A COMPARISON OF THE EFFICIENCY OF EARLY MATURING VS. LATE MATURING SORGHUMS FOR GRAIN PRODUCTION

By

AHMADREZA RAFIE

Master of Science
Tarleton State University
Stephenville, Texas
1979

Doctor of Education
Oklahoma State University
Stillwater, Oklahoma
1984

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF PHILOSOPHY
July, 1987

A COMPARISON OF THE EFFICIENCY OF EARLY

MATURING VS. LATE MATURING SORGHUMS

FOR GRAIN PRODUCTION

Thesis Approved:

Dale E. Weibel
Thesis Adviser

Robert M. Reed

Charles M. Taliaferro

Ronald W. McNew

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGEMENTS

My deepest appreciation is expressed to Dr. Dale E. Weibel, my major advisor, for his understanding and support during the entire period of research. I wish to thank Drs. Robert M. Reed, Charles M. Taliaferro, and Ronald W. McNew for their contribution and support.

I would like to thank Dr. Stephen E. Hawkins and Mr. Gary Strickland for their assistance during the research.

I wish to express my sincere appreciation to my wonderful wife, Carlin, and her mother, Jean McGinn, for their patience, understanding, and encouragement throughout the course of this study.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

CHAPTER I

INTRODUCTION

The importance of sorghum (Sorghum bicolor (L.) Moench) in the economy of the world can well be recognized by its vast distribution, mass production, and varied utilization. It is ranked after rice, wheat, and maize in the total world acreage. Sorghum is used as human food for many people in Africa, India, China, and other Far East countries. In the United States of America, sorghum is cultivated commercially and is used mainly as feed for livestock.

From 1950 to 1980, U.S. sorghum grain yields increased at an annual rate of 7%. Sorghum yield increased at a rate of 11% per year from 1950 to 1960, at 4% from 1961 to 1970, and at 2% from 1971 to 1980. The discovery of cytoplasmic-genetic male-sterility, the incorporation of new germplasm (from the Sorghum Conversion Program), selection for disease and insect resistance, as well as better production practices, have contributed to this gain (25).

It has always been easy to determine the time of bloom and the onset of grain filling in most cereals. In contrast, it has been difficult to tell when the grain stops filling--the time when the grain is physiologically mature. Researchers first discovered a way to determine this in corn. A layer of cells near the point where the kernel is attached to the cob turn dark brown as the kernel nears maturity and, finally, black when the kernel is physiologically mature.

This so-called "black layer" formation in the placental region near the point of kernel attachment also is considered as an indication of physiological maturity in grain sorghum (11,29).

The objective of this study was to determine grain production per day for the time period from planting to black layer, from planting to midbloom, and from midbloom to black layer of hybrids and varieties of grain sorghum with different maturities, thereby determing their comparative efficiency for grain production. Efficiency of grain production may not be as important in the temperate region (where only one crop per year is produced) as it is in the tropical areas. But, in tropical areas where crops can be produced 365 days per year, the amount of grain produced on a daily basis becomes important.

CHAPTER II

LITERATURE REVIEW

In recent years, the term "maturity" often has been changed to "physiological maturity" which is normally defined as occurring when the seed reaches its maximum dry weight (34). Determination of physiological maturity is important since it allows us to accurately measure the grain filling period. Eastin et al. (10) have pointed out that ultimate yield is a function of both the grain filling period and the metabolic or synthetic efficiency during that period if either seed number or potential size are not limiting.

Several methods have been used to determine physiological maturity in different crops. Booth (6) considered the end of the developmental period in oat (Avena sativa L.) to be the time when the dry matter content was within 3% of the maximum and half of the glume surface of the spikelets was straw colored. Kiesselbach and Lyness (22) considered small grain to be mature when 3/4 of the inflorescences appeared ripe.

Some researchers have used the moisture content of the grain to mark the end of the "ripening" period, while other researchers have used some measure of glume or straw color as an indicator. Olson (27) reported that wheat (Triticum aestivum L.) did not fill after the moisture content had dropped to 40%. Harlan and Pope (15) reported that barley (Hordeum vulgare L.) was fully mature when moisture content had dropped to 46%. Bishnoi (5) concluded that Triticale (Triticale hexaploid L.) seeds were physiologically mature 24 to 26 days after anthesis when the moisture content was 41%.

Attempts to describe physiological maturity in soybean (Glycine max (L.) Merrill) have relied primarily on pod and/or leaf characteristics. Kalton et al. (19) defined physiological maturity in soybean as occurring when the pods were yellowing and 50% of the leaves were yellow. Rubel et al. (32) suggested that physiological maturity occurred in soybean when seeds started to turn yellow. Major et al. (24) recorded the occurrence of physiological maturity when 75% of the leaves had senescenced. Crookston and Hill (7) compared 11 visual pod and seed characteristics as indications of the occurrence of physiological maturity to six field grown soybean cultivars. They reported that the initiation of seed shrinkage most consistently coincided with the occurrence of physiological maturity, but they felt that their estimated date of physiological maturity may have been slightly early, and the loss of green color of the pods may be the better indicator.

Fussel and Dwarte (13) state that

> . . . the appearance of the black layer on the abgerminal external surface of the grain pearl millet (Pennisetum americanum (L.) Leeke) is a useful indicator of the achievement of maximum grain dry weight (physiological maturity). This finding suggests that the black layer in pearl millet may be associated with the translocatory pathway into the grain, in a manner similar to that for corn and sorghum.

In a study conducted by Fussell and Dwarte (13), development of the black layer in pearl millet was divided into five stages based on color ranging from very little coloration (stage 1) to dark coloration (stage 5). It usually took 12 to 13 days after anthesis for appearance of stage 1 and 33 days after anthesis for appearance of stage 5. Fussell and Dwarte (13) conducted a similar study to that of Giles et al. (14). They fed C^{14}-labelled assimilate to the flagleaf and noted that the radioactivity recovered in the grain was high in stages 1 and 2, but it decreased significantly by stage 4. No radioactivity was recorded at stage 5. These researchers took sections from various stages of black layer development and found that the embryo was enlarging with each increase in stage number. Enlargement of the embryo happened in conjunction with a gradual reduction in number of endosperm cell layers between the chalazal pad and the scutellum. Most of the transfer cells had been crushed by stage 3, and by stage 4 a yellow-brown pigment was observed predominantly in the chalazal cells. By stage 5, this coloration had intensified, and the last layer of transfer cells had been extensively crushed by the embryo growth.

Anderson (3) found with sunflower (Helianthus annuus) that maximum seed dry weight coincided with maximum achene oil and linoleic acid content. Physiological maturity is a significant event in sunflower phenology since it represents the endpoint to the influence of cultural practice upon these important yield traits. A common means of estimating physiological maturity is by using the moisture content of the seed. Anderson (3) explained that physiological maturity occurred when the moisture content of the achene is approximately 40%. Such values, however, are probably subject to environmental influences as well as being inconvenient to determine. Visual methods have been employed by

Robinson (33) to study the phenology of sunflower. Plants were considered to be mature when leaves and petioles were dry and the backs of the capitula were yellow. Johnson and Jellun (18) used the change in capitulum color from green to yellow as an indicator of physiological maturity. Harrington (16) observed that development of an abscission layer at the hilum is a common occurrence with the onset of physiological maturity. In sunflowers this is reflected in the formation of a corresponding abscission layer at the point of floret attachment.

The use of black layer formation to determine physiological maturity began with corn. Researchers discovered that when corn reaches its maximum dry weight a black line forms at the base of each kernel. This line, called a black layer, was originally the placenta tissue cells that connected the kernel to the cob. These cells conduct all nutrients from the plant into the kernel. When the kernel stops growing, these cells collapse and turn black, shutting off any additional nutrients from the cob. According to Kiesselback and Walker (21), development of tissue that will eventually turn into the black layer starts soon after fertilization of the kernel. They cite this tissue as growing completely across the placento-chalazal region of the kernel by approximately 20 days after pollination and remaining active until about two weeks before maturity when visual black layer development begins. Daynard and Duncan (8) discussed black layer development as a suitable means of determining physiological maturity of corn. They found that initial visual occurrence of black layer development was highly correlated with predicted dates of maximum kernel dry weight and the definite end points for filling could be determined. Their finding indicated that a more precise physiological maturity date could be obtained by using this method than by using either kernel dry matter or moisture content. This result was confirmed by the finding of Rench and Shaw (31). They concluded that maximum kernel dry matter accumulation occurred at initial occurrence of black layer. Further, they showed that there was a loss of kernel dry weight between the initial occurrence of black layer and the completion of black layer development. Completed black layer development seems to define physiological maturity better than does maximum kernel dry weight or kernel moisture.

Baker (4) proposed that black layer formation is not necessarily correlated with any particular physiological timing mechanism or environmental variable. Cool temperature and exhaustion of assimilate supply have been suggested by Daynard and Duncan (8) to affect early black layer formation. Afuakwa et al. (1) studied the effect of temperature and sucrose availability on black layer formation. Complete defoliation at different stages of kernel maturity was used to determine the effect of a reduction in assimilate supply on black layer formation. They concluded that environmental stress can induce premature black layer formation in corn. They suggested that it was a reduction in, or termination of, the supply of sucrose to the kernels that induced black layer formation. However, they pointed out that the effect of cool temperature, drought, and defoliation may not all be explained on the basis of reduced sucrose availability. These same conditions would also be expected to affect the flux of other metabolites and hormones to the kernels.

