1978 there was herbicide injury in some experimental plots. At Isabela, Puerto Rico, bird damage was negligible in 1977 because the experimental

TABLE II

LOCATION AND CONDITIONS

Location and Latitudes	Soil Type	Year	Irrigation	Planting Date	Harvesting Date	Area Harvested	Plant/ ha	Fertilizer	Insecticide and Herbicide
						ha		Kg/ha	
Goodwell Oklahoma 36.36°N	Richfield Aridic Argistoll	1977	53.3 cm	5/24/77	10/27/77	1/961	92250	285 N	Active Propazine 3.363 kg/ha
		1978	53.3 cm	6/12/78	10/23/78	1/9226	92250	225 N	Cygon for greenbug(2 areal app.) Milogard 3.363 kg/ha
Perkins Oklahoma 35.59°N	Teller Udic Argistoll	1977	Dryland	6/7/77	9/14–9/25 1977	1/1709	71750	133–0–114 N–P205–K20	Milogard 2.8 kg/ha
		1978	Dryland	6/10/78	10/6/78	1/1709	71750	133–0–114 N–P205–K20	Milogard 2.8 kg/ha
College Station Texas 30.35°N	Norwood Typic Udifluvent	1978	35.6 cm	4/20/78	8/16/78	1/3700	96850	180–67–67 N–P205–K20	Sevimol for midge 1.2 li/ha (4 app.) Milogard 1.4 kg/ha Ramrod 4.8 kg/ha
Isabela Puerto Rico 18.28°N	Coto Soil Tropeptic Haplortox	1977	Dryland	6/8/77	10/20/77	1/1250	65600	168–56–112 N–P205–K20	Lannate 1 li/ha
		1978	Dryland	9/14/78	1/18/78	1/2500	65600	168–56–112 N–P205–K20	Lannate 2 li/ha Furadan 1 li/ha

plots were covered with a net, but in 1978 the sorghum was sprayed with mesurol* which did not prevent some bird damage.

Table III shows the categories of data which were collected. Some of the information for a given year or location was missing because the cooperator failed to collect it.

Data for black layer formation were obtained by visiting the field every other day. A few grains were removed from the central portion of a panicle and examined visually for a darkening in the placental area, the point of attachment of the kernel. Time of black layer was determined by examining three or four randomly selected heads judged to be typical of the row for each entry in each replication.

Data for forage dry weight were collected only at the Perkins station in 1977. Stover fresh weight was measured by weighing the leaf and stalk mass cut at 2.5 cm from the soil surface. Three plants were selected at random from the sample and dried at 78°C for one week to determine the moisture percentage. The stover dry weight was calculated by the following equation:

$$\text{Stover day weight} = \frac{(100 - \text{moisture \%})\ \text{Stover fresh weight}}{100}$$

Analyses of variance were computed for each location separately, all locations combined for each year, and two years combined for common locations. The analyses were used to determine the possible interactions between location and varieties, location and year, and variety and year.

Data were not available for all variables in both years. In addition to the variables listed in Table III analyses of variance were conducted also for grain yield per day from planting to mid-bloom,

*Mesurol = Methiocarb[4-(Methylthio)-3,5-xylyl methyl carbomate

TABLE III

CHARACTERISTICS STUDIED IN 1977 & 1978 AT THE VARIOUS LOCATIONS

Character	Goodwell 1977	Goodwell 1978	Perkins 1977	Perkins 1978	College Station 1977	Isabela 1977	Isabela 1978
Days from Planting to Mid-Bloom	*	*	*	*	*	*	*
Days from Planting to Black Layer	*	*	*	*		*	*
Days from Mid-Bloom to Black Layer	*	*	*	*		*	*
Plant Height Cm	*	*	*	*	*	*	*
Test Weight kg/hecto-liter	*	*	*	*	*	*	
Grain Weight kg/ha	*	*	*	*	*	*	*
Threshing Percent		*	*	*	*	*	
Stover Dry Weight			*				
Stover Moisture Percentage			*				
Maximum Dry Weight of Kernels			*				
Moisture Percentage of Kernels			*				

*Data collected

grain yield per day from planting to black layer, and grain yield per day from mid-bloom to black layer. At the Perkins location in 1977 analyses of variance were conducted for stover dry weight per day from planting to mid-bloom, stover dry weight per day from planting to black layer, stover dry weight per day from mid-bloom to black layer, and grain yield/stover dry weight ratio.

Correlation coefficients were calculated between grain yield and other variables at each location and each year.

Physiologic Maturity

The study was conducted for two years at Perkins utilizing the 16 and 12 entries the first and second year of the study, respectively. In each entry and each replication five heads were selected and tagged when the grain in the tip of the panicle showed "brown layer," the slightly dark layer before black layer, at the point of attachment. At this time about twenty grains were pinched out of the middle of each panicle from each selected plant and bulked for each entry in each replication. Sampling was continued from the middle of the panicle in the selected plants every day for ten days in 1977 and every other day for nine days in 1978. Each sample was collected in a separate plastic bag, and it was threshed by hand in the laboratory to obtain only kernels. Each sample was weighed on a Fisher Model 2000 electronic balance, and then dried in the oven at 97°C for 6-8 hours. The moisture percentage was calculated as follows:

$$\frac{\text{Fresh kernel wt.} - \text{dry kernel wt.}}{\text{Fresh kernel wt.}} \times 100$$

Dry weight was calculated on the basis of 100 kernel weight.

In this experiment the date on which the black layer appeared in the middle of the panicle (at sample site) was called "O" and -4, -3, 02, and -1 were used to designate the days on which collections were made before black layer, while 1, 2, 3, 4 and 5 were used to designate the days on which collections were made after black layer formation. In 1978 only -4, -2, 0, 2, and 4 days were used to designate the days on which collections were made before and after black layer formation.

Analyses of variance were computed for each entry separately, for all entries combined in each year, and for common entries in both years to determine the possible interaction between variety, days to black layer, and years.

CHAPTER IV

RESULTS AND DISCUSSION

Growth Periods

Table IV shows the means of the different growth periods for each entry at the Goodwell location. There were significant differences among some entries for number of days from planting to mid-bloom (MB), from planting to black layer formation (BL), and from mid-bloom to black layer. Table XXXV in the Appendix shows the analyses of variance for these periods at the Goodwell location.

Number of days from planting to flowering varied among these sorghum entries from 61.2 to 75.8 and 61.8 to 79.0 days in 1977 and 1978, respectively. The physiologic maturity, the black layer stage, occurred after 91.4 to 109.8 days in 1977 and after 97.2 to 120.6 days in 1978. The flowering and black layer occurred much later in 1978 than in 1977. The sorghum hybrid A 399 X TAM 2567 which was a medium maturity hybrid in 1977 matured later than all other entries in 1978. The tropically adapted hybrids flowered and matured later than temperate hybrids in 1977. The difference between them was not significant for flowering dates in 1978. These two groups showed greater differences in 1977 than in 1978. The increase in number of days from planting to flowering and maturity could have been affected by herbicide damage and/or the application of Parathion for controlling the greenbug infestation.

TABLE IV

MEANS FOR GROWTH PERIODS AT GOODWELL, OKLAHOMA, 1977 & 1978

Entry		Days to Mid-Bloom		Days to Black Layer		Days From Mid-Bloom to Black Layer	
		1977	1978	1977	1978	1977	1978
NB 505		61.2 e[1]	61.8 j	91.8 f	97.2 j	30.6 d	35.4 cdef
DeKalb B3S		64.6 d	62.2 j	91.4 f	101.4 ghij	26.8 e	39.2 bc
RS 610A		66.2 d	67.2 hi	92.4 fe	101.0 ghij	26.2 e	33.8 cdef
TAM 670	T	67.4 d	66.2 i	98.6 d	99.0 ij	31.2 d	32.8 def
TX 622 X TAM 430	T	71.0 c	67.4 hi	103.0 c	105.2 efgh	32.0 cd	37.8 bcde
A 399 X TAM 2567		71.2 bc	75.2 abcd	94.6 e	120.4 a	23.4 f	45.2 a
RS 671		71.8 bc	73.2 cdef	104.2 c	104.6 fgh	32.4 bcd	31.4 fg
TAM 680	T	72.0 bc	70.6 efgh	104.4 c	103.0 fghi	32.4 bcd	32.4 efg
Funks HW 1761	T	72.8 abc	73.6 bcdef	108.0 ab	112.0 bcd	35.2 ab	38.4 bcd
NB 691		72.8 abc	73.8 bcdef	105.0 c	106.6 defg	32.0 cd	32.8 def
TAM 618		73.4 abc	78.2 a	103.2 c	116.0 ab	29.8 d	37.8 bcde
Funks HW 1760	T	74.2 abc	76.8 abc	109.8 a	110.4 bcde	35.6 a	33.6 cdef
TAM 428	T	74.2 abc	76.4 abc	104.6 c	113.4 b	30.4 d	37.0 cdef
Funks G 722 DR	T	74.8 ab	73.4 bcdef	109.6 a	100.8 hij	34.8 abc	27.4 g
TAM 430	T	74.8 ab	77.6 ab	109.4 ab	120.6 a	34.6 abc	43.0 ab
B Redlan		75.8 a	79.0 a	107.2 b	116.0 ab	31.4 d	37.0 cdef

TABLE IV (Continued)

Entry		Days to Mid-Bloom 1977	Days to Mid-Bloom 1978	Days to Black Layer 1977	Days to Black Layer 1978	Days From Mid-Bloom to Black Layer 1977	Days From Mid-Bloom to Black Layer 1978
TX 618 X TAM 430	T		69.0 ghi		107.2 cdef		38.2 bcd
TX 623 X TAM 428	T		70.0 fghi		105.2 efgh		35.2 cdef
Redlan X TAM 430	T		72.0 defg		111.0 bcd		39.0 bc
TX 623	T		74.8 abcde		112.4 bc		37.6 bcde
Temperate Hybrid Means[2]		70.5	72.4	99.1	108.2	28.6	35.8
Tropically Adapted Hybrid Means[2]		72.0*	71.0	105.6**	106.8*	33.5**	35.0

[1]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghums

* and ** = significant from temperate hybrid means at .05 and .01 level of probability, respectively

It seemed that the temperate entries were more affected than the tropically adapted hybrids in such a way that the temperate hybrids flowered and matured later than the tropically adapted ones in 1978, while in 1977 the temperate entries matured earlier than the tropical ones. On the other hand, the mean minimum temperature (Tables XXVIII and XXXI in the Appendix) during the growing season in 1978 was a little cooler than in 1977, which in combination with the pesticides may have caused some adverse effect on sorghum development.

The grain filling periods, the length of time between mid-bloom and the black layer stage, were significantly different among some entries and varied from 23.4 to 35.6 in 1977 and from 27.4 to 45.2 in 1978. This period was significantly longer for tropically adapted hybrids than temperate hybrids in 1977, but not in 1978.

Table V shows the mean growth periods at the Perkins location for all entries and the analyses of variance are shown in Table XXXVI. The number of days from planting to mid-bloom varied from 48.0 to 66.4 and from 51.0 to 72.4 in 1977 and 1978, respectively. The black layer appeared 76.0 to 99.0 days after planting in 1977. In 1978, this period had a range of 77.8 to 98.2 days. All entries at this location flowered and matured much faster than at the other locations. The drought and high temperatures during this period probably were responsible for hastening the developmental stages in sorghum. In 1977, at this location, the sorghum plants developed faster than in 1978. The reason for this difference was not completely known. It seemed that the higher night temperatures during June and August (Tables XXIX and XXXII in the Appendix) might be the main factor. Also, drought in the vegetative stage sometimes delays maturity.

TABLE V

MEANS FOR GROWTH PERIODS AT PERKINS, OKLAHOMA, 1977 & 1978

Entry		Days to Mid-Bloom		Days to Black Layer		Days From Mid-Bloom to Black Layer	
		1977	1978	1977	1978	1977	1978
NB 505		48.0 j[1]	51.0 i	76.0 g	77.8 h	28.0 d	26.6 bcd
DeKalb B 35		50.2 i	53.4 h	77.4 i	81.4 g	27.2 de	28.0 abc
A 399 X TAM 2567		51.8 h	61.2 g	79.8 h	87.8 e	28.0 d	26.6 bcd
NB 691		52.0 gh	69.2 b	81.0 g	98.2 a	29.0 c	29.0 a
RS 610 A		52.8 gf	60.8 g	80.0 h	86.6 f	27.2 de	25.8 de
TAM 680	T	53.2 ef	63.0 f	80.8 g	87.8 e	27.6 d	24.8 de
RS 671		53.8 de	63.4 ef	81.0 g	88.4 e	27.2 de	25.0 de
TAM 670	T	54.2 d	63.8 def	81.2 fg	90.2 d	27.0 de	26.4 cd
B Redlan		55.8 c	67.2 c	85.0 d	95.4 b	29.2 c	28.2 abc
Funks HW 1761	T	56.2 c		81.8 f		25.6 f	
Funks G 722 DR	T	58.2 b		82.8 e		24.6 g	
TX 622 X TAM 430	T	58.4 b	69.6 b	90.2 c	98.2 a	31.8 ab	28.6 a
TAM 618		58.8 b	69.0 b	90.0 c	98.0 a	31.2 b	29.0 a
Funks HW 1760	T	59.0 b		85.4 d		26.4 ef	
TAM 428	T	66.0 a		93.0 b		27.0 de	
TAM 430	T	66.4 a		99.0 a		32.6 a	
TX 618 X TAM 430	T		65.2 de		93.6 c		28.4 ab

TABLE V (Continued)

Entry		Days to Mid-Bloom		Days to Black Layer		Days From Mid-Bloom to Black Layer	
		1977	1978	1977	1978	1977	1978
Redlan X TAM 430	T		65.4 d		93.2 c		27.8 abc
TX 623 X TAM 428	T		72.4 a		96.4 b		24.0 e
TX 623	T						
Temperate Hybrid Means[2]		52.6	63.7	80.5	90.3	27.9	26.6
Tropically Adapted Hybrid Means[2]		56.5**	66.6**	83.7**	93.2**	27.2**	26.7

[1]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghums

* and ** = significant from temperate hybrid means at .05 and .01 level of probability, respectively

The tropically adapted hybrids reached mid-bloom and black layer stage about three days later than temperate hybrids in both years. The grain filling period was also shorter in this location than at the other locations and varied from 24.6 to 32.6 in 1977 and from 24.0 to 29.0 in 1978. This period was shorter for tropically adapted hybrids than for temperate hybrids in 1977, but no differences were found for this period in 1978.

At the College Station location only the number of days from planting to mid-bloom was received and the test was grown only one year (Table VI). The flowering dates were between 63.0 to 79.0 days after planting. Significant differences existed among some entries and between the two groups of tropically adapted and temperate hybrids (Table XLIV in the Appendix). The temperate hybrids flowered an average of 1.4 days earlier than tropical ones.

