EFFECTS OF DELAYED HARVEST ON SOYBEAN YIELD, SEED QUALITY, VIABILITY, AND VIGOR

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TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

CHAPTER I

INTRODUCTION

Yield losses due to late harvest are recognized as a major production problem for the Oklahoma soybean industry. Traditionally, Oklahoma farmers grow maturity group (MG) V and VI. They plant in May and June and harvest in October and November (Sholar and Edwards, 1997). For maximum yields mid-May to mid-June plantings are necessary. But farmers can plant either earlier or later than this optimum period by carefully choosing the maturity group and cultivar. According to Sholar and Edwards (1997) maturity group III and IV for early season production and V for full season production are best for Oklahoma. Full season group IV soybeans perform best in NE Oklahoma when planted between mid-May to mid-June, whereas full season group V soybeans perform well in Central, NE and SE Oklahoma when planted after June 1. But no matter when soybeans are planted, timely harvest is very important for maximum soybean yields and seed quality. Soybean seed quality progressively deteriorates by delay in harvesting (Wilcox et al., 1974). The perfect time for harvesting early season group III and IV soybeans is early-September and mid-September, respectively. Full season (June planted) group IV and V should be harvested in the middle of October and first week of November, respectively. Unfortunately, farmers may not be able to harvest at the proper time due to unfavorable weather conditions, especially fall-rains. The objective of this study is to determine which maturity group and cultivar can best tolerate extensive harvest delays with minimum effects on yield, seed quality, viability and vigor. Another objective is to determine how much delay in harvesting can be tolerated by several soybean cultivars without affecting their yield and seed quality. This information will

help Oklahoma farmers select the proper maturity group(s) and cultivar(s) to improve their potential for a good crop even when there are unfavorable weather conditions during the harvest period.

Little information is available about the degree of deterioration in seed yield, vigor, viability, and quality of different commercial cultivars due to harvest delay. Extensive research is necessary with a range of commercial cultivars to determine which ones can best tolerate harvest delay and field weathering. Information obtained from this study will be beneficial for making management decisions by farmers.

CHAPTER II

LITERATURE REVIEW

A delay in harvesting soybeans of 8 to 10 weeks significantly reduced the seedling emergence from the harvested seed by 10 to 49 percentage points (Wilcox et al., 1974). Many state and federal seed laws and certification programs require soybean seeds to germinate at least 80%. Harvesting delays of two to three weeks are enough to reduce germination percentage below 80%. However, some cultivars exhibited above 80% germination even after very late harvest, i.e. December 15. Thus, the effect of harvest delays may be partially overcome by using selected cultivars.

According to Tecrony et al. (1980), soybean seed quality is adversely affected by freezing temperatures prior to harvest. Freeze damaged seeds are generally lower in vigor. Temperatures below -2.2°C produced significant decreases in germination percentage though the extent of loss depended on seed maturity at that time. At -17.2°C, it only takes four hours for green pod soybeans to suffer extensive germination reductions. Yellow pod soybeans will have some reduction in germination but normally will stay above 80% germination. At -12.2°C all soybeans, except the brown podded mature ones, will be killed in one or two hours and the brown podded beans will suffer reductions of germination into the 70's in less than an hour. Almost every year Oklahoma soybeans are affected by a freeze event prior to harvest. The following chart by Dr. Dennis Tecrony shows the freezing point temperature for soybeans at different moisture levels.

% Seed Moisture	Pod color	Freezing Point °C
70	Green	-2.2
60	Green-yellow	-3.3
50	Yellow	-6.6
40	Yellow-brown	-12.2
30	Brown	-15

According to Wilcox et al. (1974), deterioration of seed quality due to late harvest was also associated with infection of the seed by *Diaporthe phaseolorum* var. *sojae*. *Diaporthe* infection is one of the major disease problems in Oklahoma (Conway, 1998). To overcome this problem, prompt harvest or resistant cultivars are necessary. Field weathering resulting from delayed harvest increased susceptibility to mechanical injury and caused disease infection (Green et al., 1966; Metzer, 1967). According to Moore (1971), alternate wetting and drying of seeds in the field caused embryo destruction and lower quality.