Physiological maturity of sorghum has been determined on the basis of maximum dry weight measurement and moisture content. Pauli et al. (28) used maximum dry weight to measure physiological maturity. This method was difficult and time consuming, as in corn, and practically impossible for plant breeders to determine for thousands of entries in their programs. Moisture content does not give reliable results for use in the determination of physiological maturity. Kersting et al. (20) 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 finding showed that moisture content can not be used to determine physiological maturity. Moisture in the grain and stem is affected by humidity and rainfall during the grain filling period. An alternative method to determine physiological maturity is through the formation of black layer.

Quinby (29) first considered the use of black layer formation in sorghum and found that although the hilar layer darkened from day to day, the time at which translocation into the endosperm ceased could not be determined from the color of the black layer. Eastin et al. (11) found that black layer formation at the point of kernel attachment coincided closely with the cessation of translocation of C^{14} into the kernel. They concluded that black layer formation indicated physiological maturity or maximum accumulation of dry weight in sorghum. Giles et al. (14) concluded that physiological maturity of sorghum and black layer formation coincide following a detailed cytological study of the structure and ontogeny of the hilum region of the developing kernel. They also found that in sorghum the phloem parenchyma becomes blocked with pectic compounds and mucilage and becomes darkly pigmented owing to the deposition of phenolic compounds, initially in the vacuole and later in the cell walls. This deposition effectively closes the hilum between the horn-like projections of the inner integument.

Weibel et al. (35) 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. They suggested that to study the relationship among black layer formation, moisture content, and maximum dry weight, the researchers should sample the same portion of the panicle consistently, or determine fully matured kernel weights of the portion of the panicle sampled.

Kumar (23) used black layer formation to determine the date of the maximum accumulation of dry matter in grain sorghum. The study was conducted at four different locations in Oklahoma. He found that under non-irrigated conditions the rate of dry matter production in hybrids increased from early to medium to late maturity groups for all periods from planting to black layer, planting to midbloom, and midbloom to black layer. Under irrigated conditions, the same trend was found for dry matter accumulated per day for the period of planting to midbloom. 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 midbloom to black layer.

Amini (2) studied the dry matter accumulation in grain sorghum hybrids and lines adapted to tropical and temperate climates. He concluded that the length of the different growth periods varies from one location to another and from one year to the next year. The plants flowered and matured faster when they were moved from the temperate area to the tropical area. In contrast, the grain filling period increased when the hybrids were moved from the temperate to the tropical area. He pointed out that tropically adapted hybrids had higher dry weight accumulations per day from midbloom to black layer than temperate hybrids. Comparisons of moisture percentage and black layer showed that moisture percentage was not a good indication of physiological maturity.

Newton et al. (26) studied the soluble carbohydrates in developing sorghum caryopses. They concluded that during the early stages of endosperm development the level of monosaccharides is high due to high invertase activity which declines steadily thereafter. The sharp rise of sucrose concentrations, the rapid drop in monosaccharide concentrations, and the minimum rate of water loss after day 33 suggested that the 33rd day is indeed the time of physiological maturity. Data from this experiment showed the abrupt increase in sucrose concentrations is due to the very rapid decrease in water content beginning on days 30 to 33 and declining steadily thereafter. Black layer was observed after day 27 for this experiment, indicating a close relationship between black layer formation and physiological maturity.

CHAPTER III

MATERIALS AND METHODS

Field studies were conducted to determine grain yield of sorghum per day (in the field) of early vs. late maturity groups of hybrids and varieties. Data were collected from two experiments; "Small Hybrid-Variety Test," and "Oklahoma Grain Sorghum Performance Test."

The Small Hybrid-Variety Test was designed and conducted to study and compare the efficiency of grain production per day from planting to black layer, from planting to midbloom, and from midbloom to black layer of late and early hybrids vs. late and early varieties. Also, the efficiency of grain production on a per day basis of late hybrids and varieties vs. early hybrids and varieties for the same variables was studied. Twenty different grain sorghum hybrids and varities were selected for the study in four catagories; early variety, early hybrid, late variety, and late hybrid. Tables XXII, XXIII, XXIV, and XXV, in the appendix, show data for these entries for different locations and years for yield, yield components, growth periods, and plant height. The experiment was conducted at Perkins, Goodwell, and Mangum, Oklahoma, in 1984 and 1985. The Mangum location was discarded from the experiment due to severe drought during the growing season in both years. From the 20 entries at Perkins in 1985, six entries (one entry from the early varieties, three entries from the early hybrids, one entry from the late hybrids, and one entry from the late varieties) were discarded due to severe bird damage. Analyses were done based on the remaining 14 entries. For some variables such as days to black layer, days to midbloom, days from midbloom to black layer, data were collected prior to bird damage. Certain comparisons were made based on all entries for these variables. Also, one entry from the early hybrids was discarded at Perkins in 1984 due to severe bird damage. The entries and variables for the Small Hybrid-Variety Test are listed in Table I. The experiment at each location was arranged in a randomized complete block design with three replications. Analyses of variance were computed for each location separately, combined over locations for each year, and combined over years for each location (except for Perkins in 1985). The analyses were used to determine the differences among the means of hybrids vs. varieties and late maturity vs. early maturity groups for variables yield, grain per day from planting to black layer, days to black layer, grain per day from planting to midbloom, days to midbloom, grain per day from midbloom to black layer, days from midbloom to black layer, and plant height.

The Oklahoma Grain Sorghum Performance Tests of commercial hybrids are conducted annually by the Oklahoma Agricultural Experiment Station. These performance tests are conducted at five locations in the state. Three locations were chosen for the purpose of this study. These locations were Perkins (dryland), Mangum (dryland), and Goodwell (irrigated). During 1984 and 1985, the Mangum test was discarded because of severe drought during the growing season. In both 1984 and 1985 the tests were conducted in randomized complete block designs with three replications. The performance test at each location consisted of approximately 100 entries grouped into early, medium, and late maturity

TABLE I

VARIABLES STUDIED IN 1984 AND 1985
AT THE VARIOUS LOCATIONS

Variables	Goodwell				Perkins			
	Small H-V Test		GSPT[1]		Small H-V Test		GSPT	
	1984	1985	1984	1985	1984	1985	1984	1985
Growth Periods:								
Days from Planting to Midbloom	+[2]	+	+	+	+	+	+	+
Days from Planting to Black Layer	+	+	+	+	+	+	+	+
Days from Midbloom to Black Layer	+	+	+	+	+	+	+	+
Yield	+	+	+	+	+	NAE[3]	+	+
Yield Components:								
Grain Per Day from Planting to Midbloom	+	+	+	+	+	NAE	+	+
Grain Per day from Planting to Black Layer	+	+	+	+	+	NAE	+	+
Grain Per Day from Midbloom to Black Layer	+	+	+	+	+	NAE	+	+
Plant Height	+	+	+	+	+	NAE	+	+

[1] GSPT = Grain Sorghum Performance Test

[2] + = All entries studied

[3] NAE = Not all entries studied (six missing due to bird damage).

hybrids. Each maturity group had a different number of entries within each replication, but the same number of entries in each replication. A list of hybrids used in each maturity group for this study can be found in the research reports of the Performance Tests of Hybrid Sorghum and Corn in Oklahoma (9,17).

Midbloom data showed considerable intermingling of maturity groups and suggested regrouping of the hybrids into late, medium, and early groups. Regrouping of hybrid entries was done as follows: midbloom data collected on the commercial seed companies' hybrids were used to establish a new order from early to late maturity. The difference between the latest and earliest days to midbloom was divided by three. This quantity was added to the earliest days to midbloom to determine the range of the early maturity group. Twice the quantity was added to the earliest days to midbloom to determine the range of the medium maturity groups. The remaining range constituted the late maturity group. Regrouping of the maturity groups into early, medium, and late was done for both years (1984 and 1985) and both locations (Perkins and Goodwell). The new data sets created based on the regrouping were analyzed similarly to that for the commercial seed companies' classification grouping. Duncan's Multiple Range Test was used to compare the means of late, medium, and early maturity groups of sorghum for yield, yield components, growth periods, and plant height.

Data for black layer formation were obtained by visiting the field every other day and examining kernels for the formation of the black layer. The procedure adopted was to remove kernels from the central part of the panicles and to visually examine the hilum area of the kernels for black layer. The panicles selected at random were examined from each entry in each replication. An entry was noted as having reached the black layer stage of kernel development when kernels in the middle of the panicle showed black layer but kernels from the top of the panicle had not yet reached the black layer stage.

Tables II and III show the locations and conditions for both tests. Data for some of the variables were collected in the field, while the data for other variables were calculated. The variables and their derivation follow:

Grain Yield -- Threshed grain from a measured plot in kilogram per hectare.

Days to Midbloom -- Days from planting to a day when half the plants in the plot were flowering.

Days to Black Layer -- Days from planting to a day when a sample of panicles in the plot had kernels in the black layer stage in the middle part of the panicles.

Days from Midbloom to Black Layer -- The difference in days between days to black layer and days to midbloom.

Grain Per Day from Planting to Black Layer -- Yield divided by days to black layer.

Grain Per Day from Planting to Midbloom -- Yield divided by days to midbloom.