The growth periods at the Isabela location were significantly different among some varieties. Table XXXVII in the Appendix shows the analyses of variance for growth periods at this location for both years. Table VII shows that the mean number of days from planting to mid-bloom were between 52 to 71.4 days in 1977 and between 57.6 to 75.2 days in 1978. Black layer occurred from 83.2 to 104.4 days in 1977, and from 93.6 to 111.6 in 1978 after planting. These two periods were much shorter in 1977 than in 1978. The probable main reason was the different growth season in 1977 and 1978. The test was planted in June and harvested in October in 1977, while in 1978 it was planted in September and harvested in January. In 1978 the day length was shorter during the growing season than in 1977 which should hasten maturity but its effect seemed to be reversed (Tables XXX and XXXIV in the Appendix).

TABLE VI

MEANS FOR DAYS TO MID-BLOOM AT COLLEGE STATION, TEXAS, 1978

Entry		Days to Mid-Bloom
NB 505		63.0 i[1]
DeKalb B 35		63.4 i
RS 610 A		65.0 i
TAM 680	T	66.0 gh
TAM 670	T	66.2 gh
NB 691		67.0 fg
TX 618 X TAM 430	T	67.2 efg
Redlan X TAM 430	T	67.4 efg
A 399 X TAM 2567		67.4 efg
Funks HW 1761	T	68.2 def
RS 671		68.2 def
TX 622 X TAM 430	T	68.6 cdef
TAM 618		68.8 cde
Funks HW 1760	T	69.2 cd
Funks G 722 DR	T	70.0 e
B Redlan		70.2 c
TX 623	T	72.0 b
TAM 430	T	72.0 b
TX 623 X TAM 428	T	72.2 b
TAM 428	T	79.0 a
Temperate Hybrid Means[2]		66.9
Tropically Adapted Hybrid Means[2]		68.3**

[1]Means followed by the same letter do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghum

** = Significant from temperate hybrid means at .01 level of probability

TABLE VII

MEANS FOR GROWTH PERIODS AT ISABELA, PUERTO RICO, 1977 & 1978

Entry		Days to Mid-Bloom		Days to Black Layer		Days From Mid-Bloom to Black Layer	
		1977	1978	1977	1978	1977	1978
NB 505		52.0 i[1]	57.6 k	83.2 f	93.6 f	31.2 def	36.0 cde
A 399 X TAM 2567		53.0 hi	67.6 cde	85.8 ef	109.8 ab	32.8 bcdef	42.2 ab
NB 691		54.6 ghi	60.2 ijk	90.2 cd	102.8 ed	35.6 ab	42.6 ab
DeKalb B 35		55.8 fgh	58.8 jk	87.6 cde	99.2 e	31.8 cdef	40.4 abcd
RS 610 A		56.6 efg	62.0 ghij	87.2 ed	103.4 cde	30.6 def	41.4 abc
B Redlan		57.2 defg	63.4 fghi	91.4 c	102.4 de	34.2 f	39.0 abcd
Funks HW 1761	T	58.0 def	62.4 ghij	87.6 cde	101.8 de	29.6 f	39.4 abcd
RS 671		58.0 def	61.4 ghijk	88.2 cde	105.6 bcd	30.2 ef	44.2 a
Funks HW 1760	T	59.2 cde	61.6 ghijk	95.0 b	99.0 e	36.0 ab	37.4 bcde
Funks G 722 DR	T	60.0 cd	62.2 ghij	96.2 b	99.8 e	36.2 ab	37.6 bcde
TAM 680	T	60.0 cd	60.8 hijk	90.8 cd	102.2 de	30.8 def	41.4 abc
TAM 670	T	62.0 bc	65.6 efg	97.2 b	106.2 bcd	35.2 abc	40.6 abcd
TX 622 X TAM 430	T	63.6 b	67.2 def	101.4 a	109.8 ab	37.8 a	42.6 ab
TAM 618		64.4 b	70.2 bcd	96.2 b	103.6 cde	31.8 cdef	33.4 e
TAM 430	T	69.0 a	71.4 abc	102.4 a	111.6 a	33.4 bcde	40.2 abcd
TAM 428	T	71.4 a	75.2 a	104.4 a	107.6 abc	33.0 bcdef	34.2 e
Redlan X TAM 430	T		64.8 efgh		109.2 ab		44.4 a

TABLE VII (Continued)

Entry		Days to Mid-Bloom		Days to Black Layer		Days From Mid-Bloom to Black Layer	
		1977	1978	1977	1978	1977	1978
TX 618 X TAM 430	T		65.6 efg		109.0 ab		43.4 a
TX 623 X TAM 428	T		72.8 ab		108.4 ab		35.6 de
TX 623	T		73.2 ab		110.4 ab		37.2 bcde
Temperate Hybrid Means[2]		55.6	62.8	87.9	105.4	32.3	42.6
Tropically Adapted Hybrid Means[2]		60.5**	64.7*	94.7**	105.0	34.3**	40.3*

[1]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghums

* and ** = significant from temperate hybrid means at .05 and .01 level of probability, respectively

On the other hand, the temperatures were greater during the last three months of the growing season in 1977 than in 1978, which could be the reason for faster development of the sorghum in 1977.

The temperate hybrids flowered and matured faster than tropically adapted hybrids. It seemed that the temperate hybrids were more affected by higher temperature than tropical hybrids during the 1977 growing season.

The grain filling duration was between 29.6 to 37.8 in 1977, and between 33.4 to 44.4 days in 1978. The tropically adapted hybrids had longer grain filling periods in 1977 and shorter periods in 1978 than temperate hybrids, respectively. This indicated that the higher temperature reduced the length of grain filling periods in temperate hybrids more than tropical ones.

Table LI in the Appendix shows the analyses of variance for growth periods for all locations combined in 1977. Locations, varieties, and the interaction of location versus variety were significant. This indicated that the different entries reacted differently at different locations. In 1978 the Perkins location was eliminated from the calculations because some entries did not flower nor mature, and the different growth periods could not be recorded for those entries. The variety x location interaction was significant for planting to mid-bloom (Table LI in the Appendix). The three locations, Goodwell, College Station and Isabela, were used to calculate this interaction. Table LII in the Appendix shows that the variety x location interactions were significant when only two locations, Goodwell and Isabela, were used for calculating the period from planting to black layer and for the grain filling period. Again this table showed that the interaction between location and variety was significant in 1978.

Tables LIV and LV in the Appendix show that there were significant interactions for year x location, variety x location, year x variety, and year x variety x location. These analyses of variances indicated that the sorghum entries had different growth periods in the different locations and different years. Therefore, it was not possible to combine locations and study averages.

In general, when comparing the growth periods in different locations, it is obvious that the plants flower and mature faster when they are moved from the temperate area (Goodwell) to the tropical areas (College Station and Isabela). In contrast, the grain filling period increased when the plants were moved from the temperate region to the tropical areas.

Plant Height, Threshing Percent, and Test Weight

Table XXXVIII in the Appendix shows the analyses of variances for plant height, threshing percent, and test weight at Goodwell. The differences among some varieties for the above variables were significant in both years. Table VIII shows that the plant height varied among the varieties from 104.2 to 132.8 cm and from 104.4 to 137.6 cm in 1977 and 1978, respectively. The temperate hybrids were shorter than the tropically adapted hybrids and in general, the height of plants in both of these groups was higher in 1978 than in 1977. Probably the longer growth periods helped the plants become taller in 1978 than in 1977.

The threshing percent was recorded only in 1978 and had a range of

TABLE VIII

MEANS FOR PLANT HEIGHT, THRESHING PERCENT AND TEST WEIGHT AT GOODWELL, OKLAHOMA, 1977 & 1978

Entry		Plant Height 1977	Plant Height 1978	Threshing Percent 1978	Test Weight 1977	Test Weight 1978
		Cm	Cm		Kg/hl	Kg/hl
TX 622 X Tam 430	T	132.8 a[1]	137.6 a	74.0 ab	74.4 bcd	73.2 de
TAM 670	T	131.6 ab	130.8 bcd	61.0 bcd	75.0 bcd	71.8 e
NB 691		127.6 abc	134.2 abc	67.0 abcd	75.0 abcd	74.8 bcde
Funks G 722 DR	T	126.6 abc	130.0 bcde	63.6 abcd	77.4 a	77.6 abc
TAM 680	T	122.4 abcd	134.2 abc	75.0 a	75.0 bcd	77.6 abc
Funks HW 1760	T	118.8 bcde	129.0 cde	61.4 abcd	76.2 abc	79.2 a
A 339 X TAM 2567		116.8 cdef	114.6 gh	69.0 abc	73.6 d	73.0 de
RS 671		116.2 cdef	119.8 fg	60.6 bcd	74.0 cd	74.8 bcde
B Redlan		115.8 cdef	123.8 ef	71.0 abc	74.2 bcd	78.8 ab
TAM 618		112.6 def	111.8 hi	54.2 d	75.2 abcd	75.2 abcde
Funks HW 1761	T	112.0 def	114.6 gh	71.8 abc	76.4 ab	76.6 abcd
RS 610 A		110.6 def	113.8 gh	59.6 cd	73.4 d	73.4 cde
TAM 430	T	107.6 ef	106.8 ij	67.8 abc	72.8 d	72.8 de
DeKalb B 35		106.6 ef	113.6 gh	71.0 abc	73.0 d	74.8 bcde
TAM 428	T	106.2 ef	104.4 j	65.6 abcd	73.4 d	74.2 cde
NB 505		104.2 f	115.4 gh	67.6 abc	73.2 d	75.4 abcde

TABLE VIII (Continued)

Entry		Plant Height		Threshing Percent	Test Weight	
		1977	1978	1978	1977	1978
		Cm	Cm		Kg/hl	Kg/hl
Redlan X TAM 430	T		136.2 ab	74.2 ab		75.6 abcde
TX 623 X TAM 428	T		132.6 abcd	68.0 abc		74.6 bcde
TX 623	T		126.4 de	62.2 abcd		74.2 cde
Temperate Hybrid Means[2]		117.8	120.6	64.1	74.1	74.0
Tropically Adapted Hybrid Means[2]		124.0*	130.2**	67.9	75.7**	75.6*

[1]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghums

* and ** = significant from temperate hybrid means at .05 and .01 level of probability, respectively

54.2 to 75.0 percent. There was no significant difference found between temperate and tropically adapted hybrids.

Test weight was greater in tropically adapted hybrids than temperate hybrids in both years, and they varied from 72.8 to 77.4 kg/hl and from 71.8 to 79.2 kg/hl in 1977, and 1978, respectively.

Table IX shows the means of plant height, threshing percent and test weight at Perkins for both years. The analyses of variance for these variables can be found in Table XXXIX in the Appendix. The plant height in this location was shorter than all other locations, and this was expected because there was no irrigation at this location. The tropically adapted hybrids were taller than temperate hybrids in both years.

Because of drought in 1978, the kernels did not fill very well and resulted in the lower threshing percent than in 1977. The temperate and tropically adapted hybrids did not differ significantly in threshing percent.

The test weight for temperate hybrids was not affected by the environment as much as the tropically adapted hybrids. The temperate hybrids had a lower test weight than tropically adapted hybrids in 1977. In 1978 no significant differences were found among entries nor between the two adaptative groups.

Plant height, threshing percent and test weight varied among the sorghum entries at College Station in 1978 (Table X, and Table XL in the Appendix). The tropically adapted hybrids were taller and had a better test weight than temperate hybrids, while there was no difference between them for the threshing percent.

Table XLI in the Appendix shows that the differences among the same varieties for the above variations at Isabela were significant. The

TABLE IX

MEANS FOR PLANT HEIGHT, THRESHING PERCENT AND TEST WEIGHT AT PERKINS, OKLAHOMA, 1977 & 1478

Entry		Plant Height		Threshing Percent		Test Weight	
		1977	1978	1977	1978	1977	1978
		Cm	Cm			Kg/hl	Kg/hl
TX 622 X TAM 430	T	103.0 a[1]	88.0 a	80.6 ab	63.4 bcd	71.2 bc	66.4
NB 691		102.0 a	80.4 b	77.8 abcd	65.8 bc	71.8 ab	72.2
TAM 670	T	95.2 b	81.2 b	80.0 ab	65.4 bc	74.4 ab	70.4
TAM 680	T	91.2 c	80.4 b	78.0 abcd	70.2 a	74.6 ab	72.8
Funks HW 1760	T	91.2 c		82.6 ab		75.2 a	
Funks G 722 DR	T	89.8 c		84.2 a		70.6 bc	
NB 505		88.8 cd	77.6 bc	71.4 de	61.4 cd	72.8 ab	69.6
B Redlan		85.8 de	76.0 bcd	80.8 ab	60.4 d	72.6 ab	72.2
TAM 430	T	84.6 e		77.8 abcd		60.2 e	
RS 671		83.8 ef	74.0 cd	78.6 abc	65.6 bc	71.0 bc	70.2
DeKalb B 35		83.4 efg	76.0 bcd	73.2 cde	62.8 cd	72.8 ab	72.6
Funks HW 1761	T	83.2 efg		79.8 abc		74.6 ab	
A 399 X TAM 2567		80.4 fg	76.8 bc	81.2 ab	67.8 ab	67.8 cd	71.8
RS 610 A		80.2 fg	76.6 bc	76.8 bcd	62.8 cd	71.2 bc	70.4
TAM 618		79.8 g	70.4 d	68.6 e	52.4 e	66.2 d	67.4
TAM 428	T	79.8 g		67.0 e		54.2 f	

TABLE IX (Continued)

Entry		Plant Height		Threshing Percent		Test Weight	
		1977	1978	1977	1978	1977	1978
		Cm	Cm			Kg/hl	Kg/hl
TX 623 X TAM 428	T		82.2 b		61.8 cd		71.4
TX 618 X TAM 430	T		78.0 bc		64.6 bcd		67.0
Redlan X TAM 430	T		78.0 bc		71.2 a		71.6
TX 623	T						
Temperate Hybrid Means[2]		86.6	77.0	78.6	65.5	70.5	71.2
Tropically Adapted Means[2]		92.3**	81.3**	80.9	66.1	73.4**	69.9

[1]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghums

* and ** = significant from temperate hybrid means at .05 and .01 level of probability, respectively

TABLE X

MEANS FOR PLANT HEIGHT, THRESHING PERCENT AND TEST WEIGHT AT COLLEGE STATION, TEXAS, 1978

Entry		Plant Height	Threshing Percent	Test Weight
		Cm		Kg/hl
TX 622 X TAM 430	T	158.8 c[1]	68.2 ab	70.4 ed
NB 691		150.8 ab	65.2 abcd	72.2 cd
TX 623 X TAM 428	T	150.8 ab	66.6 abc	73.8 bc
Redlan X TAM 430	T	149.4 ab	64.4 abcd	72.8 bcd
TAM 670	T	149.2 ab	70.4 ab	74.2 abc
TAM 680	T	147.2 bc	70.4 ab	74.8 abc
Funks G 722 DR	T	142.2 bcd	71.2 a	76.6 a
Funks HW 1760	T	140.8 bcd	70.6 a	75.4 ab
TX 623	T	138.4 cde	58.2 cde	67.2 fg
DeKalb B 35		135.6 def	64.2 abcd	72.4 cd
TAM 618		132.6 def	57.0 de	65.8 gh
B Redlan		132.6 def	61.4 bcd	68.8 ef
RS 671		132.4 def	65.4 abcd	68.6 ef
TX 618 X TAM 430	T	132.2 def	68.4 ab	70.0 de
RS 610 A		130.6 ef	70.0 ab	70.4 de
A 399 X TAM 2567		127.6 f	65.2 abcd	70.6 de
NB 505		126.0 fg	63.6 abcd	73.4 bc
Funks HW 1761	T	126.0 fg	70.8 a	73.6 bc
TAM 430	T	117.4 g	41.4 f	62.0 i
TAM 428	T	105.6 h	51.8 e	63.6 hi
Temperate Hybrid Means[2]		135.4	66.5	70.5
Tropically Adapted Hybrid Means[2]		144.1**	69.0	73.5**

[1] Means followed by the same letter do not differ significantly at .05 level of probability

[2] Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghum

** = Significant from temperate hybrid means at .01 level of probability

tropically adapted hybrids were taller in 1977 than the temperate hybrids. Both groups were shorter in 1978 and no differences were found between temperate and tropically adapted hybrids (see Table XI). This difference between 1977 and 1978 may be a result of higher temperatures during the three months of the growing season in 1978, or a shorter photoperiod in 1978 (Table XXX and Table XXXIV in the Appendix).