Grain Per Day from Midbloom to Black Layer -- Yield divided by days from midbloom to black layer.

TABLE II

LOCATION AND CONDITIONS "SMALL HYBRID-VARIETY TEST"

Location and Latitudes	Soil Types	Year	Irrigation cm	Planting Date	Harvesting Date	Plant/ha	Fertilizer Kg/ha
Perkins Oklahoma 35.59°N	Teller Loam	1984	19.0	June 1	September 14	71,729	133N
	Teller Loam	1985	4.0	June 20	October 6	71,729	134N
Goodwell Oklahoma 36.36°N	Richfield Clay Loam	1984	66.0	June 1	October 5	138,350	177N
	Richfield Clay Loam	1985	59.0	May 31	October 22	138,350	168N

TABLE III

LOCATION AND CONDITIONS "OKLAHOMA GRAIN SORGHUM PERFORMANCE TEST"

Location and Latitudes	Soil Types	Year	Irrigation cm	Planting Date	Harvesting Date	Plant/ha	Fertilizer Kg/ha
Perkins Oklahoma 35.59°N	Teller Loam	1984	Dryland	May 30	September 27 - October 3	71,729	133N
	Teller Loam	1985	Dryland	May 30	October 1	71,729	134N
Goodwell Oklahoma 36.36°N	Richfield Clay Loam	1984	66.0	June 1	September 26 - October 3	138,350	177N
	Richfield Clay Loam	1985	59.0	June 3	October 8	138,350	168N

Plant Height -- Distance in centimeters measured from the soil surface to the top of the panicle of a representative sample of plants in a plot.

The entries used for both tests were constantly threatened by birds, particularly the early maturity groups of sorghum. As it was described before, some of the entries were damaged severely and it was impractical to estimate the grain yield for those entries. In some cases the bird damage was not too severe and we were able to estimate the yield lost due to bird damage. This procedure was as follows: prior to harvest, the percentage of bird damage was estimated for the entries with bird damage. The following formula was used to estimate the real grain yield for that entry as if bird damage had not occurred.

Grain Yield = 100 x grain yield after bird damage/(100 - percentage of bird damage)

CHAPTER IV

RESULTS AND DISCUSSION

Small Hybrid-Variety Test

Table IV shows the means for hybrids and varieties for yield, yield components (grain per day from planting to black layer, grain per day from planting to midbloom, and grain per day from midbloom to black layer), growth periods (days to black layer, days to midbloom, and days from midbloom to black layer), and plant height for Goodwell and Perkins in 1984. For Goodwell, there were significant differences between the means of hybrids and varieties for yield, yield components, and growth periods except for days to midbloom. Plant height, also, did not show a significant difference between the means of hybrids and varieties. Where significant differences were found, hybrids exceeded varieties in every case. These findings confirm the results from Eastin and Sullivan (12) whereby hybrids had a longer grain filling period than their parents, although not all the entries used as varieties for this experiment were parents of the hybrids. For Perkins there were significant differences between the means of hybrids and varieties for yield, yield components, and growth periods except for days from midbloom to black layer and for plant height. Hybrids exceeded varieties except for days to black layer and days to midbloom.

TABLE IV

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR HYBRIDS VS. VARIETIES IN "SMALL HYBRID-VARIETY TEST" FOR GOODWELL AND PERKINS, 1984

Location	Hybrid or Variety	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Goodwell	Hybrid	7566.4[a3]	76.3[a]	99.2[a]	108.9[a]	69.7[a]	260.4[a]	29.4[a]	129.3[a]
	Variety	5871.9[b]	59.1[b]	98.4[b]	82.3[b]	70.5[a]	218.2[b]	27.8[b]	127.5[a]
Perkins	Hybrid	5328.6[a]	61.6[a]	86.6[b]	95.0[a]	56.3[b]	177.7[a]	30.3[a]	114.1[a]
	Variety	4450.4[b]	49.2[b]	90.3[a]	74.9[b]	59.3[a]	144.5[b]	31.0[a]	112.3[a]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

This suggested that the hybrids bloomed and matured more rapidly than varieties at Perkins in the lower elevation of the Great Plains compared to Goodwell in the higher elevation.

Table V shows the means of maturity groups for yield, yield components, growth periods, and plant height for Goodwell and Perkins in 1984. For Goodwell, there were significant differences between the means of late and early maturity groups for all variables except grain per day from planting to midbloom. This could possibly be due to the large difference between the means of days to midbloom of late and early maturity groups and also to high variation within the individual observations for this variable. Where differences existed, the late maturity groups exceeded the early groups except for plant height at Goodwell. Therefore, one could conclude that late maturing sorghums yield more per day than early maturing sorghums.

Results from Perkins showed a similar trend to those from Goodwell except the comparison of the variable grain per day from planting to black layer, which was not significant. The lack of a significant difference between late and early maturity groups was due to a large difference between the means of days from planting to black layer for late and early maturity groups and, at the same time, a rather small difference between the means of late and early maturity groups for yield.

Table VI shows the means for hybrids and varieties for yield, yield components, growth periods, and plant height for Goodwell and Perkins in 1985. At Goodwell there were significant differences between the means of hybrids and varieties for all variables except for days from midbloom to black layer. In contrast, the Goodwell data for 1984 showed a

TABLE V

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR LATE VS. EARLY MATURITY GROUPS IN "SMALL HYBRID-VARIETY TEST" FOR GOODWELL AND PERKINS, 1984

Location	Maturity	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Goodwell	Late	7614.7[a][3]	71.2[a]	107.3[a]	98.5[a]	77.7[a]	261.2[a]	29.6[a]	125.5[b]
	Early	5630.0[b]	62.8[b]	89.3[b]	90.8[a]	61.2[b]	212.7[b]	27.4[b]	129.3[a]
Perkins	Late	5269.0[a]	56.0[a]	94.4[a]	84.3[a]	62.6[a]	168.5[a]	31.8[a]	113.0[a]
	Early	4510.1[b]	54.8[a]	82.5[b]	85.6[a]	52.9[b]	153.8[b]	29.5[b]	113.0[a]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

TABLE VI

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR HYBRIDS VS. VARIETIES IN "SMALL HYBRID-VARIETY TEST" FOR GOODWELL AND PERKINS, 1985

Location	Hybrid or Variety	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Goodwell	Hybrid	5827.9[a3]	55.3[a]	105.4[a]	83.7[a]	69.8[b]	165.2[a]	35.6[a]	128.0[a]
	Variety	4501.8[b]	41.2[b]	109.1[b]	61.8[b]	72.8[a]	126.0[b]	36.3[a]	125.5[b]
Perkins[4]	Hybrid	4875.1[a]	47.8[a]	102.4[a]	83.3[a]	58.6[a]	112.5[a]	43.8[a]	122.4[a]
	Variety	2943.6[b]	29.3[b]	100.1[b]	51.3[b]	57.6[b]	68.5[b]	42.6[b]	118.4[b]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

[4]Results for Perkins 1985 is based on 14 entries (6 entries were eliminated due to bird damage). Table VIII shows the results for Perkins in 1985 based on all entries for some of the variables.

non-significant difference between the means of hybrids and varieties for days to midbloom and plant height while showing a significant difference for days from midbloom to black layer. Hybrids exceeded varieties for yield and all yield components, while reaching black layer and midbloom in significantly less days than varieties, indicating that hybrids are more efficient than varieties for grain production on per day basis. More days were required to reach black layer in 1985 than in 1984 and that hybrids matured faster than varieties in 1985. Quinby (30) studied the length of grain filling period for 12 hybrids and their parents by measuring maximum dry weight of kernels at physiological maturity. He reported that there were no significant differences in length of grain filling period between parents and hybrid. This is in contrast with findings by Eastin (12), already described.

Table VII shows the means for maturity groups for yield, yield components, growth periods, and plant height for Goodwell and Perkins in 1985. The data for Goodwell showed significant differences between the means of late and early maturity groups for yield and growth periods. Significant differences were not observed between the means of late and early maturity gruops for two of the three yield components (grain per day from planting to black layer and grain per day from planting to midbloom). The means for the third variable (grain per day from midbloom to black layer of late and early maturity groups) were significantly different. The lack of significant differences between the means of late and early maturity groups for grain per day from planting to black layer and grain per day from planting to midbloom could be due partially to the large differences between the means of late and early maturity groups for days to black layer and days to midbloom.

TABLE VII

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR LATE VS. EARLY MATURITY GROUPS IN "SMALL HYBRID-VARIETY TEST" FOR GOODWELL AND PERKINS, 1985

Location	Maturity	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Goodwell	Late	5709.3 a[3]	49.3 a	116.6 a	73.0 a	78.7 a	154.1 a	37.9 a	125.7 a
	Early	4620.5 b	47.2 a	97.9 b	72.5 a	63.8 b	137.0 b	34.0 b	127.8 a
Perkins[4]	Late	3994.5 a	37.9 a	106.1 a	66.5 a	60.5 a	88.0 a	45.6 a	123.2 a
	Early	3474.1 a	36.4 b	94.4 a	62.9 b	54.7 b	86.5 a	39.7 b	116.4 b

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

[4]Results for Perkins 1985 is based on 14 entries (6 entries were eliminated due to bird damage). Table IX shows the results for Perkins in 1985 based on all entries for some variables.