The threshing percent was higher and the test weight was lower for the temperate hybrids than for the tropically adapted hybrids at Isabela in 1977.

Grain Yield

Table XII shows the mean grain yields for both years at Goodwell. The differences among varieties were significant for both years (Table XLII in the Appendix). The grain yield varied from 3191 kg/ha for DeKalb B35 to 6120 for Funks HW 1761 in 1977. In 1978 the grain yield ranged from 4639 kg/ha for TAM 618 to 9018 kg/ha for Funks HW 1761. The grain yield was lower in 1977 than in 1978, which was the result of heavy infestation of crabgrass during that year. No differences were found between tropically adapted hybrids and temperate hybrids in 1977. In 1978 the tropically adapted hybrids, on the average, produced 723 kg/ha more than temperate hybrids. In this year some plants suffered from the application of herbicide and insecticide, resulting in some possible differential adverse effect on the temperate hybrids as compared with tropically adapted grain sorghums. However, it was interesting to have such good performance of tropically adapted hybrids in the temperate area.

Grain yields at Perkins for the different entries are listed in Table XIII, and the differences among these entries were highly

TABLE XI

MEANS FOR PLANT HEIGHT, THRESHING PERCENT AND TEST WEIGHT AT ISABELA, PUERTO RICO, 1977 & 1978

Entry		Plant Height 1977	Plant Height 1978	Threshing Percent 1977	Test Weight 1977
		Cm	Cm		Kg/hl
TX 622 X TAM 430	T	158.4 a[1]	128.0 a	68.0 bc	61.0 cd
B Redlan		146.0 b	121.2 abc	74.2 ab	73.6 a
NB 691		145.0 b	118.2 abcd	73.6 abc	65.8 abcd
TAM 680	T	138.6 bc	123.8 ab	72.0 abc	70.0 abc
Funks G 722 DR	T	137.2 bc	110.2 bcde	70.2 abc	72.2 ab
TAM 670	T	131.0 cd	118.6 abcd	59.8 e	65.6 abcd
RS 671		129.6 cde	105.0 def	73.0 abc	66.0 abcd
Funks HW 1760	T	124.2 ed	106.6 cdef	69.2 abc	69.4 abc
TAM 430	T	123.2 ed	102.2 ef	59.6 e	59.8 d
NB 505		122.8 ed	106.4 cdef	75.4 a	65.0 abcd
Funks HW 1761	T	122.4 ed	102.2 ef	69.6 abc	68.4 abcd
TAM 618		121.6 ed	101.6 ef	61.0 de	62.2 cd
RS 610 A		121. ed	110.6 bcde	68.8 abc	61.0 cd
A 399 X TAM 2567		119.4 edf	121.0 abc	73.2 abc	62.2 cd
DeKalb B 35		118.8 ef	105.4 def	69.2 abc	63.4 bcd
TAM 428	T	109.4 f	92.4 f	66.8 cd	58.6 abcd
TX 623	T		118.6 abcd		
Redlan X TAM 430	T		115.2 abcde		
TX 623 X TAM 428	T		113.2 abcde		
TX 618 X TAM 430	T		110.0 bcde		
Temperate Hybrid Means[2]		128.8	113.7	72.2	63.8
Tropically Adapted Hybrid Means[2]		135.3**	114.2	68.1**	67.9*

TABLE XI (Continued)

[1]Means followed by the same letter in same column do not differ significantly

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghums

* and ** = Significant from temperate hybrid means at .01 level of probability

TABLE XII

MEANS FOR GRAIN YIELDS AT GOODWELL, OKLAHOMA
1977 & 1978

Entry		Grain Yield 1977	Grain Yield 1978
		Kg/ha	Kg/ha
Funks HW 1761	T	6120 a[1]	9018 a
Funks G 722 DR	T	5946 ab	7553 ab
RS 671		5091 abc	6768 bcde
NB 691		4716 bcd	7363 abc
A 399 X TAM 2567		4690 bcde	6962 bcd
Funks HW 1760	T	4028 cdef	7468 ab
RS 610 A		3897 cdef	5527 def
TAM 618		3644 def	4639 f
TAM 670	T	3592 def	5635 cdef
B Redlan		3504 def	6714 bcde
NB 505		3443 def	5043 ef
TAM 428	T	3417 def	5508 def
TX 622 X TAM 430	T	3400 def	7529 ab
TAM 680	T	3374 def	7741 ab
TAM 430	T	3234 ef	6606 bcde
DeKalb B 35		3191 f	6576 bcde
Redlan X TAM 430	T		7936 ab
TX 623 X TAM 428	T		6975 bcd
TX 618 X TAM 430	T		6650 bcde
TX 623	T		6339 bcdef
Temperate Hybrid Means[2]		4599	6655
Tropically Adapted Hybrid Means[2]		4410	7378*

[1]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghum

* = Significant from temperate hybrid means at .05 level of probability

TABLE XIII

MEANS FOR GRAIN YIELDS AT PERKINS, OKLAHOMA, 1977 & 1978

Entry		Grain Yield 1977	Grain Yield 1978
		Kg/ha	Kg/ha
Funks HW 1760	T	5057 a[1]	
Funks G 722 DR	T	4442 b	
NB 691		4247 bc	854 ed
Funks HW 1761	T	4023 bcd	
A 399 X TAM 2567		3862 cde	1584 abc
RS 671		3770 cde	1519 abc
TAM 670	T	3764 cde	1413 bc
TX 622 X TAM 430	T	3725 cde	724 def
TAM 680	T	3617 de	1966 a
RS 610 A		3582 de	1536 abc
DeKalb B 35		3317 e	1782 ab
B Redlan		2634 f	541 ef
NB 505		2575 f	1454 bc
TAM 430	T	1520 g	
TAM 618		1002 h	363 f
TAM 428	T	714 h	
Redlan X TAM 430	T		1949 a
TX 618 X TAM 430	T		1138 cd
TX 623 X TAM 428	T		413 ef
Temperate Hybrid Means[2]		3865	1373
Tropically Adapted Hybrid Means[2]		4105*	1267

[1]Means followed by the same letter in same column do not differ significantly

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghum

* = Significant from temperate hybrid means at .05 level of probability

significant (Table XLIII in the Appendix). In 1977, the tropically adapted hybrids produced significantly more yield than the temperate hybrids, but in 1978 because of extreme drought both groups produced much less grain yield in 1977. The temperate hybrids produced about 106 kg/ha more grain yield than the tropically adapted hybrids (but this difference was not significant). Some of the tropically adapted hybrids which had the highest yield in 1977 did not produce any grain yield at all in 1978.

At College Station, the grain yields varied from 1547 to 6983 kg/ha (Table XIV). The highest yielding entry had tropical adaptability but some of the temperate hybrids like NB 691 did not differ significantly from it. Tropically adapted hybrids, on the average, produced about 1000 kg/ha more than temperate hybrids. The tropically adapted hybrids were those which have specific adaptation for south and central Texas, and it was expected that they should give good yields in this region.

Table XV shows the mean grain yield at Isabela for both years. An analyses of variance showed that there were significant differences among some of the entries (Table XLV in the Appendix). The highest grain yield in this location was 5893 and 4352 kg/ha from the same hybrids in 1977 and 1978, respectively. The grain yields in 1978 were lower than in 1977 because of severe bird damage. At this location, again the tropically adapted hybrids yielded more than temperate adapted hybrids but the differences were not significant. The nighttime temperatures during the growing season were higher than Goodwell, Oklahoma, but lower than at College Station, Texas (Tables XXVIII, XXX, XXXI, XXXIII, and XXXIV), and the range of temperatures from maximum

TABLE XIV

MEANS FOR GRAIN YIELDS AND DRY MATTER ACCUMULATIONS AT COLLEGE STATION, TEXAS, 1978

Entry		Grain Yield	Grain/Day From PL to MB
		Kg/ha	Kg/ha
TX 622 X TAM 430	T	6983 a[1]	102.8 a
Funks HW 1760	T	6782 ab	98.2 a
TX 618 X TAM 430	T	6523 ab	97.2 a
TAM 670	T	6355 abc	96.0 ab
Funks HW 1761	T	6288 abc	92.1 ab
Redlan X TAM 430	T	6211 abc	92.2 ab
TAM 680	T	6116 abcd	92.7 ab
Funks G 722 DR	T	6110 abcd	87.4 abc
NB 691		5841 abcd	87.0 abc
A 399 X TAM 2567		5595 abcde	83.2 abc
RS 610 A		5350 bcde	82.3 abcd
TX 623 X TAM 428	T	4966 cde	68.8 cde
DeKalb B 35		4711 def	74.4 bcde
RS 671		4227 efg	62.1 def
NB 505		3457 fgh	54.9 efg
B Redlan		3201 gh	45.7 fgh
TX 623	T	2999 gh	41.8 fgh
TAM 618		2455 hi	35.8 ghi
TAM 430	T	2155 hi	30.1 hi
TAM 428	T	1547 i	19.6 i
Temperate Hybrid Means[2]		5253	78.7
Tropically Adapted Hybrid Means[2]		6259**	91.9**

[1]Means followed by the same letter in same column do not differ significantly

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghum

** = Significant from temperate hybrid means at .01 level of probability

TABLE XV

MEANS FOR GRAIN YIELDS AT ISABELA, PUERTO RICO, 1977 & 1978

Entry		Grain Yield 1977	1978
		Kg/ha	Kg/ha
TX 622 X TAM 430	T	5893 a[1]	4352 a
Funks G 722 DR	T	5447 ab	2878 bcde
NB 691		5249 ab	3060 bcde
A 399 X TAM 2567		5241 ab	4050 ab
Funks HW 1760	T	5200 ab	3440 abcd
TAM 680	T	5075 abc	2679 cdef
Funks HW 1760	T	4749 bc	2684 cdef
TAM 670	T	4537 bcd	3298 abcde
RS 671		4522 bcd	2324 cdef
DeKalb B 35		4509 bcd	2177 ef
RS 610 A		4113 cde	2403 cdef
NB 505		4072 cde	1612 f
B Redlan		3587 def	2265 def
TAM 430	T	3453 ef	2852 bcde
TAM 428	T	3408 ef	2581 cdef
TAM 618		2808 f	1601 f
Redlan X TAM 430	T		3522 abc
TX 623	T		3521 abc
TX 623 X TAM 428	T		3351 abcde
TX 618 X TAM 430	T		3309 abcde
Temperate Hybrid Means[2]		4781	2959
Tropically Adapted Hybrid Means[2]		5158	3279

[1]Means followed by the same letter in same column do not differ significantly

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghum

to minimum were less than in the temperate areas. These conditions probably were not severe for the temperate varieties and did not change their performance.

Table XVI shows the mean grain yields averaged over Goodwell, Perkins, and Isabela in 1977, and for Goodwell, College Station, and Isabela in 1978. The best entries in 1977 were Funks G 722 DR, Funks HW 1761, and Funks HW 1760, which are tropically adapted and NB 691, a temperate hybrid. In 1978 TX 622 X TAM 430, Funks HW 1761, Funks HW 1760, Redlan X TAM 430, TAM 680, TX 18 X TAM 430, and Funks G 722 DR (all tropically adapted hybrids) and A 399 X TAM 2567 (a temperate hybrid) had the highest yields.

There was no significant difference between temperate and tropically adapted hybrids for grain yield in 1977. In 1978 this difference was significant. The probable reason was the addition of College Station to the experiment in which the tropically adapted hybrids were specifically adapted.

Tables LI, LII, and LIII in the Appendix show that all interactions between variety x location in 1977 and in 1978 were significant. For the two years combined, the year x location, variety x location, and year x variety x location interaction were significant (Table LVI in the Appendix). The common varieties in two years and three locations were used to compute these interactions. These indicated that grain yields of these common entries were affected differently by various locations, and each location had a different effect on grain yield in a different year. The year x variety interaction was not significant which meant the environment in both years had the same effect on "both good and poor varieties."

TABLE XVI

MEANS FOR GRAIN YIELDS, AVERAGE OVER LOCATIONS

Entry		Grain Yield 1977	Grain Yield 1978[1]
		Kg/ha	Kg/ha
Funks G 722 DR	T	5278 a[2]	5480 abc
Funks HW 1761	T	4980 ab	5997 ab
Funks HW 1760	T	4761 abc	5897 abc
NB 691		4738 abc	5421 bc
A 399 X TAM 2567		4598 bc	5536 abc
RS 671		4461 bcd	4440 de
TX 622 X TAM 430	T	4339 cde	6288 a
TAM 680	T	4022 def	5512 abc
TAM 670	T	3964 def	5096 cd
RS 610 A		3864 efg	4426 de
DeKalb B 35		3672 fgh	4488 de
NB 505		3363 gh	3370 fgh
B Redlan		3422 hi	4060 ef
TAM 430	T	2736 ij	3871 efg
TAM 428	T	2513 j	3212 gh
TAM 618		2485 j	2898 h
Redlan X TAM 430	T		5890 abc
TX 618 X TAM 430	T		5494 abc
TX 623 X TAM 428	T		5098 cd
TX 623	T		4286 de
Temperate Hybrid Means[3]		4415	4956
Tropically Adapted Hybrid Means[3]		4557	5639**

[1]Average over locations in 1978, except Perkins

[2]Means followed by the same letter in same column do not differ significantly at the .05 level of probability

[3]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghum

** = Significant from temperate hybrid means at .01 level of probability

The analyses of variance which are listed in Table LVII in the Appendix for grain yield were calculated by using only two locations (Goodwell and Isabela) and 16 common varieties for both years. Even by eliminating the Perkins location which was not a good trial because of drought in 1978, all interactions were significant.