Results for Perkins in 1985 (Table VI) were based on 14 entries. Six of the entries (one entry from early varieties, three entries from early hybrids, one entry from late hybrids, and one entry from late varieties) were eliminated due to severe bird damage. The means for all comparisons between hybrids and varieties were significantly different. Table VIII shows the results for Perkins in 1985 for those variables not involving yield (days to black layer, days to midbloom, and days from midbloom to black layer) for all 20 entries. Significant differences were observed among the means of hybrids and varieties for two of the three growth period variables. Days from midbloom to black layer did not show a significant difference between the means of hybrids and varieties. The results from Perkins in 1985 (using data from Table VIII) had the same pattern as those for Perkins in 1984 (Table IV) when comparing hybrids and varieties. In these same comparisons, hybrids matured significantly faster than varieties, while varieties matured significantly faster than hybrids in data from the reduced number of entries (Table VI). One might question the incomplete data. Results for late and early maturity groups from Perkins in 1985 were obtained based on 14 entries (Table VII). No significant differences were observed among the means of late and early maturity groups for yield and yield components. There were significant differences for growth periods. The results for all 20 entries for growth period for maturity groups are shown in Table IX. Significant differences were observed among the means of late and early maturity groups for growth periods. Based on the data collected in 1985, late and early maturity groups of sorghum produced the same amount of grain per day from planting to black layer, from planting to midbloom, and from midbloom to black layer.

TABLE VIII

MEANS FOR GROWTH PERIODS[1] FOR HYBRIDS VS. VARIETIES IN "SMALL HYBRID-VARIETY TEST" FOR PERKINS, 1985, BASED ON ALL ENTRIES

Hybrid or Variety	Days to BL	Days to MB	Days From MB to BL
Hybrid	98.5[b2]	55.6[b]	42.9[a]
Variety	100.2[a]	57.6[a]	42.6[a]

[1]Growth Periods refer to variables days from PL to BL, days from PL to MB, and days from MB to BL.

[2]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

TABLE IX

MEANS FOR GROWTH PERIODS[1] FOR MATURITY GROUPS IN "SMALL HYBRID-VARIETY TEST" FOR PERKINS, 1985, BASED ON ALL ENTRIES

Maturity Groups	Days to BL	Days to MB	Days From MB to BL
Late	105.8[a2]	60.2[a]	45.6[a]
Early	92.9[b]	53.0[b]	39.9[b]

[1]Growth Periods refer to variables days from PL to BL, days from PL to MB, and days from MB to BL.

[2]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

Because of bird damage in this test and the complete loss of some entries, conclusion based on these results should be interpreted cautiously.

Table X shows the means of hybrids and varieties for yield, yield components, growth periods, and plant height in 1984, averaged over both locations. There were significant differences between the means of hybrids and varieties for yield, yield component variables (higher mean for hybrids), and growth period variables (higher mean for varieties except days from midbloom to black layer). No significant difference was observed between the means of hybrids and varieties for plant height. It was noted that the results for 1984, averaged over locations, showed the same trend as those for Perkins in 1985 (Table VIII) and Perkins in 1984 (Table IV) for variables days to black layer and days to midbloom (higher mean for varieties than for hybrids). In summary, this table shows that, on the average, hybrids reach midbloom and black layer faster than varieties. Also, the hybrids were more efficient in producing grain on a per day basis.

Table XI shows the means of late and early maturity groups for yield, yield components, growth periods, and plant height in 1984, averaged over locations. The results indicated that there were significant differences between the means of maturity groups for all variables except grain per day from planting to midbloom and for plant height. In all significant comparisons, late maturity sorghums exceeded early maturity sorghums. In summary, the table showed that late maturity sorghums produced more yield per day than early maturity sorghums.

Table XII shows the means of hybrids and varieties for Goodwell, averaged over years, for yield, yield components, growth periods, and

TABLE X

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR HYBRIDS VS. VARIETIES IN "SMALL HYBRID-VARIETY TEST" AVERAGED OVER LOCATIONS, 1984

Hybrid or Variety	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Hybrid	6391.8^{a}[3]	68.5^{a}	92.6^{b}	101.6^{a}	62.6^{b}	216.9^{a}	29.9^{a}	121.2^{a}
Variety	5161.2^{b}	54.1^{b}	94.3^{a}	78.6^{b}	64.9^{a}	181.3^{b}	29.4^{a}	119.9^{a}

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

TABLE XI

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR LATE VS. EARLY MATURITY GROUPS IN "SMALL HYBRID-VARIETY TEST" AVERAGED OVER LOCATIONS, 1984

Maturity Groups	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Late	6441.9 [a3]	63.6 [a]	100.9 [a]	91.4 [a]	70.2 [a]	214.8 [a]	30.7 [a]	121.9 [a]
Early	5040.6 [b]	58.6 [b]	85.7 [b]	88.1 [a]	57.1 [b]	181.7 [b]	28.5 [b]	119.1 [a]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

TABLE XII

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR HYBRIDS VS. VARIETIES IN "SMALL HYBRID-VARIETY TEST" FOR GOODWELL AVERAGED OVER YEARS

Hybrid or Variety	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Hybrid	6651.5[a3]	65.3[a]	102.4[b]	95.7[a]	69.8[b]	210.3[a]	32.7[a]	128.8[a]
Variety	5186.8[b]	50.2[b]	103.7[a]	72.0[b]	71.7[a]	172.0[b]	32.1[a]	126.5[b]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

plant height. Results from this table indicated that there were significant differences among the means of hybrids and varieties for all variables except days from midbloom to black layer. Hybrids exceeded varieties for yield and yield components while varieties required more days to mature. These results were consistent with the findings of other years and locations.

Table XIII shows the means of maturity groups for yield, yield components, growth periods, and plant height for Goodwell averaged over years. There were significant differences among the means of late and early maturity groups for all variables except grain per day from planting to midbloom. Late maturity sorghums exceed early maturity sorghums in all comparisons. The data showed the trend for late maturity sorghums to produce more grain per day than early maturing sorghums. Lack of significance between the means of late and early maturity groups for variable grain per day from planting to midbloom was consistent for both years and both locations. This suggests that the efficiencies of grain production on per day basis were the same for both late and early maturity groups up to the midbloom period.

Oklahoma Grain Sorghum Performance Test

Table XIV shows the means of late, medium, and early maturity groups (maturity grouping based on commercial seed companies' classification) for yield, yield components, growth periods, and plant height for Perkins (dryland) in 1984. There were significant differences among the means of late and medium maturity for all variables except days from midbloom to black layer and plant height. There were significant differences among means of medium and early

TABLE XIII

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR LATE VS. EARLY MATURITY GROUPS IN "SMALL HYBRID-VARIETY TEST" FOR GOODWELL AVERAGED OVER YEARS

Maturity Groups	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Late	6662.0[a][3]	60.3[a]	111.9[a]	85.8[a]	78.2[a]	207.7[a]	33.8[a]	129.8[a]
Early	5098.2[b]	54.7[b]	93.8[b]	81.5[a]	62.9[b]	172.8[b]	30.9[b]	125.5[b]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

TABLE XIV

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR MATURITY GROUPS OF THE "GRAIN PERFORMANCE TEST" FOR PERKINS, 1984, MATURITY GROUPS BASED ON COMMERCIAL SEED COMPANIES' CLASSIFICATION

Maturity Groups	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Late	3536.5[a3]	40.2[a]	88.0[a]	59.5[a]	61.1[a]	126.1[a]	28.3[a]	81.3[a]
Medium	2950.6[b]	34.6[b]	85.3[b]	51.9[b]	57.3[b]	104.2[b]	28.1[a]	81.5[a]
Early	3097.1[b]	38.0[ab]	81.6[c]	57.2[ab]	54.1[c]	113.6[ab]	27.3[b]	83.3[a]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

maturity groups for days to black layer, days to midbloom, and days from midbloom to black layer. There were significant differences among the means of late and early maturity groups for variables: yield, days to black layer, days to midbloom, and days from midbloom to black layer. No significant differences were observed among the means of medium and early or late and early for grain per day from planting to black layer, grain per day from planting to midbloom, grain per day from midbloom to black layer, or plant height. The late maturity group of hybrids produced more grain per day than the medium maturity group, but not more than early maturity group of hybrids. The medium maturity group of hybrids did not produce more grain per day than early maturity group of hybrids. Results from this test indicated that even though there was a significant difference between the means of early and late maturity groups of hybrids for the variable yield, due to high differences between the means of days to black layer (higher for late hybrids), the rate of grain production on a daily basis remained the same for both late and early maturity groups of hybrids.