When the two irrigated locations, Goodwell and College Station, were compared in 1978 (Tables XII and XIV) it became clear that both temperate and tropically adapted hybrids lost their yielding ability when they were moved from the temperate to the tropical area, but the former was affected more than the latter.

Dry Matter Accumulation

The dry matter accumulation is the measure of photosynthetic efficiency and it is possible to compare different sorghums by their rate of dry matter accumulation during different growth periods.

Table XVII shows dry matter accumulation per day for periods from planting (PL) to mid-bloom (MB), from planting to black layer (BL), and from mid-bloom to black layer at Goodwell. The analyses of variance for these variables are listed in Table XLII, and the differences between varieties for dry matter accumulation per day for all growth periods were highly significant. There was no significant difference found between temperate and tropically adapted hybrids for grain yield per day from planting to mid-bloom, and grain yield per day from planting to black layer in 1977, but in 1978 the tropically adapted hybrids produced more grain yield per day than temperate hybrids for these growth periods. The grain yield per day from mid-bloom to black layer was greater in temperate hybrids than tropically adapted hybrids in 1977,

TABLE XVII

MEANS FOR DRY MATTER ACCUMULATIONS PER DAY FOR DIFFERENT GROWTH PERIODS AT GOODWELL, OKLAHOMA, 1977 & 1978

Entry		Grain/Day From PL to MB 1977	Grain/Day From PL to MB 1978	Grain/Day From PL to BL 1977	Grain/Day From PL to BL 1978	Grain/Day From MB to BL 1977	Grain/Day From MB to BL 1978
		Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha
Funks HW 1761	T	84.0 a[1]	122.2 a	56.6 a	80.6 a	173.8 ab	241.2 ab
Funks G 722 DR	T	79.5 ab	101.5 abcd	54.3 ab	73.9 abc	171.6 abc	273.6 a
RS 671		71.0 abc	92.6 bcde	48.9 abcd	64.8 abcdef	157.0 abcd	215.4 bcd
A 399 X TAM 2567		66.3 abcd	92.9 bcde	49.6 abc	57.9 cdef	200.1 a	154.7 defg
NB 691		64.8 bcd	100.3 abcd	45.0 abcde	69.1 abcd	146.8 bcde	225.7 abc
RS 610 A		58.5 cde	82.2 def	42.0 bcdef	54.7 defg	153.3 abcde	164.0 defg
NB 505		56.4 cde	81.6 def	37.5 cdef	51.9 efg	112.8 def	143.1 fg
Funks HW 1760	T	54.3 cde	97.2 abcde	36.7 cdef	67.7 abcde	113.0 def	228.4 abc
TAM 670	T	53.1 cde	85.1 cde	36.5 cdef	57.0 cdef	117.2 def	173.0 cdefg
TAM 618		49.7 de	59.7 f	35.3 def	40.2 g	122.4 cdef	123.9 g
DeKalb B 35		49.1 de	106.0 abcd	35.0 ef	64.8 abcdef	124.0 cdef	167.8 cdefg
TX 622 X TAM 430	T	47.8 de	112.3 ab	32.9 ef	71.6 abcd	106.0 def	198.5 bcdef
TAM 680	T	47.3 de	109.6 abc	32.4 ef	75.1 ab	103.3 ef	239.4 ab
B Redlan		46.8 de	84.9 cde	32.8 ef	57.9 cdef	110.8 def	182.5 bcdefg
TAM 428	T	46.1 de	72.6 ef	32.7 ef	48.7 fg	112.6 def	149.5 efg

TABLE XVII (Continued)

Entry		Grain/Day From PL to MB 1977	Grain/Day From PL to MB 1978	Grain/Day From PL to BL 1977	Grain/Day From PL to BL 1978	Grain/Day From MB to BL 1977	Grain/Day From MB to BL 1978
		Kg/hl	Kg/hl	Kg/hl	Kg/hl	Kg/hl	Kg/hl
TAM 430	T	43.1 e	85.3 cde	29.5 f	54.9 defg	94.2 f	155.3 defg
Redlan X TAM 430	T		110.3 abc		71.5 abcd		207.6 bcde
TX 623 X TAM 428	T		99.9 abcd		66.4 abcde		199.5 bcdef
TX 618 X TAM 430	T		96.3 bcde		61.8 bcdef		175.0 cdefg
TX 623	T		85.3 cde		56.8 def		172.5 cdefg
Temperate Hybrid Means[2]		65.1	92.0	46.4	61.6	164.3	189.8
Tropically Adapted Hybrid Means[2]		61.0	103.8*	41.6	69.5*	130.8**	215.1*

[1]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghums

* and ** = significant from temperate hybrid means at .05 and .01 level of probability, respectively

but in 1978 this situation was reversed. The total grain yield was not significantly different in these two groups in 1977, but the grain filling period was much shorter for temperate hybrids than tropically adapted ones. The temperate hybrids were more efficient during unfavorable conditions which existed in 1977 because of heavy infestation with weeds, and they were less efficient during the more favorable season.

Table XVIII shows the mean dry matter accumulations per day for the different growth periods at Perkins. The differences among sorghum entries were significant for dry matter accumulations per day for all growth periods (Table XLIII in the Appendix). No differences were found between tropically adapted and temperate hybrids for dry matter accumulations per day during the growth periods of planting to mid-bloom and from planting to black layer in either 1977 or 1978. Dry matter accumulation from mid-bloom to black layer in 1977 was greater for tropically adapted hybrids than temperate hybrids. No difference was found between these two groups in 1978. It seemed that when conditions were favorable for growth, tropically adapted hybrids were more efficient during the grain filling period, but in adverse conditions they were less efficient than temperate hybrids.

At College Station only grain yield per day from planting to mid-bloom was recorded (Table XIV). The differences among the sorghum entries for this variable were significant (Table XLIV in the Appendix), and the tropically adapted hybrids produced significantly more grain yield per day than the temperate hybrids. Tropical hybrids were more efficient than temperate hybrids. This was expected because these hybrids are best adapted in this area.

TABLE XVIII

MEANS FOR DRY MATTER ACCUMULATIONS PER DAY FOR DIFFERENT GROWTH PERIODS AT PERKINS, OKLAHOMA, 1977 & 1978

Entry		Grain/Day From PL to MB		Grain/Day From PL to BL		Grain/Day From MB to BL	
		1977	1978	1977	1978	1977	1978
		Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha
Funks HW 1760	T	85.8 a[1]		59.2 a		191.6 a	
NB 691		81.7 ab	12.4 ef	52.4 bc	8.7 de	146.5 bc	29.4 de
Funks G 722 DR	T	76.3 bc		53.6 ab		180.7 a	
A 399 X TAM 2567		74.6 bcd	24.9 abc	48.4 bcd	18.0 ab	137.9 ed	59.5 b
Funks HW 1761	T	71.7 cde		49.2 bcd		157.0 b	
RS 671		70.1 cde	24.0 bcd	46.5 cde	17.2 ab	138.7 bcd	60.9 b
TAM 670	T	69.4 cde	22.1 cd	46.3 cde	15.7 bc	139.5 bcd	53.9 bc
TAM 680	T	68.0 cde	31.2 ab	44.8 de	22.4 a	131.1 cde	79.2 a
RS 610 A		67.8 cde	25.4 bc	44.8 de	17.8 ab	131.8 cde	59.4 b
DeKalb B 35		66.1 de	33.5 a	42.9 de	21.9 a	121.9 de	63.6 b
TX 622 X TAM 430	T	63.8 e	10.5 ef	41.3 e	7.4 de	117.2 e	25.4 def
NB 505		53.6 f	28.4 abc	33.9 f	18.7 ab	92.0 f	54.8 bc
B Redlan		47.2 f	8.1 f	31.0 f	5.7 e	90.1 f	19.1 ef
TAM 430	T	22.9 g		15.4 g		46.6 g	
TAM 618		17.1 gh	5.3 f	11.1 gh	3.7 e	32.1 gh	12.4 f
TAM 428	T	10.8 h		7.7 h		26.3 h	

TABLE XVIII (Continued)

Entry		Grain/Day From PL to MB 1977	Grain/Day From PL to MB 1978	Grain/Day From PL to BL 1977	Grain/Day From PL to BL 1978	Grain/Day From MB to BL 1977	Grain/Day From MB to BL 1978
		Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha
Redlan X TAM 430	T		29.9 abc		21.0 ab		69.9 ab
TX 618 X TAM 430	T		17.6 de		12.2 cd		39.5 cd
TX 623 X TAM 428	T		5.8 f		4.3 e		16.7 ef
TX 623	T						
Temperate Hybrid Means[2]		73.5	21.9	48.0	15.4	138.7	52.3
Tropically Adapted Hybrid Means[2]		72.5	19.5	49.1	13.8	152.9**	47.4

[1]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghums

** = significant from temperate hybrid means at .01 level of probability

Table XIX shows the means of dry matter accumulation per day for the different growth periods at Isabela. The differences among sorghum entries were significant (Table XLV in the Appendix), but the only significant difference between temperate and tropically adapted hybrids for any of the growth periods was for grain yield per day from mid-bloom to black layer in 1978. This result indicated that the two groups of hybrids have the same efficiency in a location such as Isabela where the conditions are favorable for sorghum production and the night-time temperature is not as high as at College Station. The tropically adapted hybrids were more efficient for grain yield production per day for the grain filling period in 1978. This might have been the result of a combination of shorter day lengths, lower temperatures, and more precipitation during the growth season compared to 1977.

These variables were averaged over locations for each entry and for the two groups of temperate and tropically adapted hybrids, and they are listed in Table XX. In 1977, the averages over three locations for each entry were significantly different. These variables also were averaged for each entry in 1978 from only two locations. The Perkins location, because of drought, and the College Station location, because all data were not available, were eliminated from computation. In this year the differences among varieties were also significant.

The entries with the greater dry matter accumulations per day from planting to mid-bloom in 1977 almost always had the greatest dry matter accumulations per day from planting to black layer, too. In 1978, this relation could also be observed. However, the relation between these variables and dry matter accumulations per day from mid-bloom to black layer did not always exist.

TABLE XIX

MEANS FOR DRY MATTER ACCUMULATIONS PER DAY FOR DIFFERENT GROWTH PERIODS AT ISABELA, PUERTO RICO, 1977 & 1978

Entry		Grain/Day From PL to MB		Grain/Day From PL to BL		Grain/Day From MB to BL	
		1977	1978	1977	1978	1977	1978
		Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha
A 399 X TAM 2567		98.9 a[1]	60.4 ab	61.1 a	37.1 ab	160.1 ab	97.0 ab
NB 691		96.2 ab	50.9 abcde	58.2 ab	29.8 abcd	147.8 ab	72.7 bcdefg
TX 622 X TAM 430	T	93.4 ab	65.1 a	58.4 ab	39.7 a	156.2 ab	102.8 a
Funks G 722 DR	T	90.8 abc	46.9 abcdef	56.7 ab	29.1 abcd	151.0 ab	77.0 abcdef
Funks HW 1760	T	87.9 abc	56.3 abc	54.6 ab	35.0 abc	143.9 ab	94.6 abc
TAM 680	T	85.6 abc	44.2 bcdef	56.2 ab	26.3 bcde	165.0 a	65.6 cdefg
Funks HW 1761	T	82.8 abc	43.7 bcdef	54.9 ab	26.6 bcde	163.0 ab	68.6 bcdefg
DeKalb B 35		80.9 abcd	37.1 cdefg	51.5 ab	22.0 de	141.9 ab	54.1 defg
NB 505		78.3 bcd	28.1 fg	48.9 bc	17.2 e	130.8 bcd	44.5 g
RS 671		77.9 bcd	38.0 cdefg	51.4 ab	21.8 de	152.0 ab	51.7 efg
TAM 670	T	73.0 cd	50.2 abcde	46.7 bc	31.0 abcd	130.6 bcd	82.0 abcd
RS 610 A		72.8 cd	39.7 cdefg	47.2 bc	23.3 de	134.6 abc	57.1 defg
B Redlan		62.9 de	35.8 defg	39.3 cd	22.2 de	105.1 cde	58.2 defg
TAM 430	T	51.4 ef	39.8 cdefg	33.7 d	25.2 cde	100.6 de	68.6 bcdefg
TAM 428	T	47.7 ef	34.3 efg	32.6 d	24.0 cde	103.5 cde	79.9 abcde
TAM 618		43.7 f	22.8 g	29.3 d	15.4 e	89.1 e	48.4 fg

TABLE XIX (Continued)

Entry		Grain/Day From PL to MB		Grain/Day From PL to BL		Grain/Day From MB to BL	
		1977	1978	1977	1978	1977	1978
		Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha
Redlan X TAM 430	T		54.9 abcd		32.3 abcd		78.8 abcde
TX 618 X TAM 430	T		50.5 abcde		30.2 abcd		76.0 abcdef
TX 623	T		48.6 abcde		31.9 abcd		93.8 abc
TX 623 X TAM 428	T		46.3 abcdef		31.0 abcd		94.2 abc
Temperate Hybrid Means[2]		86.5	47.3	54.5	28.0	148.7	69.6
Tropically Adopted Hybrid Means[2]		85.6	50.9	54.6	31.2	151.6	82.2*

[1]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghums

* = Significant from temperate hybrid means at .05 level of probability

TABLE XX

MEANS FOR DRY MATTER ACCUMULATIONS PER DAY FOR DIFFERENT GROWTH PERIODS, AVERAGE OVER LOCATIONS, 1977 & 1978

Entry		Grain/Day From PL to MB 1977[1]	Grain/Day From PL to MB 1978[2]	Grain/Day From PL to BL 1977[1]	Grain/Day From PL to BL 1978[3]	Grain/Day From MB to BL 1977[1]	Grain/Day From MB to BL 1978[3]
		Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha
Funks G 722 DR	T	82.2 a	78.6 bcd	54.9 a	51.5 abc	167.8 a	175.2 a
NB 691		80.9 a	79.4 bcd	51.9 a	49.5 abcd	147.0 bc	149.2 abcd
A 399 X TAM 2567		79.9 a	78.8 bcd	53.0 a	47.5 abcde	166.1 ab	125.6 cdefg
Funks HW 1761	T	79.5 a	86.0 ab	53.6 a	53.6 ab	164.6 ab	154.9 abc
Funks HW 1760	T	76.0 ab	83.9 abc	50.2 ab	51.4 abc	149.5 abc	161.5 ab
RS 671		73.0 abc	64.2 efg	48.9 abc	43.3 cdefg	149.2 abc	133.6 bcdef
TX 622 X TAM 430	T	68.3 bcd	93.1 a	44.2 bcd	55.7 a	126.5 de	150.7 abcd
TAM 680	T	66.9 bc	82.2 abc	44.5 bcd	50.7 abc	133.2 bc	152.5 abcd
TS 610 A		66.4 bc	68.1 def	44.7 bcd	39.0 efg	139.9 bc	110.5 fgh
DeKalb B 35		65.4 bc	72.5 cde	43.1 bc	43.4 bcdefg	129.3 cde	111.0 fgh
TAM 670	T	65.2 cd	77.1 bcd	43.2 dc	44.0 bcdefg	129.1 cde	127.5 cdef
NB 505		62.8 d	54.8 gh	40.1 d	34.5 gh	111.9 ef	93.8 gh
B Redlan		52.3 e	55.5 gh	34.4 e	40.0 defg	102.0 f	120.3 defg
TAM 430	T	39.1 f	51.7 hi	26.2 f	40.0 defg	80.4 g	111.9 fgh
TAM 618		36.8 f	39.4 j	25.2 f	27.8 h	81.2 g	86.2 h
TAM 428	T	34.9 f	42.2 ij	24.3 f	36.3 fgh	80.8 g	114.7 efgh

TABLE XX (Continued)

Entry		Grain/Day From PL to MB 1977[1]	Grain/Day From PL to MB 1978[2]	Grain/Day From PL to BL 1977[1]	Grain/Day From PL to BL 1978[2]	Grain/Day From MB to BL 1977[1]	Grain/Day From MB to BL 1978[2]
		Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha	Kg/ha
Redlan X TAM 430	T		85.8 ab		51.9 abc		143.2 abcdef
TX 618 X TAM 430	T		81.3 abc		46.0 abcdef		125.5 cdefg
TX 623 X TAM 428	T		71.7 cde		48.7 abcde		146.8 abcde
TX 623	T		58.7 fgh		44.3 bcdefg		133.3 bcdef
Temperate Hybrid Means[5]		75.1	72.6	49.6	44.8	150.6	129.7
Tropically Adapted Hybrid Means[5]		73.0	82.2**	48.4	50.4**	145.1	148.6**

[1]Mean of all locations in 1977

[2]Mean of all locations except Perkins in 1978

[3]Mean of only Goodwell and Isabela in 1978

[4]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[5]Only medium and late maturing hybrids

T = Tropically adapted grain sorghums

** = Significant from temperate hybrid means at .01 level of probability

In 1978, the tropically adapted hybrids produced more grain yield per day for all of the different growth periods than did the temperate hybrids.

Tables LI, LII, LIII, LVI, and LVII in the Appendix show that all interactions between variety x location in 1977 and 1978, and between year x location, variety x location, year x variety, and year x variety x location were significant for dry matter accumulations per day for all the different growth periods. These significant interactions suggested that the different year and location had a completely different effect on the different sorghum entries.

Forage Study

Table XXI shows the stover dry weight, stover moisture percentage and grain/stover ratio. There were significant differences among the varieties for the above variables (Table XLVIII in the Appendix). Because all of these entries were harvested about two weeks after black layer, there was little variability among them for moisture percentage. There was no significant difference found in moisture percentage between temperate and tropically adapted hybrids.

Stover dry weights had great variability from one variety to another. The range of weights was from 2276 to 7847 kg/ha. The tropically adapted hybrids had much more stover than temperate hybrids because they were taller and had more leaves and larger leaves. This resulted in a grain/stover ratio for the tropical hybrids of 0.85 as compared with 1.00 for the temperate hybrids.

The stover dry weight accumulations per day for the different growth periods are listed in Table XXII. The differences among

TABLE XXI

MEANS FOR STOVER DRY WEIGHTS, MOISTURE PERCENTAGE, AND GRAIN/STOVER RATIOS AT PERKINS, OKLAHOMA, 1977

Entry		Stover Dry Weight	Stover Moisture	Grain/Stover Ratio
		Kg/ha	%	
TAM 430	T	7847 a[1]	69.0 abc	0.20 g
TAM 428	T	7261 a	68.8 abc	0.10 g
TX 622 X TAM 430	T	6367 b	68.8 abc	0.60 f
TAM 618		6113 bc	70.7 ab	0.17 g
Funks HW 1760	T	5412 cd	68.5 abc	0.94 bcd
Funks G 722 DR	T	4977 de	68.4 abc	0.90 d
Funks HW 1761	T	4606 ef	65.8 c	0.88 de
TAM 670	T	4449 efg	70.7 ab	0.86 de
RS 671		4384 efg	68.0 bc	0.87 de
TAM 680	T	4008 fg	70.4 ab	0.92 cd
NB 691		3913 fg	68.6 abc	1.09 ab
DeKalb B 35		3854 fg	72.1 a	0.87 de
A 399 X TAM 2567		3709 g	69.6 ab	1.05 abc
B Redlan		3673 g	71.8 ab	0.72 ef
RS 610 A		3646 g	68.1 bc	0.99 abcd
NB 505		2276 h	70.3 ab	1.13 a
Temperate Hybrid Means[2]		3913	68.6	1.00
Tropically Adapted Hybrid Means[2]		4970**	68.8	0.85**

[1]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghum

** = Significant from temperate hybrid means at .01 level of probability

TABLE XXII

MEANS FOR STOVER DRY WEIGHT ACCUMULATION PER DAY FOR DIFFERENT GROWTH PERIODS AT PERKINS, OKLAHOMA, 1977

Entry		Stover/Day from PL to MB	Stover/Day from PL to BL	Stover/Day from MB to BL
		Kg/ha	Kg/ha	Kg/ha
TAM 430	T	118.3 a[1]	79.3 a	240.6 ab
TAM 428	T	110.0 ab	78.1 ab	270.2 a
TX 622 X TAM 430	T	109.0 ab	70.5 bc	200.2 c
TAM 618		103.4 bc	67.9 cd	196.5 c
Funks HW 1760	T	91.8 cd	63.4 cde	205.3 c
Funks G 722 DR	T	85.5 de	60.1 def	202.2 c
TAM 670	T	82.2 def	54.8 efgh	164.5 de
Funks HW 1761	T	82.0 def	56.3 efg	179.9 cd
RS 671		81.6 def	54.1 fgh	161.1 def
DeKalb B 35		76.8 efg	49.8 ghi	141.8 efg
TAM 680	T	75.3 efg	49.6 ghi	145.2 efg
NB 691		75.2 efg	48.3 ghi	134.9 fg
A 399 X TAM 2567		71.6 efg	46.5 hi	132.3 g
RS 610 A		69.1 fg	45.6 hi	114.0 fg
B Redlan		65.8 g	43.2 i	125.7 g
NB 505		47.4 h	29.9 j	81.3 h
Temperate Hybrid Means[2]		74.4	48.6	140.6
Tropically Adapted Hybrid Means[2]		87.6**	59.1**	182.9**

[1]Means followed by the same letter in same column do not differ significantly at .05 level of probability

[2]Only medium and late maturing hybrids were used

T = Tropically adapted grain sorghum

** = Significant from temperate hybrid means at .01 level of probability

varieties were significant for all of these variables (Table XLIX in the Appendix). Tropically adapted hybrids produced more stover dry weight per day than temperate hybrids from planting to mid-bloom, planting to black layer and from mid-bloom to black layer.

Correlations between grain yield and other variables at each location are listed in Tables XLVI and XLVII in the Appendix for 1977 and 1978, respectively. Significant negative correlations existed between grain yield and days to mid-bloom at Isabela in 1977 and at Perkins, College Station, and Isabela in 1978. This indicated that the early flowering hybrids yielded more than late flowering hybrids. There were no significant correlations between days to black layer and grain yield, with one exception, which indicated that maturity was not necessarily related to grain yield. The one exception was at Perkins in 1978 where, because of drought, the early maturity types had a better chance to survive and produce some grain yield.

Correlations between grain yield and days from mid-bloom to black layer were not significant in 1977. In 1978 these correlations were positive and significant at Perkins and Isabela. In both of these locations the grain yield in 1978 was lower than in 1977 because of environmental conditions, and hybrids with longer grain filling durations had a better chance to transfer photosynthate to the kernels.

The correlations between plant height and grain yield were positive and significant at Goodwell and at Isabela in 1977. There were positive correlations between grain yield and threshing percent at most locations in 1977 and 1978. Significant positive correlations were obtained at four of the six locations between grain yield and test weight. This indicated that the better yielding hybrids usually have a better quality of grain, also. The correlations between grain yield and dry matter accumulations per day for all the different growth periods were positive and significant, but these correlations are difficult to interpret.

No signification correlation existed between stover dry weight and grain yield which means selecting hybrids for high grain yield will not necessarily give high forage production.

Physiologic Maturity

Table LVIII and LIX in the Appendix show the analyses of variance for kernel dry weight and moisture percentage in 1977 and 1978, respectively. The effect of variety and day and the interaction between variety x day were significant for kernel dry weight and kernel moisture percentage. In order to reduce the effect of kernal size which is known to be different among varieties, an analysis of variance was conducted for the ratio of kernel dry weight to kernel dry weight at black layer stage (day 0) for each hybrid. Therefore, the data for kernel dry weight which is presented in Tables XXIII and XXIV were computed on the basis of this ratio and were multiplied by 100.

The analyses of variance for this ratio (Table LX in the Appendix) indicated that the differences among the varieties were not significant in 1977. In 1978 the differences among varieties were still significant even by using the ratio instead of the actual dry weights. The variety x day interaction was significant for both years which indicated that the dry weight of kernels for each variety was different, relative to the black layer stage. This suggested that the day on which the maximum dry weight occurred was different among varieties.

TABLE XXIII

MEANS OF PERCENTAGES OF KERNEL DRY WEIGHT IN RESPECT TO DRY WEIGHT AT BLACK LAYER STAGE, PERKINS, OKLAHOMA, 1978

Entry	Days From Black Layer									
	-4	-3	-2	-1	0	1	2	3	4	5
NB 505	84.6 g[1]	86.6 fg	93.9 ef	98.5 de	100.0 cde	101.0 bcde	106.7 abcd	110.5 ab	115.5 a	109.0 abc
DeKalb B 35	86.2 g	87.7 fg	93.1 ef	97.2 de	100.0 cd	104.5 bc	109.8 b	109.8 b	117.0 a	117.4 a
RS 610 A	92.7 d	97.5 c	99.2 bc	97.9 c	100.0 bc	103.0 ab	104.7 a	104.5 a	105.1 a	105.7 a
A 399 X TAM 2567	87.4 c	92.3 b	94.6 b	95.0 b	100.0 a	100.1 a	100.7 a	103.0 a	101.3 a	101.2 a
TAM 618	90.3 f	95.2 de	94.8 e	97.1 cde	100.0 bc	99.3 bcd	102.5 ab	106.7 a	102.7 ab	102.1 b
TAM 670	88.3 d	94.6 c	97.2 bc	97.1 bc	100.0 abc	102.4 ab	104.6 a	105.0 a	100.3 abc	101.0 ab
TX 622 X TAM 430	92.9 c	95.4 bc	99.3 ab	99.5 ab	100.0 ab	99.1 ab	99.8 ab	103.0 a	103.1 a	103.0 a
TAM 428	97.1 b	99.4 ab	101.1 a	102.8 a	100.0 ab	100.8 a	100.3 ab	100.0 ab	102.3 a	101.7 a
TAM 430	93.8 e	96.9 d	95.9 de	98.3 cd	100.0 bc	102.6 ab	100.6 bc	103.3 a	104.0 a	103.7 a
RS 671	88.2 c	93.9 b	91.9 bc	93.3 bc	100.0 a	99.0 a	103.6 a	104.0 a	103.5 a	102.5 a
NB 691	84.3 d	89.2 cd	93.2 bc	96.3 b	100.0 b	100.2 b	108.6 a	108.5 a	109.8 a	112.0 a
B Redlan	82.2 d	87.5 c	88.3 c	96.8 b	100.0 ab	100.7 ab	101.6 a	98.6 ab	99.6 ab	103.0 a
TAM 680	90.2 d	94.8 cd	98.1 bc	100.3 ab	100.0 ab	102.8 ab	100.6 ab	104.2 a	101.3 ab	100.0 ab
Funks G 722 DR	85.1 e	86.4 e	88.1 e	97.5 d	100.0 cd	101.7 abc	100.6 bcd	104.2 a	102.5 abc	103.8 ab
Funks HW 1760	77.1 f	81.4 f	87.9 e	94.6 d	100.0 cd	100.1 bcd	102.2 bc	105.1 abc	106.4 ab	109.5 a
Funks HW 1761	91.8 d	94.3 cd	97.2 cd	95.6 cd	100.0 bc	104.9 ab	106.6 ab	104.4 ab	108.5 a	105.1 ab

[1]Means with same letter in same row are not significantly different. Duncan's Multiple Range Test was computed from actual data.

TABLE XXIV

MEANS OF PERCENTAGE OF KERNEL DRY WEIGHT IN RESPECT TO DRY WEIGHT AT BLACK LAYER STAGE, 1978

Entry	Days From Black Layer				
	-4	-2	0	2	4
NB 505	85.0 d[1]	91.5 c	100.0 b	104.0 a	105.1 a
DeKalb B 35	81.2 d	87.8 c	100.0 b	105.5 a	107.5 a
RS 610 A	80.0 c	93.9 b	100.0 a	102.8 a	103.2 a
A 399 X TAM 2567	80.4 d	95.5 c	100.0 b	109.0 a	105.7 a
TAM 618	94.7 b	101.7 a	100.0 a	98.5 ab	97.3 ab
TAM 670	90.6 b	98.6 a	100.0 a	101.0 a	101.3 a
TX 622 X TAM 430	86.7 b	100.1 a	100.0 a	101.5 a	101.1 a
RS 671	84.9 c	94.1 b	100.0 a	105.8 a	105.2 a
NB 691	75.1 c	93.0 b	100.0 a	103.0 a	101.9 a
B Redlan	95.6 c	99.9 bc	100.0 bc	104.5 ab	108.1 a
TAM 680	79.7 c	88.2 b	100.0 a	99.3 a	102.6 a
Redlan X TAM 430	96.6 c	104.3 ab	100.0 bc	107.0 ab	110.7 a

[1]Means with the same letter in same row are not significantly different. Duncan's Multiple Range Test was computed from actual data.

The day on which the maximum dry weight occurred was determined when there was no significant increase in kernel dry weight observed, compared to the preceding day or days for each variety.

Tables XXIII and XXIV show that the maximum dry weight production occurred between three days before to four days after black layer in 1977, and two days before to two days after black layer in 1978. Eight of 16 varieties in 1977, and nine of 12 varieties in 1978, reached their maximum dry weight accumulation at black layer stage or at one day after. The variation among the varieties in 1978 was much less than in 1977, which was the result of severe drought that year.

It was obvious that black layer was a good indication of physiologic maturity for most sorghums in this study. However, some very early maturing hybrids reached their physiologic maturity 3 to 4 days after black layer.

The moisture percentages varied from 27.6 to 38.4 in 1977 and from 26.8 to 38.7 in 1978 at black layer stage (Tables XXV and XXVI). This suggested that the black layer formation was not completely related to moisture content of the kernel. Also by looking at the moisture percentage on the day on which each variety reached its maximum dry weight, the variation of 26.6 to 34.5% in 1977 and 28.9 to 38.7% in 1978 can be observed. This indicated that the moisture content of the kernel is also not a good indication of maximum dry weight.