Table XV shows the means of late, medium, and early maturity groups (maturity grouping based on midbloom data) for yield, yield components, growth periods, and plant height at Perkins in 1984. This table shows that there were significant differences among the means of late, medium, and early maturity groups of hybrids for days to black layer, days to midbloom, and days from midbloom to black layer. This was not surprising since the entries in the test were arranged in order of midbloom data for analysis. No significant differences were observed among the means of late, medium, and early maturity groups for yield or for grain per day from planting to black layer. Late hybrids produced

TABLE XV

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR MATURITY GROUPS OF THE "GRAIN PERFORMANCE TEST" FOR PERKINS, 1984, MATURITY GROUPS BASED ON MIDBLOOM DATA

Maturity Groups	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Late	3293.6[a][3]	36.6[a]	90.6[a]	52.5[b]	63.2[a]	121.9[a]	27.4[c]	80.3[b]
Medium	3299.0[a]	38.8[a]	85.3[b]	57.8[a]	57.3[b]	118.1[ab]	28.0[b]	81.5[b]
Early	3083.1[a]	37.6[a]	81.9[c]	57.8[a]	53.3[c]	108.2[b]	28.5[a]	83.8[a]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

less grain per day from planting to midbloom than medium or early hybrids. Neither late, medium, nor early maturity groups produced more grain per day consistently than any other group in the reordering of the data. Regrouping for maturity based on the midbloom data caused some changes, but, if there were significant differences among the means of late, medium, and early maturity groups of hybrids for grain yield and grain yield per day from planting to black layer, regrouping based on midbloom data failed to detect them. Another possibility is that there was high variation with each variable.

Table XVI shows the means of late, medium, and early maturity groups for Goodwell (irrigated) in 1984 based on the commercial seed companies' classification. There were significant differences among the means of late, medium, and early maturity groups (with late > medium > early) for yield, days to black layer, days to midbloom, days from midbloom to black layer, and plant height. There were significant differences among the means of late over medium and late over early, but not medium over early, for the yield components. Late maturity hybrids produced more grain on per day basis than medium or early maturity hybrids. The efficiency of grain production on a per day basis remained the same for early and medium maturity groups for the yield component variables.

Table XVII shows the means of late, medium, and early maturity groups of hybrids for Goodwell (irrigated) in 1984, based on midbloom data for yield, yield components, growth periods, and plant height. Regrouping did not change the results concluded from Table XVI except for days from midbloom to black layer of late and medium maturity groups of hybrids.

TABLE XVI

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR MATURITY GROUPS OF THE "GRAIN PERFORMANCE TEST" FOR GOODWELL, 1984, MATURITY GROUPS BASED ON COMMERCIAL SEED COMPANIES' CLASSIFICATION

Maturity Groups	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Late	9489.9[a][3]	91.0[a]	104.3[a]	135.6[a]	69.9[a]	277.0[a]	34.4[a]	137.7[a]
Medium	7762.4[b]	78.1[b]	99.1[b]	115.3[b]	67.1[b]	243.3[b]	32.0[b]	132.1[b]
Early	6809.7[c]	75.1[b]	90.7[c]	113.0[b]	60.3[c]	225.5[b]	30.1[c]	120.9[c]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

TABLE XVII

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR MATURITY GROUPS OF THE "GRAIN PERFORMANCE TEST" FOR GOODWELL, 1984, MATURITY GROUPS BASED ON MIDBLOOM DATA

Maturity Groups	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Late	10060.5^{a3}	95.8^{a}	105.1^{a}	140.9^{a}	71.5^{a}	300.4^{a}	33.6^{a}	137.7^{a}
Medium	8134.8^{b}	80.4^{b}	101.1^{b}	120.5^{b}	67.4^{b}	243.2^{b}	33.6^{a}	133.4^{b}
Early	6518.5^{c}	72.5^{b}	90.1^{c}	109.1^{b}	59.9^{c}	217.6^{b}	30.2^{b}	122.9^{c}

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

Table XVIII shows the means of the maturity groups for yield, yield components, growth periods, and plant height for Perkins (dryland) in 1985 based on the commercial seed companies' classification. There were significant differences among the means of maturity groups (late > medium > early) for days to black layer and days to midbloom. For yield and the yield component variables, the medium maturity group behaved similarly to the late maturity group of hybrids. Significant differences were observed between the means of late and early maturity groups for all variables. Both late and medium maturity groups of hybrids produced more grain per day than the early maturity group of hybrids. Data from this table suggested that grain per day was the same for late and medium hybrids.

Table XIX shows the means of maturity groups for yield, yield components, growth periods and plant height for Perkins (dryland) in 1985 based on midbloom data. Regrouping of the hybrids based on midbloom data produced results in which it was possible to detect differences among the means of late and early groups of hybrids for all variables as in Table XVIII. Results from the two sets of data were similar. In both analyses, late hybrids produced more grain per day than early hybrids for all three yield components.

Table XX shows the means of maturity groups for yield, yield components, growth periods, and plant height for Goodwell (irrigated) in 1985 based on the commercial seed companies' classification of maturity. Even though there was an increase in yield as maturity increased, there were no significant differences for yield or any of the yield components among the means of late, medium, and early maturity groups. There were significant differences among growth periods for the maturity groups and

TABLE XVIII

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR MATURITY GROUPS OF THE "GRAIN PERFORMANCE TEST" FOR PERKINS, 1985, MATURITY GROUPS BASED ON COMMERCIAL SEED COMPANIES' CLASSIFICATION

Maturity Groups	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Late	3869.6[a][3]	38.2[a]	101.2[a]	58.7[a]	66.0[a]	111.0[a]	35.2[a]	107.2[a]
Medium	3636.5[a]	38.1[a]	95.5[b]	58.9[a]	61.5[b]	108.8[a]	34.1[b]	102.9[b]
Early	2912.2[b]	31.8[b]	91.6[c]	50.5[b]	57.6[c]	86.1[b]	34.0[b]	100.6[b]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

TABLE XIX

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR MATURITY GROUPS OF THE "GRAIN PERFORMANCE TEST" FOR PERKINS, 1985, MATURITY GROUPS BASED ON MIDBLOOM DATA

Maturity Groups	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Late	3976.1[a][3]	39.7[a]	100.4[a]	59.0[a]	67.4[a]	121.6[a]	32.9[c]	106.4[a]
Medium	3533.2[b]	36.7[a]	96.1[b]	58.0[a]	60.8[b]	100.6[b]	35.2[b]	104.1[b]
Early	2595.6[c]	28.2[b]	92.2[c]	46.5[b]	55.9[c]	71.8[c]	36.3[a]	99.1[c]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

TABLE XX

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR MATURITY GROUPS OF THE "GRAIN PERFORMANCE TEST" FOR GOODWELL, 1985, MATURITY GROUPS BASED ON COMMERCIAL SEED COMPANIES' CLASSIFICATION

Maturity Groups	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Late	5319.0[a3]	49.4[a]	110.0[a]	73.6[a]	72.4[a]	143.7[a]	37.6[a]	131.3[a]
Medium	5018.9[a]	48.5[a]	104.4[b]	72.0[a]	69.6[b]	145.8[a]	34.8[b]	127.5[b]
Early	4929.9[a]	48.1[a]	100.0[c]	75.0[a]	65.7[c]	145.4[a]	34.3[b]	124.7[c]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

for plant height. This result is similar to what Kumar (23) concluded from a similar study at a similar location. Lack of significance among the means of yield and, consequently, yield components could be due partially to high variation within each maturity group for yield.

Table XXI shows the means of maturity groups for yield, yield components, growth periods, and plant height for Goodwell (irrigated) in 1985, based on the midbloom data. Regrouping of the data caused very little change in the results compared to the commercial seed companies' classification. The means of late and early maturity groups for yield, however, were significantly different. There were, in both analyses, significant differences among the means of late, medium, and early maturity groups for days to black layer, days to midbloom, days from midbloom to black layer, and plant height variables. Similar to findings from Table XX, also no significant differences were observed among means of late, medium, and early maturity groups for grain per day from planting to black layer, grain per day from planting to midbloom and grain per day from midbloom to black layer.

TABLE XXI

MEANS FOR YIELD, YIELD COMPONENTS[1], GROWTH PERIODS[2], AND PLANT HEIGHT FOR MATURITY GROUPS OF THE "GRAIN PERFORMANCE TEST" FOR GOODWELL, 1985, MATURITY GROUPS BASED ON MIDBLOOM DATA

Maturity Groups	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
Late	5378.4[a][3]	48.7[a]	110.7[a]	73.8[a]	73.0[a]	144.8[a]	37.7[a]	131.6[a]
Medium	5070.5[ab]	48.9[a]	103.5[b]	73.7[a]	68.7[b]	147.5[a]	34.8[b]	126.8[b]
Early	4621.1[b]	47.2[a]	98.1[c]	71.8[a]	64.4[c]	138.7[a]	33.7[c]	124.7[c]

[1]Yield components refer to variables grain per day from PL to BL, grain per day from PL to MB, and grain per day from MB to BL.

[2]Growth periods refer to variables days to BL, days to MB, and days from MB to BL.

[3]Means followed by the same letter in the same column do not differ significantly at 0.05 level of probability.

CHAPTER V

SUMMARY AND CONCLUSIONS

Field studies were conducted to determine grain yield of sorghum per day (in the field) of early vs. late maturity types. Data were collected from two experiments; Small Hybrid-Variety Test and Oklahoma Grain Sorghum Performance Test. These experiments were conducted for two years over three locations.

The Small Hybrid-Variety Test was designed and conducted to study and compare the efficiency of grain production per day of late and early hybrids vs. late and early varieties. Also, the efficiency of grain production per day of late hybrids and varieties vs. early hybrids and varieties was compared. Twenty entries were selected for the study and grouped into four different categories; early varieties, early hybrids, late varieties, and late hybrids. The experiment was conducted in a randomized complete block design with three replications. One location was discarded both years due to severe drought. Also, six entries (one entry from early varieties, three entries from early hybrids, one entry from late hybrids, and one entry from late varieties) from the Perkins location in 1985 were discarded due to severe bird damage.