TABLE XXV

MEANS OF KERNEL MOISTURE PERCENTAGE BEFORE, DURING, AND AFTER BLACK LAYER STAGE, PERKINS, OKLAHOMA, 1977

	Days From Black Layer									
Entry	-4	-3	-2	-1	0	1	2	3	4	5
NB 505	41.1 a[1]	40.3 a	37.5 b	35.7 c	34.2 d	32.5 e	30.0 f	26.4 g	39.9 h	17.3 i
DeKalb B 35	46.5 a	45.7 a	42.6 b	41.3 e	38.4 d	34.6 e	33.4 e	30.8 f	26.6 g	21.6 h
RS 610 A	39.7 a	36.4 b	34.0 c	30.2 d	28.3 d	28.3 d	24.4 e	22.0 f	18.7 g	14.7 h
A 399 X TAM 2567	36.3 a	35.2 a	32.4 b	28.5 c	28.0 c	27.0 c	22.6 d	21.6 d	18.5 e	14.6 f
TAM 618	40.2 a	36.7 b	35.1 bc	33.6 cd	31.4 d	29.2 e	28.4 ec	27.6 ef	26.8 fg	25.3 g
TAM 670	37.8 a	34.9 b	31.0 c	29.1 a	28.4 d	28.2 d	25.7 e	24.2 e	21.7 f	17.1 g
TX 622 X TAM 430	39.0 a	36.1 b	35.1 b	31.9 c	28.9 d	28.6 d	27.7 d	26.8 de	25.3 e	22.2 f
TAM 428	36.9 a	36.3 ab	34.5 b	30.6 c	29.4 c	27.4 d	25.4 e	27.6 d	24.8 e	24.1 e
TAM 430	39.8 a	37.8 a	35.0 b	31.6 c	31.0 c	29.8 cd	28.5 de	27.7 de	27.0 e	26.7 e
RS 671	41.5 a	39.1 b	35.9 c	32.7 d	31.1 de	30.2 e	26.7 f	24.6 f	21.1 g	15.8 h
NB 691	42.9 a	40.7 ab	39.6 b	36.8 c	33.6 d	31.7 de	29.9 ef	29.2 f	25.5 g	24.2 g
B Redlan	39.8 a	36.0 b	34.7 b	34.3 b	30.1 c	28.6 cd	27.3 d	23.0 e	22.9 e	19.9 f
TAM 680	37.4 a	34.9 b	32.9 b	29.5 c	27.6 cd	27.0 d	23.0 e	20.1 f	18.9 f	15.6 g
Funks G 722 DR	38.0 a	35.0 a	35.5 bc	32.4 c	28.5 d	27.5 d	24.7 e	21.8 f	19.3 g	19.9 g
Funks HW 1760	39.7 a	38.3 a	35.5 b	33.4 c	30.4 d	28.3 e	27.2 e	23.1 f	20.9 g	20.9 g
Funks HW 1761	38.0 a	35.4 b	33.6 c	30.4 d	29.0 de	27.5 e	25.3 f	22.4 g	20.5 h	15.7 i

[1]Means with the same letter in same row are not significantly different

TABLE XXVI

MEANS OF KERNEL MOISTURE PERCENTAGES BEFORE, DURING AND AFTER BLACK LAYER STAGE, PERKINS, OKLAHOMA, 1978

	Days From Black Layer				
Entry	-4	-2	0	2	4
NB 505	41.9 a[1]	40.0 b	31.9 c	28.9 d	25.1 e
DeKalb B 35	45.7 a	44.2 a	35.9 b	31.9 c	27.9 d
RS 610 A	47.4 a	41.4 b	37.2 c	33.3 d	29.0 e
A 399 X TAM 2567	44.2 a	49.4 b	35.5 c	31.8 d	27.1 e
TAM 618	38.0 a	35.1 b	31.1 c	27.6 d	25.0 e
TAM 670	40.3 a	34.6 b	26.8 c	24.5 d	23.1 e
TX 622 X TAM 430	41.3 a	36.1 b	29.9 c	27.2 d	23.8 e
RS 671	46.9 a	43.3 b	38.7 c	34.9 d	25.6 e
NB 691	42.5 a	37.6 b	32.9 c	28.9 d	24.7 e
B Redlan	40.0 a	37.6 b	31.0 c	28.5 d	24.3 e
TAM 680	45.2 a	40.8 b	36.0 c	31.4 d	23.5 e
Redlan X TAM 430	41.3 a	37.4 b	30.7 b	28.4 b	24.5 d

[1]Means with the same letter in the same row are not significantly different

CHAPTER VI

SUMMARY AND CONCLUSIONS

Field studies were conducted to determine the performance of some temperate and tropically adapted grain sorghum hybrids at temperate, sub-tropical and tropical climates in two years. Sixteen and twenty grain sorghum hybrids in three maturity classes were selected for study in 1977 and 1978, respectively.

The experiment was arranged in a randomized complete block design with five replications. The experiment was conducted at Perkins and Goodwell, Oklahoma, and at Isabela, Puerto Rico, in 1977. In 1978 the experiment was grown at College Station, Texas, in addition to the other three locations.

With certain exceptions, data were collected for date of mid-bloom, date of black layer formation, plant height, head weight, grain yield, and test weight. This made it possible to study days to mid-bloom, days to black layer formation, days from mid-bloom to black layer, threshing percent, grain yield per day from planting to mid-bloom, grain yield from planting to black layer, grain yield from mid-bloom to black layer, and the other variables directly. In 1977 the stover dry weight, stover moisture content, stover dry weight per day for the different growth periods and grain/stover ratio were studied in addition to the above data.

In 1977 and 1978 at the Perkins location, a study was conducted to determine physiologic maturity in relation to black layer formation by utilizing the same entries which were used in the first and second year of the study. Randomly selected plants were tagged 4 days before black layer for notation and a sample of kernels was taken from the middle of the panicle. Sampling was continued from the middle of the panicle of the selected plants every day for ten days in 1977, and every other day for nine days in 1978. The moisture percentage and dry weight of 100 kernels were determined for each sample.

The results showed that the length of the different growth periods varied from one location to another and from one year to the next year. The temperature, moisture, and day length affected these periods. The plants flowered and matured faster when they were moved from the temperate area (Goodwell) to the tropical area (College Station and Isabela). In contrast, the grain filling period increased when the hybrids were moved from the temperate to the tropical areas. At the Perkins location, drought and high temperatures during these studies caused the plants to flower and mature faster than at any other location. In general, tropically adapted hybrids flowered and matured later, and had longer grain filling periods than temperate hybrids.

Plant heights, threshing percent, and test weight varied in different locations and in different climates. In general, tropically adapted hybrids were taller and had better test weight than temperate hybrids, while the differences between threshing percent for these two groups was not significant either year in most of the locations.

No difference was found for grain yield between temperate and tropically adapted hybrids in 1977 at Goodwell. The highest yield was obtained by two tropically adapted hybrids and one temperate hybrid. In 1978 the tropically adapted hybrids produced more grain yield than the temperate one in this location. The higher grain yield was obtained with tropically adapted hybrids at Perkins in 1977. In 1978, because of severe drought, both groups yielded much lower than in 1977, and the difference was not significant. At College Station, the tropically adapted hybrids produced much more grain yield than the temperate hybrids, which confirmed the adaptability of these hybrids to this location. No difference was found at Isabela between temperate and tropically adapted hybrids in either year.

In general, more differences were found among individual entries in a test than when comparing groups of the sorghum hybrids. It was suggested that in each location the high yielding individual entry must be selected regardless of its adaptability to temperate or tropical climate.

The dry weight accumulations per day for the period from planting to mid-bloom was higher for tropically adapted hybrids than temperate hybrids at Goodwell and College Station in 1978, but did not differ significantly in other locations in 1977 and 1978. The differences between temperate and tropically adapted hybrids for dry matter accumulations per day from planting to black layer were not significant except at Goodwell in 1978. Tropically adapted hybrids had higher dry weight accumulations per day from mid-bloom to black layer than temperate hybrids at Goodwell and Isabela in 1978 and at Perkins in 1977. In 1977, it was lower in tropically adapted hybrids than temperate hybrids at Goodwell.

Stover dry weight, grain/stover ratio and dry stover weight per day from all different growth periods were higher in tropically adapted hybrids than temperate hybrids. No difference was found between these two groups for stover moisture content.

The maximum dry weight production occurred between 3 days before to 4 days after black layer formation in 1977, and 2 days before to 2 days after black layer formation in 1978. Black layer was a good and almost precise indication of physiologic maturity. However, there were some variations in each variety in different years, and in general, the very early hybrids matured about 3 days after black layer formation. The moisture content of the kernels at both maximum dry weight and black layer stage in different entries was not constant and had variations of about 10 percent. Thus, moisture percentage was not a good indication of physiologic maturity in these materials.

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APPENDIX

TABLE XXVII

SOURCES OF SORGHUM SEEDS

Entry	Pedigree	1977	1978
NB 505	Martin x NB 3494	Nebraska	Nebraska
DeKalb B 35	---	Nebraska	Nebraska
RS 610 A	TX 618 x TX 422	Texas	77-2281 x 2282
A 399 x TAM 2567	A 399 x TAM 2567	Texas	77-2293 x 2294
RS 671	Redlan x TX 415	Nebraska	Nebraska
NB 691	Redlan x NB 9040	Nebraska	Nebraska
TAM 618	Kafir derivative	Texas	77-2295
B Redlan	Kafir derivative	70-2082	75-2082
TAM 670	TX 618 x TAM 428	Texas	77-2279 x 2280
TAM 680	Redlan x TAM 428	Texas	77-2285 x 2286
Funks HW 1761	---	Funks	Funks
Funks G 722 DR	---	Funks	Funks
Funks HW 1760	---	Funks	Funks
TX 622 x TAM 430	TX 622 x TAM 430	Texas	78-2283 x 2284
TX 618 x TAM 430	TX 618 x TAM 430		77-2287 x 2288
Redlan x TAM 430	Redlan x TAM 430		77-2285 x 2284
TX 623 x TAM 428	TX 623 x TAM 428		77-2291 x 2292
TX 623	(TX 3197 x SC 0170-6-4-4) -731321		77-2291
TAM 428	SC 110-9	74-2291	77-2280
TAM 430	(SC 175 x TX 2536) derivative	Texas	77-2284

TABLE XXVIII

CLIMATOLOGICAL DATA AT GOODWELL, OKLAHOMA,[1] FOR 1977

Month	Mean Monthly Day Length[2]	Mean Monthly Temperature				Monthly Precipitation	
		Maximum	Minimum	Average	Departure From Normal	Total	Departure From Normal
	hr	°C	°C	°C	°C	cm	cm
Jan.	10.3	2.9	-11.8	- 4.4	- 6.3	0.9	0.1
Feb.	11.0	13.9	- 4.9	4.5	0.4	0.1	-1.1
Mar.	12.0	17.1	- 2.1	7.5	0.6	1.1	-0.6
Apr.	13.5	20.1	6.5	13.3	- 0.1	12.3	9.5
May	14.4	25.7	11.7	18.7	0.2	11.3	5.0
Jun.[3]	15.0	32.9	16.6	24.8	1.1	2.1	-5.1
Jul.[3]	15.0	34.6	19.0	26.8	0.6	5.3	-3.5
Aug.[3]	14.4	31.0	17.4	24.2	- 1.3	13.8	6.8
Sep.[3]	13.5	30.1	13.2	21.6	0.4	3.0	-0.9
Oct.[3]	12.0	23.2	5.1	14.2	- 0.9	0.3	-3.5
Nov.	11.0	16.1	- 2.1	7.0	- 0.3	1.63	0.3
Dec.	10.3	12.0	- 6.5	2.8	- 0.2	0.1	-9.0

[1]Climatological Data, Oklahoma. National Oceanic and Atmospheric Administration, Environmental Data Service Publication Vol. 86, 1977.

[2]Effective day length estimated from Francis (18).

[3]Months in growth season.

TABLE XXIX

CLIMATOLOGICAL DATA AT PERKINS, OKLAHOMA, FOR 1977

Month	Mean Monthly Day Length[1]	Mean Monthly Temperature[2]				Monthly Precipitation[3]	
		Maximum	Minimum	Average	Departure From Normal	Total	Departure From Normal
	hr	°C	°C	°C	°C	cm	cm
Jan.	10.3	4.2	- 9.0	- 2.4	-5.2	0.6	-3.3
Feb.	10.9	14.4	- 1.7	6.4	0.8	3.0	-0.8
Mar.	12.0	18.6	3.8	11.2	1.8	6.4	0.8
Apr.	13.4	23.4	10.0	16.7	0.6	5.7	-2.4
May	14.3	28.2	16.3	22.3	1.9	21.5	8.6
Jun.[4]	14.9	32.8	20.4	26.6	1.6	4.8	-6.8
Jul.[4]	14.9	35.2	22.2	28.7	1.1	8.0	-0.8
Aug.[4]	14.3	32.9	21.5	27.2	- .2	7.3	-0.8
Sep.[4]	13.4	30.1	18.4	24.2	1.3	4.5	-5.2
Oct.	12.0	24.8	9.1	16.9	-0.2	3.2	-5.0
Nov.	10.9	17.1	4.7	10.9	1.2	3.9	-0.9
Dec.	10.3	11.2	- 2.8	4.2	-0.1	1.0	-2.6

[1]Effective day length. Estimated from Francis (18).

[2]Climatological Data, Oklahoma. National Oceanic and Atmospheric Administration, Environmental Data Service Publication Vol. 86, 1977.

[3]Data from Agricultural Experiment Station, Oklahoma State University.

[4]Months in growth season.

TABLE XXX

CLIMATOLOGICAL DATA AT ISABELA, PUERTO RICO,[1] FOR 1977

Month	Mean Monthly Day Length[2]	Mean Monthly Temperature				Monthly Precipitation	
		Maximum	Minimum	Average	Departure From Normal	Total	Departure From Normal
	hr	°C	°C	°C	°C	cm	cm
Jan.	11.2	27.7	17.8	22.8	-0.3	14.4	5.2
Feb.	11.5	27.9	17.0	22.5	-0.6	1.4	-6.2
Mar.	12.0	28.5	17.7	23.1	-0.6	8.0	0.2
Apr.	13.0	28.1	18.5	23.3	-1.0	5.1	-8.8
May	13.5	29.6	19.6	24.6	-0.5	16.2	-2.0
Jun.[3]	13.8	29.9	20.9	25.4	-0.3	10.5	-7.3
Jul.[3]	13.8	29.1	20.9	25.0	-1.2	11.7	-0.3
Aug.[3]	13.5	30.5	21.5	26.0	-0.2	13.5	-1.9
Sep.[3]	13.0	30.1	20.8	25.5	-0.5	8.5	-7.2
Oct.[3]	12.0	29.7	20.9	25.3	-0.4	18.7	3.2
Nov.	11.5	29.3	19.9	24.6	-0.3	23.5	8.4
Dec.	11.2	28.8	19.0	23.9	0.1	2.2	-10.2

[1] Climatological Data, Puerto Rico. National Oceanic and Atmospheric Administration, Environmental Data Service Publication Vol. 23, 1977.

[2] Effective day length estimated from Francis (18).

[3] Months in growth season.