Results from the Small Hybrid-Variety Test showed that in comparing early and late hybrids vs. early and late varieties, hybrids produced more grain per day than varieties in both locations and years. The variables, days to black layer and days to midbloom, were higher for varieties than for hybrids indicating that in this study hybrids reached maturity faster than varieties. Differences between the means of plant height for hybrids and varieties were seldom significant. Data from Goodwell combined over years indicated that late maturity groups of hybrids and varieties produced more grain per day from planting to black layer than early maturity groups of hybrids and varieties. Similar results for Perkins failed to show an advantage for late maturity. Results from 1984 averaged over both locations confirmed that late maturity groups of hybrids and varieties produced more grain per day than early maturity groups of hybrids and varieties. Results from Perkins for 1985 should be considered cautiously due to elimination of some entries from the test because of severe bird damage.

Hybrids clearly produced more grain per day than did varieties in the comparisons of the yield components. Late maturity hybrids and varieties produced more grain per day or less grain per day than did early hybrids and varieties depending on location and year.

The entries for the second experiment consisted of the Oklahoma Grain Sorghum Performance Test of commercial hybrids tested annually by the Oklahoma Agriculture Experiment Station. In both years, the experimental design for the test was a randomized complete block design with three replications. The test at each location consisted of approximately 100 entries, grouped into late, medium, and early maturity groups of hybrids according to the commercial seed companies' own classification.

Midbloom data showed considerable intermingling of maturity groups and suggested regrouping of the hybrid entries into late, medium, and early maturity groups. The new data set, created by regrouping, was analyzed similar to that for the commercial seed companies' grouping.

Results from the Oklahoma Grain Sorghum Performance Test based on the commercial seed companies' classification for maturity groups indicated that for Perkins (dryland) in 1984 and 1985, the late maturity group of hybrids produced more grain per day compared to that of either early or medium maturity groups of hybrids. Inconsistency among maturity groups for grain production per day could be due partially to high variation within medium and early groups of hyrids. Variables days from planting to black layer and days from planting to midbloom decreased from late to early maturity groups.

Plant height varied significantly among the maturity groups in some comparisons. Usually the late maturity group was taller, but the differences were probably not large. Results from regrouping of the entries based on midbloom data for Perkins in 1984 and 1985 caused very few changes in the conclusions drawn from results based on the commercial seed companies' classification. Results from Goodwell (irrigated) in 1984 showed that the rate of grain production per day was higher for late than for early and medium maturity groups of hybrids. This finding was consistent for all yield component variables. There was a decrease in the magnitude of the growth period variables from late to early maturity groups. Results from Goodwell (irrigated) in 1985 indicated that the grain production per day was similar for the three maturity groups. The growth period variables decreased from late to early maturity groups. Data from Goodwell in 1984 and 1985 showed that, under irrigated conditions, the late hybrids were taller than medium and early hybrids, and medium hybrids were taller than early hybrids.

Regrouping of hybrids for Goodwell in 1984 and 1985 did not cause any major changes in the conclusion drawn from the results of grouping of the entries based on the commercial seed companies' classification.

The evidence suggests that often the late maturity groups of hybrids are more efficient in the production of grain on a daily basis. The late maturity group of hybrids would probably be more productive in tropical areas than the early maturity groups of hybrids.

LITERATURE CITED

1. Afaukwa, J. J., R. K. Crookston, and R. J. Jones. 1984. Effect of temperature and sucrose availability on kernel black layer development in maize. Crop Sci. 24:285-288.

2. Amini, I. 1979. Growth and yield analyses of temperate and "tropically" adapted grain sorghum. (Unpub. Ph.D. thesis, Oklahoma State University).

3. Anderson, W. K. 1975. Maturation of sunflower. Australian J. Exp. Agric. and An. Hus. 15:833.

4. Baker, R. 1971. Black layer development. One way to tell when your corn is mature. Crops and Soils. 24(1):8-9.

5. Bishnoi, U. R. 1974. Physiological maturity of seeds in Triticale hexaploid L. Crop Sci. 14:819-829.

6. Booth, E. G. 1929. Daily growth of the oat kernel and effect on germination of immaturity and controlled low temperature. Minn. Agric. Exp. Stn. Tech. Bull. 62.

7. Crookston, R. K., and D. S. Hill. 1978. A visual indicator of the physiological maturity of soybean seed. Crop Sci. 18:867-870.

8. Daynard, T. B., and W. G. Duncan. 1969. The black layer and grain maturity in corn. Crop Sci. 9:473-476.

9. Denman, C. E., R. W. McNew, R. G. Merritt, H. E. Reeves, and G. L. Strickland. 1985. Performance test of hybrid sorghum and corn in Oklahoma-1984. Okla. Agric. Exp. Stn. Rep. P-868.

10. Eastin, J. D., R. M. Castleberry, W. M. Ross, P. T. Nordquist, C. O. Gardner, R. F. Mumm, and C. Y. Sullivan. 1972. Grain filling period variability in a random mating population. pp. 198-199. In The physiology of yield and management of sorghum in relation to genetic improvement. Univ. of Neb. Ann. Rep. No. 6.

11. Eastin, T. D., J. H. Hultquist, and C. Y. Sullivan. 1973. Physiologic maturity in grain sorghum. Crop Sci. 13:175-178.

12. Eastin, J. D., and C. Y. Sullivan. 1972. Performance of sorghum hybrids under dry land and irrigated conditions. pp. 266-270. In The physiology of yield and management of sorghum in relation to genetic improvement. Univ. of Neb. Ann. Rep. No. 6.

13. Fussel, L. K., and D. M. Dwarte. 1980. Structural changes of grain associated with black region formation in Pennisetum americanum. J. Exp. Bot. 31:645-654.

14. Giles, K. L., H. C. M. Bassett, and J. D. Eastin. 1975. The structure and ontogeny of the hilum region of Sorghum bicolor. Aust. J. Bot. 23:795-802.

15. Harlan, H. V., and M. N. Pope. 1923. Water content of barley kernels during growth and maturation. J. Agric. Res. 23:333-360.

16. Harrington, J. F. 1972. Seed storage and longevity. p. 145. In T. T. Kozlowski (ed). Seed Biology Vol. 3. Academic Press, New York.

17. Hawkins, S. E., C. E. Denman, D. E. Weibel, R. W. McNew, and R. G. Merritt. 1986. Performance test of hybrid sorghum and corn in Oklahoma-1985. Okla. Agric. Exp. Stn. Rep. P-882.

18. Johnson, B. J., and M. D. Jellum. 1972. Effect of planting date on sunflower yield, oil and plant characteristics. Agron. J. 64:747.

19. Kalton, R. R., C. R. Weber, and J. C. Eldredge. 1949. The effect of injury simulating hail damage to soybean. Iowa Agric. Home Econ. Exp. Stn. Res. Bull. 359.

20. Kersting, J. G., F. C. Strikler, and A. W. Pauli. 1961. Grain sorghum caryopsis development. I. Changes in dry weight, moisture percentage, and viability. Agron. J. 53:36-38.

21. Kiesselbach, T. A., and E. R. Walker. 1952. Structure of certain specialized tissue in the kernel of corn. Am. J. Bot. 39:561-569.

22. Kiesselbach, T. A., and W. E. Lyness 1924. Spring small grain. Neb. Agric. Exp. Stn. Bull. 201.

23. Kumar, M. 1975. Use of black layer to study dry matter accumulation in grain sorghum. (Unpub. M.S. thesis, Oklahoma State University).

24. Major, D. J., D. R. Johnson, J. W. Tanner, and I. C. Anderson. 1975. Effect of daylength and temperature on soybean development. Crop Sci. 15:174-179.

25. Miller, F. R., and Y. Kebede. 1981. Genetic contribution to yield gains in sorghum, 1950 to 1980. pp. 1-14. In W. R. Fehr (ed.). Genetic contributions to yield gain of five major crop plants. CSSA Special Pub. No. 7. Madison, Wisconsin.

26. Newton, R. J., D. H. Meckenstock, and F. R. Miller. 1983. Soluble carbohydrates in developing sorghum caryopses. Crop Sci. 23:80-82.

27. Olson, G. A. 1923. A study of factors affecting the nitrogen content of wheat and of the changes that occur during the development of wheat. J. Agric. Res. 24:939-953.

28. Pauli, A. W., F. C. Strickler, and J. R. Lawless. 1964. Developmental phases of grain sorghum (Sorghum vulgare Pers.) as influenced by variety, location, and planting date. Crop Sci. 4:10-13.

29. Quinby, J. R. 1971. Time of physiologic maturity of sorghum parents and hybrids. Sorghum Newsletter. 14:98.

30. Quinby, J. R. 1975. The grain filling period of sorghum parents and hybrids. Crop Sci. 12:690-691.

31. Rench, W. E., and R. H. Shaw. 1971. Black layer development in corn. Agron. J. 63:303-305.

32. Rubel, A., R. W. Rinne, and D. T. Canvin. 1972. Protein, oil and fatty acid in developing soybean seeds. Crop Sci. 12:739-741.

33. Robinson, R. G. 1971. Sunflower phenology-year, variety, and date of planting effects on day and growing degree-day summation. Crop Sci. 11:635.

34. Shaw, R. H., and W. E. Loomis. 1950. Basis for the prediction of corn yield. Plant Physiol. 25:225-244.

35. Weibel, D. E., A. Sotomayor-Rios, H. M. Pava, and R. W. McNew. 1982. Relationship of black layer to sorghum kernel moisture content and maximum kernel weight in the tropics. Crop Sci. 22:219-223.

TABLE XXII

MEANS FOR YIELD, YIELD COMPONENTS, GROWTH PERIODS, AND PLANT HEIGHT FOR INDIVIDUAL ENTRIES IN "SMALL HYBRID-VARIETY TEST" FOR GOODWELL IN 1984

Entry	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
BOK8	3071.0^{f}	36.9^{e}	83.3^{hi}	52.4^{f}	58.7^{h}	124.5^{h}	24.7^{b}	110.3^{hi}
BMA4	3790.3^{ef}	47.4^{de}	80.0^{j}	72.0^{ef}	52.7^{i}	138.8^{gh}	27.3^{ef}	122.6^{bcdefg}
Early Kalo	6281.6^{bcd}	73.0^{abcd}	86.3^{g}	92.0^{abcde}	68.3^{e}	359.0^{a}	18.0^{h}	156.1^{a}
Martin	4885.7^{def}	54.1^{cde}	90.0^{f}	74.7^{def}	65.0^{f}	199.1^{defgh}	25.0^{fg}	120.1^{defg}
BOKY40	5513.9^{cde}	57.1^{bcde}	96.7^{e}	82.8^{bcdef}	66.7^{ef}	184.1^{efgh}	30.0^{de}	127.4^{bcdef}
MA4X783101-1	--[1]	--	--	--	--	--	--	--
Martin X 783101-1	6397.9^{bcd}	78.3^{abc}	81.7^{ij}	110.3^{abcd}	58.0^{h}	270.4^{abcde}	23.7^{g}	129.9^{bc}
CK-60 X 783101-1	6630.6^{bcd}	78.4^{abc}	84.3^{gh}	116.0^{ab}	57.0^{h}	241.8^{bcdef}	27.3^{ef}	129.9^{bc}
Martin X 783503	7049.4^{abcd}	72.9^{abcd}	96.7^{e}	113.2^{abc}	62.3^{g}	205.2^{defgh}	34.3^{ab}	118.3^{fgh}
Redlan X 783505	7049.4^{abcd}	67.4^{abcd}	104.3^{cd}	104.5^{abcde}	67.7^{e}	191.5^{efgh}	36.7^{a}	127.4^{bcd}
A69X63EXROKY62	9562.0^{a}	90.7^{bc}	105.3^{a}	124.9^{a}	76.7^{cd}	333.1^{ab}	28.7^{e}	130.6^{b}
A69X63EXROKY47	8166.1^{ab}	77.5^{abc}	105.3^{bc}	107.0^{abcde}	76.3^{cd}	282.4^{abcde}	29.0^{e}	125.0^{bcdefg}
AOK11XROKY62	8444.8^{ab}	81.2^{ab}	104.0^{cd}	112.6^{abc}	75.0^{d}	291.2^{abcd}	29.0^{e}	120.8^{cdefg}
AOK11XROKY47	6491.0^{bcd}	62.2^{bcd}	104.3^{cd}	84.5^{bcdef}	76.7^{cd}	235.7^{bcdefg}	27.7^{e}	119.3^{efgh}
A73X32EXROKY47	8305.7^{ab}	78.2^{abc}	106.3^{bc}	160.5^{abcde}	78.0^{bc}	293.0^{abcd}	28.3^{e}	119.3^{efgh}
ROKY 62	7049.4^{abcd}	65.4^{abcd}	107.7^{b}	83.1^{bcdef}	84.7^{a}	306.8^{abc}	23.0^{g}	117.6^{gh}
ROKY 47	7886.9^{abc}	67.3^{abcd}	117.3^{a}	92.0^{abcde}	85.7^{a}	251.1^{bcdef}	31.7^{cd}	117.6^{gh}
ROKY 10	6072.2^{bcde}	52.4^{cde}	115.7^{a}	76.3^{cdef}	79.7^{b}	168.1^{fgh}	36.0^{ab}	107.8^{i}
ROKY 15	7956.7^{abc}	77.5^{abc}	102.7^{d}	115.5^{ab}	69.0^{e}	235.8^{bcdefg}	33.7^{bc}	128.1^{bcde}
Redlan	6211.9^{bcd}	59.7^{bcde}	104.0^{cd}	82.8^{bcdef}	75.0^{d}	214.8^{cdefgh}	29.0^{e}	123.2^{bcdefg}

[1] Entry discarded due to severe bird damage.

TABLE XXIII

MEANS FOR YIELD, YIELD COMPONENTS, GROWTH PERIODS, AND PLANT HEIGHT FOR INDIVIDUAL ENTRIES IN "SMALL HYBRID-VARIETY TEST" FOR GOODWELL IN 1985

Entry	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
BOK8	3350.1^{hi}	34.7^{ghi}	95.7^{hi}	53.1^{ghi}	63.3^{e}	100.6^{fgh}	33.3^{ij}	116.9^{fgh}
BMA4	2722.1^{i}	29.2^{i}	93.0^{i}	46.8^{i}	58.3^{fg}	78.2^{defgh}	34.7^{j}	126.7^{cde}
Early Kalo	5095.1^{def}	53.3^{abcde}	96.0^{i}	76.8^{bcde}	66.3^{de}	174.4^{h}	29.7^{abcde}	137.2^{ab}
Martin	3420.0^{ghi}	33.8^{hi}	101.3^{h}	49.3^{hi}	69.7^{c}	109.0^{gh}	31.7^{hij}	116.9^{fgh}
BOKY40	4536.7^{efgh}	42.3^{efgh}	107.3^{fg}	56.7^{defgh}	69.0^{cd}	119.2^{bcdef}	38.3^{ghij}	124.2^{def}
MA4X783101-1	4815.9^{ef}	52.8^{abcde}	91.3^{i}	85.3^{abc}	56.3^{g}	138.2^{cdefg}	35.0^{defghi}	137.9^{a}
Martin X 783101-1	4327.3^{fgh}	45.7^{cdefgh}	94.7^{i}	71.9^{cdef}	60.0^{f}	125.2^{defgh}	34.7^{fghi}	121.8^{defg}
CK-60 X 783101-1	5444.1^{cdef}	57.2^{abcd}	95.3^{i}	91.7^{ab}	59.3^{fg}	152.2^{cdefg}	36.0^{cdefgh}	126.7^{cde}
Martin X 783503	5583.7^{abcdef}	57.8^{abc}	96.7^{hi}	85.0^{abc}	65.7^{e}	180.5^{gh}	31.0^{abcd}	110.3^{h}
Redlan X 783505	6909.7^{a}	65.0^{a}	106.3^{g}	98.2^{a}	70.3^{c}	192.4^{cdefg}	36.0^{abc}	115.2^{gh}
A69X63EXROKY62	5932.6^{abcde}	50.9^{bcde}	116.7^{cd}	76.4^{bcde}	77.7^{b}	152.3^{bcde}	39.0^{cdefgh}	134.0^{abc}
A69X63EXROKY47	6281.6^{abcd}	54.3^{abcde}	115.7^{de}	81.3^{abcd}	77.3^{b}	164.0^{bcdef}	38.3^{bcdefg}	129.8^{bcd}
AOK11XROKY62	6840.0^{ab}	61.7^{ab}	111.0^{efg}	87.5^{abc}	78.3^{b}	209.0^{gh}	32.7^{a}	126.7^{cde}
AOK11XROKY47	6630.6^{abc}	60.8^{ab}	109.0^{fg}	88.5^{abc}	75.0^{b}	196.6^{efgh}	34.0^{ab}	120.1^{efg}
A73X32EXROKY47	5513.9^{bcdef}	47.2^{cdefg}	117.0^{cd}	71.0^{cdefg}	77.7^{b}	141.6^{bcd}	39.3^{defghi}	113.4^{gh}
ROKY 62	5374.3^{cdef}	44.4^{defgh}	121.0^{bc}	60.1^{efghi}	89.3^{a}	169.8^{gh}	31.7^{abcdef}	117.6^{fgh}
ROKY 47	4815.9^{ef}	38.1^{fghi}	126.7^{a}	55.4^{fghi}	86.7^{a}	121.6^{bc}	40.0^{ghi}	111.0^{h}
ROKY 10	4676.3^{efg}	37.6^{fghi}	124.3^{ab}	59.6^{efghi}	78.3^{b}	101.7^{a}	46.0^{ij}	110.3^{h}
ROKY 15	5653.4^{abcdef}	50.3^{bcdef}	112.3^{def}	80.9^{abcd}	70.0^{c}	133.6^{ab}	42.3^{efghi}	121.8^{defg}
Redlan	5374.3^{cdef}	47.8^{cdef}	112.3^{def}	70.1^{cdefg}	76.7^{b}	151.4^{cdefg}	35.7^{cdefgh}	127.4^{cde}

TABLE XXIV

MEANS FOR YIELD, YIELD COMPONENTS, GROWTH PERIODS, AND PLANT HEIGHT FOR INDIVIDUAL ENTRIES IN "SMALL HYBRID-VARIETY TEST" FOR PERKINS IN 1984