TABLE XXXI

CLIMATOLOGICAL DATA AT GOODWELL, OKLAHOMA, FOR 1978

Month	Mean Monthly Day Length[2]	Mean Monthly Temperature				Monthly Precipitation	
		Maximum	Minimum	Average	Departure From Normal	Total	Departure From Normal
	hr	°C	°C	°C	°C	cm	cm
Jan.	10.3	3.1	-10.8	- 3.9	-5.7	0.3	-0.5
Feb.	11.0	1.8	-10.7	- 4.4	-8.6	2.2	0.9
Mar.	12.0	15.1	- 1.1	7.0	0.1	0.6	-1.1
Apr.	13.5	23.7	5.3	14.5	1.1	1.5	-1.37
May	14.4	22.8	9.0	15.9	-2.6	15.6	9.3
Jun.[3]	15.0	20.3	15.9	23.1	-0.6	6.7	-0.2
Jul.[3]	15.0	34.7	18.8	26.8	1.1	3.2	-5.6
Aug.[3]	14.4	32.5	16.3	24.4	-1.1	0.1	-7.0
Sep.[3]	13.5	29.2	13.3	21.2	0	3.8	-0.1
Oct.[3]	12.0	23.3	5.4	14.4	-0.7	1.1	-2.7
Nov.	11.0	12.3	0.4	6.4	-0.9	2.0	0.6
Dec.	10.3	7.4	-8.7	- 0.6	-3.6	0.4	-0.7

[1] Climatological Data, Oklahoma. National Oceanic and Atmospheric Administration, Environmental Data Service Publication Vol. 87, 1978.

[2] Effective day length estimated from Francis (18).

[3] Months in growth season.

TABLE XXXII

CLIMATOLOGICAL DATA AT PERKINS, OKLAHOMA, FOR 1978

Month	Mean Monthly Day Length[1]	Mean Monthly Temperature[2]				Monthly Precipitation[3]	
		Maximum	Minimum	Average	Departure From Normal	Total	Departure From Normal
	hr	°C	°C	°C	°C	cm	cm
Jan.	10.3	1.2	- 9.6	- 4.2	7.0	2.3	1.6
Feb.	10.9	1.9	- 7.1	- 2.6	-8.1	6.7	3.0
Mar.	12.0	15.0	0.9	8.0	-1.3	3.7	-1.9
Apr.	13.4	24.2	10.2	17.2	1.1	4.7	-3.3
May	14.3	25.2	13.8	19.5	-0.8	18.5	5.6
Jun.[4]	14.9	30.2	19.4	24.8	-0.2	11.7	0.1
Jul.[4]	14.9	36.8	22.2	29.5	1.8	2.3	-6.5
Aug.[4]	14.3	34.3	20.2	27.3	0.1	1.4	-6.7
Sep.[4]	13.4	31.8	18.9	25.4	2.4	1.2	-8.5
Oct.	12.0	25.1	7.1	16.1	-1.1	5.0	-3.2
Nov.	10.9	16.1	4.4	10.3	0.6	9.4	4.6
Dec.	10.3	9.9	- 4.3	2.8	-1.7	Trace	-3.6

[1]Effective day length. Estimated from Francis (18).

[2]Climatological Data, Oklahoma. National Oceanic and Atmospheric Administration, Environmental Data Service Publication Vol. 87, 1978.

[3]Data from Agricultural Experiment Station, Oklahoma State University, at Perkins Station.

[4]Months in growth season.

TABLE XXXIII

CLIMATOLOGICAL DATA AT COLLEGE STATION, TEXAS,[1] FOR 1978

Month	Mean Monthly Day Length[2]	Mean Monthly Temperature				Monthly Precipitation	
		Maximum	Minimum	Average	Departure From Normal	Total	Departure From Normal
	hr	°C	°C	°C	°C	cm	cm
Jan.	10.6	8.9	0.5	4.7	-5.4	9.5	3.0
Feb.	11.1	12.1	2.4	7.3	-4.9	7.2	-0.8
Mar.	12.0	21.1	8.2	14.7	-0.6	6.5	-0.1
Apr.[3]	13.4	26.3	15.4	20.9	0.6	5.3	-5.3
May[3]	14.0	31.0	19.6	25.3	1.3	5.8	-5.3
Jun.[3]	14.4	33.8	22.5	28.2	0.7	6.4	-2.9
Jul.[3]	14.4	36.6	24.1	30.4	1.2	1.4	-5.2
Aug.[3]	14.0	36.4	23.1	30.0	0.8	1.5	-5.2
Sep.	13.4	31.3	22.1	26.7	0.6	13.5	2.9
Oct.	12.0	27.8	14.3	21.1	-0.1	0.9	-6.8
Nov.	11.1	21.5	11.8	16.7	1.4	15.6	7.6
Dec.	10.6	15.2	4.2	9.7	-1.8	7.3	0.9

[1]Climatological Data, Texas. National Oceanic and Atmospheric Administration, Environmental Data Service Publication Vol. 83, 1978.

[2]Effective day length. Estimated from Francis (18).

[3]Months in growth season.

TABLE XXXIV

CLIMATOLOGICAL DATA AT ISABELA, PUERTO RICO,[1] FOR 1978

Month	Mean Monthly Day Length[2]	Mean Monthly Temperature				Monthly Precipitation	
		Maximum	Minimum	Average	Departure From Normal	Total	Departure From Normal
	hr	°C	°C	°C	°C	cm	cm
Jan.[3]	11.2	28.1	17.7	22.9	-0.1	7.6	- 1.5
Feb.	11.5	27.2	18.1	22.7	-0.4	17.9	10.2
Mar.	12.0	27.8	18.4	23.1	-0.6	10.3	2.6
Apr.	13.0	28.6	19.6	24.1	-0.2	21.4	7.5
May	13.5	29.3	19.9	24.6	-0.5	20.8	2.6
Jun.	13.8	29.7	20.7	25.2	-0.5	21.4	3.6
Jul.	13.8	30.2	21.4	25.8	-0.4	13.7	1.7
Aug.	13.5	30.2	21.6	25.9	-0.3	24.0	8.6
Sep.[3]	13.0	30.1	20.9	25.5	-0.6	18.2	2.5
Oct.[3]	12.0	29.8	20.1	25.0	-0.8	13.0	- 2.5
Nov.[3]	11.5	28.8	20.1	24.5	-0.5	5.6	- 9.5
Dec.[3]	11.2	28.3	18.7	23.5	-0.3	8.1	- 4.3

[1] Climatological Data, Puerto Rico. National Oceanic and Atmospheric Administration, Environmental Data Service Publication Vol. 24, 1978.

[2] Effective day length. Estimated from Francis (18).

[3] Months in growth season.

TABLE XXXV

ANALYSES OF VARIANCE FOR GROWTH PERIODS AT GOODWELL, OKLAHOMA, 1977 & 1978

Source	Year	d.f.	Days to Mid-Bloom		Days to Black Layer		Days From MB to BL	
			MS	OSL	MS	OSL	MS	OSL
Replication	1977	4	5.17	0.5032	1.73	0.6630	1.28	0.8797
	1978	4	5.54	0.6350	7.87	0.7208	8.15	0.6949
Variety	1977	15	86.34	0.0001	212.80	0.0001	57.53	0.0001
	1978	19	126.64	0.0001	241.08	0.0001	82.48	0.0001
Temperate vs. Tropical	1977	1	28.21	0.0360	509.60	0.0001	298.00	0.0001
	1978	1	25.23	0.0916	65.33	0.0409	9.36	0.4265
Error	1977	60	6.13		2.88		4.33	
	1978	76	8.65		18.66		14.64	

TABLE XXXVI

ANALYSES OF VARIANCE FOR GROWTH PERIODS AT PERKINS, OKLAHOMA, 1977 & 1978

Source	Year	d.f.	Days to Mid-Bloom		Days to Black Layer		Days From MB to BL	
			MS	OSL	MS	OSL	MS	OSL
Replication	1977	4	0.30	0.6619	0.40	0.2655	1.08	0.1253
	1978	4	3.73	0.1200	2.07	0.0285	2.19	0.2972
Variety	1977	15	131.01	0.0001	188.98	0.0001	24.03	0.0001
	1978	13	178.15	0.0001	202.45	0.0001	13.68	0.0001
Temperate vs. Tropical	1977	1	185.65	0.0001	126.75	0.0001	5.60	0.0028
	1978	1	102.08	0.0001	106.80	0.0001	0.05	0.8617
Error	1977	60	0.49		0.29		0.57	
	1978	52	1.94		0.70		1.74	

TABLE XXXVII

ANALYSES OF VARIANCE FOR GROWTH PERIODS AT ISABELA, PUERTO RICO, 1977 & 1978

			Days to Mid-Bloom		Days to Black Layer		Days From MB to BL	
Source	Year	d.f.	MS	OSL	MS	OSL	MS	OSL
Replication	1977	4	36.48	0.0001	23.56	0.0264	4.11	0.6162
	1978	4	21.58	0.0485	95.59	0.0001	44.72	0.0214
Variety	1977	15	144.48	0.0001	202.83	0.0001	30.45	0.0001
	1978	19	130.59	0.0001	113.77	0.0001	59.50	0.0001
Temperate vs. Tropical	1977	1	290.08	0.0001	563.07	0.0001	46.41	0.0079
	1978	1	54.16	0.0141	1.75	0.6875	75.38	0.0259
Error	1977	60	4.81		7.99		6.14	
	1978	76	8.59		10.73		14.59	

TABLE XXXVIII

ANALYSES OF VARIANCE FOR PLANT HEIGHT, THRESHING PERCENT AND TEST WEIGHT AT GOODWELL, OKLAHOMA, 1977 & 1978

Source	Year	d.f.	Plant Height		Threshing Percent		Test Weight	
			MS	OSL	MS	OSL	MS	OSL
Replication	1977	4	135.11	0.2247			1.11	0.7870
	1978	4	15.53	0.5588	102.57	0.2890	9.88	0.2925
Variety	1977	15	421.12	0.0001			8.93	0.0003
	1978	19	532.46	0.0001	154.64	0.0248	19.70	0.0024
Temperate vs. Tropical	1977	1	466.25	0.0283			35.00	0.0006
	1978	1	1264.27	0.0001	206.42	0.1139	35.45	0.0030
Error	1977	60	92.35				2.59	
	1978	76	20.60		80.72		7.83	

TABLE XXXIX

ANALYSES OF VARIANCE FOR PLANT HEIGHT, THRESHING PERCENT AND TEST WEIGHT AT PERKINS, OKLAHOMA, 1977 & 1978

Source	Year	d.f.	Plant Height		Threshing Percent		Test Weight	
			MS	OSL	MS	OSL	MS	OSL
Replication	1977	4	24.73	0.0099	5.36	0.9081	5.50	0.5588
	1978	4	54.84	0.0252	8.20	0.5328	11.29	0.5002
Variety	1977	15	275.47	0.0001	121.25	0.0001	163.30	0.0001
	1978	13	86.07	0.0001	105.84	0.0001	22.58	0.0884
Temperate vs. Tropical	1977	1	385.33	0.0001	61.65	0.0947	106.80	0.0003
	1978	1	227.07	0.0008	4.32	0.5199	17.76	0.2527
Error	1977	60	6.79		21.38		7.29	
	1978	52	18.06		10.29		13.28	

TABLE XL

ANALYSES OF VARIANCE FOR PLANT HEIGHT, THRESHING PERCENT AND TEST WEIGHT AT COLLEGE STATION, TEXAS, 1978

Source	d.f.	Plant Height		Threshing Percent		Test Weight	
		MS	OSL	MS	OSL	MS	OSL
Replication	4	242.99	0.0012	109.84	0.0206	4.02	0.3867
Variety	19	821.84	0.0001	278.04	0.0001	76.72	0.0001
Temperate vs. Tropical	1	1052.03	0.0001	90.03	0.1156	129.74	0.0001
Error	76	48.48		35.54		3.82	

TABLE XLI

ANALYSES OF VARIANCE FOR PLANT HEIGHT, THRESHING PERCENT AND TEST WEIGHT AT ISABELA, PUERTO RICO, 1977 & 1978

Source	Year	d.f.	Plant Height		Threshing Percent		Test Weight	
			MS	OSL	MS	OSL	MS	OSL
Replication	1977	4	277.68	0.0042	6.93	0.8760	18.11	0.7441
	1978	4	35.82	0.8402				
Variety	1977	15	803.20	0.0001	125.52	0.0001	86.48	0.0118
	1978	19	405.31	0.0001				
Temperate vs. Tropical	1977	1	514.83	0.0067	193.60	0.0052	203.36	0.0225
	1978	1	3.46	0.8537				
Error	1977	60	65.20		22.99		37.07	
	1978	76	101.06					

TABLE XLII

ANALYSES OF VARIANCE FOR GRAIN YIELD AND DRY MATTER ACCUMULATIONS PER DAY FOR THE DIFFERENT GROWTH PERIODS AT GOODWELL, OKLAHOMA, 1977 & 1978

Source	Year	d.f.	Grain Yield		Grain/Day From PL to MB		Grain/Day From PL to BL		Grain/Day From MB to BL	
			MS	OSL	MS	OSL	MS	OSL	MS	OSL
Replication	1977	4	116608.43	0.9739	33.86	0.9473	9.61	0.9805	45.53	0.9972
	1978	4	2302620.21	0.1787	374.99	0.2938	204.69	0.1786	2439.32	0.2168
Variety	1977	15	4516216.02	0.0001	771.77	0.0001	359.36	0.0001	4703.16	0.0001
	1978	19	5654606.04	0.0001	1099.73	0.0001	500.98	0.0001	7538.10	0.0001
Temperate vs. Tropical	1977	1	428122.96	0.5051	205.42	0.2986	277.80	0.0886	13462.83	0.0014
	1978	1	7244350.26	0.0270	1941.70	0.0127	864.18	0.0108	8875.20	0.0230
Error	1977	60	952108.20		186.87		92.70		1197.74	
	1978	76	1424231.88		279.99		126.58		1649.01	

TABLE XLIII

ANALYSIS OF VARIANCE FOR GRAIN YIELDS AND DRY MATTER ACCUMULATIONS PER DAY FOR DIFFERENT GROWTH PERIODS AT PERKINS, OKLAHOMA, 1977 & 1978

			Grain Yield		Grain/Day From PL to MB		Grain/Day From PL to BL		Grain/Day From MB to BL	
Source	Year	d.f.	MS	OSL	MS	OSL	MS	OSL	MS	OSL
Replication	1977	4	5769269.44	0.0060	194.97	0.0052	83.80	0.0053	714.63	0.0072
	1978	4	288632.38	0.0454	75.11	0.0564	36.82		427.41	0.0206
Variety	1977	15	7656351.02	0.0001	2647.68	0.0001	1200.00	0.0001	11892.61	0.0001
	1978	13	1556703.85	0.0001	491.00	0.0001	227.54	0.0001	2370.65	0.0001
Temperate vs. Tropical	1977	1	688323.00	0.0325	12.71	0.6064	13.22	0.4246	2395.84	0.0006
	1978	1	134535.36	0.2743	68.98	0.1386	31.40	0.1382	281.92	0.1534
Error	1977	60	143714.91		47.39		20.45		184.08	
	1978	52	110206.18		30.49		13.85		134.31	

TABLE XLIV

ANALYSES OF VARIANCE FOR DAYS TO MID-BLOOM, GRAIN YIELD AND DRY MATTER ACCUMULATION PER DAY AT COLLEGE STATION, TEXAS, 1978

Source	d.f.	Days to Mid-Bloom		Grain Yield		Grain/Day From PL to MB	
		MS	OSL	MS	OSL	MS	OSL
Replication	4	16.93	0.0001	1364517.69	0.2494	422.37	0.1272
Variety	19	63.34	0.0001	14375202.22	0.0001	3317.77	0.0001
Temperate vs. Tropical	1	28.45	0.0001	14018068.80	0.0003	2434.10	0.0016
Error	76	1.31		989903.65		227.76	

TABLE XLV

ANALYSES OF VARIANCE FOR GRAIN YIELDS AND DRY MATTER ACCUMULATIONS PER DAY FOR DIFFERENT GROWTH PERIODS AT ISABELA, PUERTO RICO, 1977 & 1978

Source	Year	d.f.	Grain Yield		Grain/Day From PL to MB		Grain/Day From PL to MB		Grain/Day From MB to BL	
			MS	OSL	MS	OSL	MS	OSL	MS	OSL
Replication	1977	4	493929.05	0.4281	296.28	0.1258	76.43	0.2953	181.14	0.8310
	1978	4	562213.42	0.4983	182.97	0.3922	94.86	0.1822	1082.08	0.0344
Variety	1977	15	3725419.17	0.0001	1469.79	0.0001	500.29	0.0001	2937.38	0.0001
	1978	19	2657737.86	0.0001	559.21	0.0002	199.99	0.0001	1523.36	0.0001
Temperate vs. Tropical	1977	1	1706302.08	0.0715	8.71	0.8150	0.08	0.9710	106.39	0.6440
	1978	1	1416763.28	0.1476	183.74	0.3100	144.59	0.1222	2171.59	0.0216
Error	1977	60	506730.26		157.66		60.62		493.16	
	1978	76	661825.43		175.92		59.18		394.37	

TABLE XLVI

ESTIMATED CORRELATION COEFFICIENTS BETWEEN GRAIN YIELD AND OTHER VARIABLES, 1977

Variables	Location		
	Goodwell	Perkins	Isabela
Days to Mid-Bloom	0.019	-0.103	-0.347**
Days to Black Layer	-0.056	0.005	-0.125
Days from MB to BL	-0.069	0.099	0.156
Plant Height	0.461**	0.116	0.395**
Threshing Percent		0.193	0.627**
Test Weight	0.443**	0.365**	0.465**
Yield/Day from PL to MB	0.990**	0.995**	0.980**
Yield/Day from PL to BL	0.995**	0.996**	0.979**
Yield/Day from MB to BL	0.940**	0.969**	0.895**
Stover Dry Weight		0.138	

** = Significant at .01 level of probability

TABLE XLVII

ESTIMATED CORRELATION COEFFICIENTS BETWEEN GRAIN YIELD AND OTHER VARIABLES, 1978

Variables	Goodwell	Perkins	College St.	Isabela
Days to Mid-Bloom	-0.096	-0.595**	-0.309**	-0.380**
Days to Black Layer	0.015	-0.391**		0.172
Days from MB to BL	0.089	0.380**		0.439**
Plant Height	-0.203	0.205	0.223	0.201
Threshing Percent	0.648**	0.464**	0.588**	
Test Weight	-0.205	0.182	0.318**	
Yield/Day from PL to MB	0.974**	0.992**	0.996**	0.985**
Yield/Day from PL to BL	0.978**	0.996**		0.990**
Yield/Day from MB to BL	0.819**	0.985**		0.916**

** = Significant at .01 level of probability

TABLE XLVIII

ANALYSES OF VARIANCE FOR STOVER DRY WEIGHT AND STOVER MOISTURE PERCENTAGE AT PERKINS, OKLAHOMA, 1977

		Stover Dry Weight		Stover Moisture Percentage	
Source	d.f.	MS	OSL	MS	OSL
Replication	4	831268.93	0.0473	10.21	0.1717
Variety	15	10909768.93	0.0001	12.82	0.0235
Temperate vs. Tropical	1	13400646.75	0.0001	0.45	0.7889
Error	60	324212.73		6.16	

TABLE XLIX

ANALYSES OF VARIANCE FOR STOVER DRY WEIGHT PER DAY FOR DIFFERENT GROWTH PERIODS AT PERKINS, OKLAHOMA, 1977

		Stover/Day From PL to MB		Stover/Day From PL to BL		Stover/Day From MB to BL	
Source	d.f.	MS	OSL	MS	OSL	MS	OSL
Replication	4	248.94	0.0432	116.60	0.0372	1118.54	0.0335
Variety	15	1730.14	0.0001	879.98	0.0001	11443.81	0.0001
Temperate vs. Tropical	1	2108.92	0.0001	1324.17	0.0001	21464.38	0.0001
Error	60	94.79		40.87		398.84	

TABLE L

ANALYSES OF VARIANCE FOR GROWTH PERIODS, ALL LOCATIONS COMBINED, 1977

Source	d.f.	Days to Mid-Bloom		Days to Black Layer		Days From MB to BL	
		MS	OSL	MS	OSL	MS	OSL
Location	2	5024.56	0.0001	6701.55	0.0001	1516.16	0.0001
Error a	12	13.98		8.62		2.16	
Variety	15	289.84	0.0001	467.72	0.0001	47.24	0.0001
Var x Loc	30	35.94	0.0001	68.44	0.0001	32.38	0.0001
Error b	180	3.81		3.72		3.69	

TABLE LI

ANALYSES OF VARIANCE FOR GRAIN YIELD, DAYS TO MID-BLOOM AND DRY MATTER ACCUMULATIONS PER DAY, ALL LOCATIONS COMBINED, 1978[1]

Source	d.f.	Grain Yield		Days to MB		Grain/Day From PL to MB	
		MS	OSL	MS	OSL	MS	OSL
Location	2	365932566.11	0.0001	1128.97	0.0001	60823.23	0.0001
Error a	12	1409783.77		14.69		326.78	
Variety	19	14830097.37	0.0001	233.53	0.0001	3532.37	0.0001
Var. x Loc.	38	3928724.36	0.0001	43.52	0.0001	722.17	0.0001
Error b	228	1025320.32		6.18		233.89	

[1]Perkins locations not used for calculation

TABLE LII

ANALYSES OF VARIANCE FOR GROWTH PERIODS AND DRY MATTER ACCUMULATIONS PER DAY AT GOODWELL AND ISABELA, 1978

Source	d.f.	Days to Black Layer		Days From MB to BL		Grain/Day From PL to BL		Grain/Day From MB to BL	
		MS	OSL	MS	OSL	MS	OSL	MS	OSL
Location	1	578.00	0.0102	551.12	0.0018	60609.20	0.0001	675436.09	0.0001
Error a	8	51.73		26.43		149.77		176069.88	
Variety	19	262.37	0.0001	76.03	0.0001	507.15	0.0001	5297.87	0.0001
Var. x Loc.	19	92.48	0.0001	65.95	0.0001	193.82	0.0077	3763.58	0.0001
Error b	152	12.20		14.62		92.88		1021.69	

TABLE LIII

ANALYSES OF VARIANCE FOR GRAIN YIELDS AND DRY MATTER ACCUMULATIONS PER DAY, ALL LOCATIONS COMBINED 1977

Source	d.f.	Grain Yield		Grain/Day From PL to MB		Grain/Day From PL to BL		Grain/Day From MB to BL	
		MS	OSL	MS	OSL	MS	OSL	MS	OSL
Location	2	32651796.54	0.0001	8947.40	0.0001	2279.02	0.0001	7630.04	0.0001
Error a	12	39577.30		175.03		56.65		313.77	
Variety	15	11554997.19	0.0001	3714.88	0.0001	1551.49	0.0001	13430.90	0.0001
Var. x Loc.	30	2171494.51	0.0001	587.18	0.0001	254.08	0.0001	3051.13	0.0001
Error b	180	534184.46		130.64		57.92		624.99	

TABLE LIV

ANALYSES OF VARIANCE FOR GROWTH PERIODS AT THREE LOCATIONS IN TWO YEARS COMBINED[1]

		Days to Mid-Bloom		Days to Black Layer		Days From MB to BL	
Source	d.f.	MS	OSL	MS	OSL	MS	OSL
Location	2	4361.19	0.0001	8207.65	0.0001	2165.21	0.0001
Year	1	2133.09	0.0001	6881.97	0.0001	1352.19	0.0001
Year x Loc.	2	517.59	0.0001	267.69	0.0001	624.39	0.0001
Error a	24	10.73		18.40		9.59	
Variety	10	458.28	0.0001	639.14	0.0001	43.41	0.0001
Var. x Loc.	20	678.24	0.0001	91.69	0.0001	22.91	0.0001
Year x Loc.	10	43.97	0.0001	111.28	0.0001	47.58	0.0001
Year x Var. x Loc.	20	20.66	0.0001	68.90	0.0001	48.10	0.0001
Error b	240	4.71		4.06		5.30	

[1] Only common variety in all locations and all years were used. College Station was not included.

TABLE LV

ANALYSES OF VARIANCE FOR GROWTH PERIODS AT GOODWELL AND ISABELA IN TWO YEARS COMBINED[1]

Source	d.f.	Days to Mid-Bloom		Days to Black Layer		Days From MB to BL	
		MS	OSL	MS	OSL	MS	OSL
Location	1	7430.51	0.0001	3836.45	0.0001	591.33	0.0001
Year	1	594.05	0.0001	5445.00	0.0001	2436.53	0.0001
Year x Loc.	1	266.45	0.0009	540.80	0.0004	47.28	0.0573
Error a	16	16.17		26.95		11.27	
Variety	15	350.39	0.0001	453.96	0.0001	42.74	0.0001
Var. x Loc.	15	115.58	0.0001	140.31	0.0001	47.24	0.0001
Year x Var.	15	28.30	0.0001	167.85	0.0001	89.09	0.0001
Year x Var. x Loc.	15	9.69	0.0001	56.74	0.0001	63.58	0.0001
Error b	240	7.10		8.22		9.00	

[1]Only common variety for 1977 was used

TABLE LVI

ANALYSES OF VARIANCE FOR GRAIN YIELD AND DRY MATTER ACCUMULATIONS PER DAY AT THREE LOCATIONS IN TWO YEARS COMBINED[1]

Source	d.f.	Grain Yield		Grain/Day From PL to MB		Grain/Day From PL to BL		Grain/Day From MB to BL	
		MS	OSL	MS	OSL	MS	OSL	MS	OSL
Location	2	227310508.83	0.0001	29198.44	0.0001	13789.81	0.0001	164176.69	0.0001
Year	1	15241352.73	0.0006	15155.40	0.0001	7356.33	0.0001	76795.08	0.0001
Year x Loc.	2	182455672.43	0.0001	50943.79	0.0001	19839.46	0.0001	128835.18	0.0001
Error a	24	979609.64		231.34		103.70		1066.48	
Variety	10	11732561.04	0.0001	3321.53	0.0001	1312.60	0.0001	11055.38	0.0001
Var. x Loc.	20	1937181.84	0.0001	358.20	0.0005	150.37	0.0004	1674.92	0.0001
Year x Var.	10	961858.87	0.0854	397.50	0.0026	160.07	0.0033	1956.46	0.0004
Year x Var. x Loc.	20	2155301.74	0.0001	604.18	0.0001	270.01	0.0001	3508.55	0.0001
Error b	240	571678.50		141.39		58.57		587.11	

[1]Only common varieties in all locations in all years were used. College Station was not included.

TABLE LVII

ANALYSES OF VARIANCE FOR GRAIN YIELDS AND DRY MATTER ACCUMULATIONS PER DAY AT GOODWELL AND ISABELA IN TWO YEARS COMBINED[1]

Source	d.f.	Grain Yield		Grain/Day From PL to MB		Grain/Day From PL to BL		Grain/Day From MB to BL	
		MS	OSL	MS	OSL	MS	OSL	MS	OSL
Location	1	242143624.28	0.0001	18464.85	0.0001	13926.03	0.0001	269203.44	0.0001
Year	1	14469131.33	0.0043	108.44	0.5584	0.34	0.9589	1450.71	0.2525
Year x Loc.	1	371076048.90	0.0001	94397.81	0.0001	39191.69	0.0001	302973.62	0.0001
Error a	16	1308045.95		303.62		125.15		1029.53	
Variety	15	11041200.66	0.0001	3721.30	0.0001	1005.54	0.0001	9270.53	0.0001
Var. x Loc.	15	3203206.26	0.0001	492.82	0.0019	179.56	0.0042	2544.73	0.0007
Year x Var.	15	1717658.45	0.0140	430.94	0.0072	168.59	0.0077	2832.41	0.0002
Year x Var. x Loc.	15	1747433.99	0.0121	502.51	0.0015	219.27	0.0005	3810.94	0.0001
Error b	240	844537.26		196.35		82.54		925.88	

[1]Only common varieties for 1977 were used

TABLE LVIII

ANALYSES OF VARIANCE FOR KERNEL DRY WEIGHT AND MOISTURE PERCENTAGE AT PERKINS, OKLAHOMA, 1977

		Kernel Dry Weight		Kernel Moisture Percentage	
Source	d.f.	MS	OSL	MS	OSL
Variety	15	9.1660	0.0001	332.30	0.0001
Error a	60	0.1761		23.91	
Day	9	1.3285	0.0001	3347.62	0.0001
Var. x Day	135	0.0214	0.0001	13.50	0.0001
Error b	576	0.0079		2.26	

TABLE LIX

ANALYSES OF VARIANCE FOR KERNEL DRY WEIGHT AND MOISTURE PERCENTAGE AT PERKINS, OKLAHOMA, 1978

		Kernel Dry Weight		Kernel Moisture Percentage	
Source	d.f.	MS	OSL	MS	OSL
Variety	11	3.2378	0.0001	178.71	0.0001
Error a	44	0.0875		11.21	
Day	4	1.4476	0.0001	2958.86	0.0001
Var. x Day	44	0.0433	0.0001	8.72	0.0001
Error b	192	0.0059		1.97	

TABLE LX

ANALYSES OF VARIANCE FOR RATIO OF KERNEL DRY WEIGHT TO KERNEL DRY WEIGHT AT BLACK LAYER STAGE AT PERKINS, OKLAHOMA, 1977 & 1978

Source	Year	d.f.	MS	OSL
Variety	1977	15	0.018086	0.3283
	1978	11	0.023398	0.0003
Error a	1977	60	0.015616	
	1978	44	0.005571	
Day	1977	8	0.316885	0.0001
	1978	3	0.433155	0.0001
Var. x Day	1977	120	0.006712	0.0001
	1978	33	0.009302	0.0001
Error b	1977	512	0.001625	
	1978	239	0.001262	

VITA

Iraj Amini

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