Entry	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
BOK8	3794.6^{fg}	46.5^{def}	81.7^{hi}	71.2^{cde}	53.3^{j}	133.8^{fgh}	28.3^{def}	98.7^{b}
BMA4	2981.4^{g}	38.8^{f}	77.0^{j}	62.2^{e}	48.0^{l}	103.2^{h}	29.0^{cdef}	103.6^{b}
Early Kalo	4987.1^{bcdef}	60.4^{abcde}	82.7^{hi}	90.7^{abcd}	55.0^{ij}	181.0^{abcdef}	27.0^{ef}	114.4^{ab}
Martin	4336.6^{cdefg}	47.6^{cdef}	91.0^{efg}	72.7^{cde}	59.7^{efg}	138.5^{efgh}	31.3^{abcde}	106.1^{b}
BOKY40	4174.0^{efg}	45.5^{ef}	91.0^{efg}	71.0^{cde}	58.7^{gh}	126.8^{gh}	33.0^{abc}	112.7^{ab}
MA4X783101-1	4282.4^{defg}	58.1^{abcde}	73.7^{k}	97.3^{abc}	44.0^{m}	144.0^{defgh}	29.7^{cdef}	124.2^{a}
Martin X 783101-1	4824.5^{bcdef}	58.1^{abcde}	83.0^{hi}	95.3^{abc}	50.7^{k}	149.9^{cdefgh}	32.3^{abcd}	110.3^{ab}
CK-60 X 783101-1	5041.3^{bcdef}	63.3^{abc}	79.7^{ij}	101.4^{ab}	49.7^{kl}	168.0^{bcdefg}	30.0^{cdef}	112.7^{ab}
Martin X 783503	4932.9^{bcdef}	61.8^{abcde}	79.7^{ij}	92.2^{abcd}	53.7^{j}	188.9^{abcde}	86.0^{f}	102.9^{b}
Redlan X 783505	5746.1^{abc}	67.9^{ab}	84.7^{h}	102.0^{ab}	56.7^{hi}	204.0^{ab}	28.0^{def}	105.4^{b}
A69X63EXROKY62	5529.2^{abcde}	61.4^{abcde}	90.3^{fg}	88.9^{abcde}	63.7^{bc}	211.5^{ab}	26.7^{f}	104.6^{b}
A69X63EXROKY47	5691.8^{abcd}	64.0^{abc}	89.0^{g}	96.4^{abc}	59.0^{fgh}	190.7^{abcd}	30.0^{cdef}	109.5^{ab}
AOK11XROKY62	5312.4^{abcde}	54.5^{bcdef}	97.3^{ab}	85.0^{abcde}	62.3^{bcd}	152.8^{cdefgh}	35.0^{a}	111.0^{ab}
AOK11XROKY47	5312.4^{abcde}	55.0^{bcdef}	96.7^{b}	86.7^{abcde}	61.3^{cdef}	150.2^{cdefgh}	35.3^{a}	109.5^{ab}
A73X32EXROKY47	6613.4^{a}	71.6^{a}	92.3^{defg}	106.7^{a}	62.0^{cde}	218.0^{a}	30.3^{bcdef}	109.5^{ab}
ROKY 62	4932.9^{bcdef}	49.2^{cdef}	100.3^{a}	73.7^{cde}	67.0^{a}	148.1^{cdefgh}	33.3^{abc}	109.5^{ab}
ROKY 47	6017.1^{ab}	62.7^{abcd}	96.0^{bc}	93.2^{abcd}	64.7^{b}	195.0^{abc}	31.3^{abcde}	103.6^{b}
ROKY 10	4716.1^{bcdef}	50.3^{cdef}	94.0^{bcde}	75.5^{bcde}	62.7^{bcd}	150.1^{cdefgh}	31.3^{abcde}	109.5^{ab}
ROKY 15	4228.2^{efg}	45.6^{ef}	92.7^{cdef}	67.5^{de}	62.7^{bcd}	141.1^{defgh}	30.0^{cdef}	112.0^{ab}
Redlan	4336.6^{cdefg}	45.6^{ef}	95.7^{bcd}	71.5^{cde}	61.0^{defg}	126.1^{gh}	34.7^{ab}	113.4^{ab}

TABLE XXV

MEANS FOR YIELD, YIELD COMPONENTS, GROWTH PERIODS, AND PLANT HEIGHT FOR INDIVIDUAL ENTRIES IN "SMALL HYBRID-VARIETY TEST" FOR PERKINS IN 1985

Entry	Yield Kg/ha	Grain/Day From PL to BL Kg/ha	Days to BL	Grain/Day From PL to MB Kg/ha	Days to MB	Grain/Day From MB to BL Kg/ha	Days From MB to BL	Plant Height cm
BOK8	2942.1^{bcd}	32.3^{bcd}	91.0^{h}	56.2^{bc}	52.3^{g}	75.8^{bcd}	38.7^{ef}	103.6^{f}
BMA4	2240.6^{d}	25.7^{cd}	87.3^{i}	44.8^{c}	50.0^{h}	59.9^{d}	37.3^{f}	114.4^{bcdef}
Early Kalo	2174.8^{d}	22.8^{d}	95.0^{g}	38.9^{c}	56.0^{ef}	55.9^{d}	39.0^{ef}	127.4^{a}
Martin	2574.9^{cd}	26.4^{cd}	97.3^{f}	45.3^{c}	57.0^{def}	63.7^{cd}	40.3^{de}	108.5^{ef}
BOKY40	--[1]	--	98.3	--	57.0	--	41.3	114.4
MA4X783101-1	--	--	87.0	--	44.3	--	42.7	144.6
Martin X 783101-1	--	--	87.3	--	50.0	--	37.3	117.6
CK-60 X 783101-1	--	--	89.3	--	50.3	--	39.0	122.5
Martin X 783503	4939.0^{abc}	51.6^{ab}	96.0^{fg}	89.0^{ab}	55.3^{f}	123.4^{ab}	40.7^{de}	103.6^{f}
Redlan X 783505	5973.2^{a}	59.5^{a}	100.0^{e}	103.4^{a}	57.7^{cde}	140.3^{a}	42.3^{cd}	113.4^{bcdef}
A69X63EXROKY62	4878.7^{abc}	47.4^{abc}	103.0^{d}	78.7^{abc}	62.0^{b}	112.2^{abc}	41.0^{de}	126.7^{a}
A69X63EXROKY47	--	--	106.7	--	59.7	--	47.0	127.4
AOK11XROKY62	4427.0^{abcd}	42.8^{abcd}	103.7^{d}	74.6^{abc}	59.3^{c}	100.5^{abcd}	44.3^{bc}	117.6^{abcde}
AOK11XROKY47	3734.3^{abcd}	35.6^{abcd}	105.0^{cd}	63.5^{abc}	59.0^{c}	81.0^{bcd}	46.0^{ab}	122.5^{abc}
A73X32EXROKY47	5298.8^{ab}	49.8^{abc}	106.7^{bc}	90.8^{ab}	58.3^{cd}	110.2^{abcd}	48.3^{a}	124.2^{ab}
ROKY 62	3053.7^{bcd}	27.0^{cd}	113.0^{a}	46.5^{c}	65.7^{a}	64.5^{cd}	47.3^{a}	109.5^{def}
ROKY 47	2394.2^{d}	22.3^{d}	107.7^{b}	37.9^{c}	63.3^{b}	53.9^{d}	44.3^{bc}	112.7^{cdef}
ROKY 10	--	--	103.0	--	58.7	--	44.3	110.3
ROKY 15	4291.5^{abcd}	40.5^{abcd}	106.0^{bc}	72.6^{abc}	59.0^{c}	91.8^{abcd}	47.0^{ab}	116.9^{abcde}
Redlan	3877.3^{abcd}	37.4^{abcd}	103.7^{d}	68.1^{abc}	57.0^{def}	83.1^{bcd}	46.7^{ab}	120.1^{abcd}

[1] Entry discarded due to severe bird damage.

VITA

Ahmadreza Rafie

Candidate for the Degree of

Doctor of Philosophy

Thesis: A COMPARISON OF THE EFFICIENCY OF EARLY MATURING VS. LATE MATURING SORGHUMS FOR GRAIN PRODUCTION

Major Field: Agronomy--Crop Science

Biographical:

Personal Data: Born in Nahavan, Iran, April 2, 1952, the son of Mohamadreza and Vajihe Rafie. Married to Carlin McGinn on August 17, 1985; with one son, Bryan Arash.

Education: Graduated from Kharazmi High School at Tehran in May, 1969; received Bachelor of Science degree in Agriculture Engineering from Hamedan Agriculture College in December, 1974; received the Master of Science degree from Tarleton State University, Stephenville, Texas, in December, 1979; received Doctoral degree in Agriculture Education at Oklahoma State University in May, 1984; completed requirements for the Doctor of Philosophy degree at Oklahoma State University in July, 1987.

Professional Experience: Vocational Agriculture Teacher, Shiraz, Iran, 1974-1976; Research Coordinator, Agrotechnique Company, Tehran, Iran, 1977-1978; Graduate Teaching and Research Assistant, Department of Statistics, 1983-1984; Graduate Teaching and Research Assistant, Department of Agronomy, 1984-1986; Visiting Professor, Department of Agriculture Education, Oklahaoma State University, 1986 to present.