Tecrony et al. (1980) reported that though seed viability remains the same after a harvest delay of one to two months, seed vigor declined rapidly after four to thirty-nine days of harvest delay. High vigor seeds produced better soybean stands (especially under adverse soil conditions) than low vigor seeds even if they have acceptable standard germination percentages (Tecrony and Egli, 1977; Johnson and Wax, 1978). However, seed vigor declination after maturity was closely related to air temperature, relative humidity, and precipitation. The decline in seed vigor following maturity was hastened

by high temperatures and moist conditions (Tecrony et al., 1980). Thus it appears that late maturing cultivars as well as delays in planting may provide a more favorable field environment for soybean seed development and maturation in most soybean producing areas. This is supported by reports from certified seed producers that higher seed quality occurs for early maturing cultivars when produced following wheat in a double crop situation compared to conventional planting at normal spring dates. Even though later planting may improve seed quality, it delays maturation and increases the chances of freezing temperature occurring prior to harvest. That is why later planting is not always recommendable. However, Wilcox et al. (1974) concluded that early maturing cultivars were more adversely affected by delayed harvest than late maturing cultivars. Declines in seed vigor following harvest maturity occurred three to six weeks sooner than similar declines in viability (Tecrony et al., 1980).

In 1978, Paschal and Ellis reported that genetic variability exists for seed quality characters. Tecrony et al. (1984) reported that small seed size and high seed coat impermeability might improve soybean seed quality. Also hard seeded cultivars may show more resistance to field weathering.

Soybean seed quality can be reduced by a wide range of environmental factors during seed production both before and after the seed reaches harvestable moisture content. (Delouche, 1974). Soybean seed attains its highest potential quality at physiological maturity (maximum dry seed weight) (Andrews, 1966, Wahab and Burris; 1971; Delouche, 1974) and remains high until harvest maturity.

It appears that soybean seed quality at harvest is determined by environmental conditions both before and after the seed reaches a harvestable moisture level. The two

environmental variables which were found to be most detrimental to seed vigor following harvest maturity were high temperatures and /or high levels of moisture (Tecrony et al., 1980).

There was a quadratic relationship between the mean air temperature during the period from harvest maturity to the first significant decline in seed vigor and the length of the period. As the average air temperature during the period decreases from 20 to 12°C, the number of days to the first significant decline in vigor increased from approximately 5 to 40 days (Tecrony et al., 1980).

CHAPTER III

MATERIALS AND METHOD

1. CULTURAL PRACTICES

This experiment was conducted at the Central Oklahoma Research Station Complex, Chickasha (irrigated) on a McCLain silty clay loam soil (dark reddish-brown, friable) lying on nearly level benches above overflow and the Vegetable Research Station, Bixby (rainfed) on a Wynona silt loam soil (Cumulic Haplaquolls) with 0 to 1% slope in 1997 and 1998. Soybeans were planted by an experimental plot planter as a monocrop on June 4, 1997 and June 17, 1998 at Bixby and June 12, 1997 and May 29, 1998 at Chickasha. No fertilizer was applied to the fields. Soil test indicated that no phosphorus or potassium was needed. All seeds were inoculated with *Rhyzobium japonicum*. For weed control, a pre-emergence herbicide (Treflan) was applied at the rate of 1.632 l/ha. One cultivation was also conducted with a cultivator and tractor. Manual weeding was used in both fields to maintain weed-free conditions. No insecticide or pesticide was used. Seeds were machine planted using 8 seeds/foot on a 75 cm row spacing (approximately 3 seeds per square foot) at Bixby and using 10 seeds/foot on a 100 cm row spacing (approximately 3 seeds per square foot) at Chickasha with 4 rows/plot. Soybeans were first harvested (50 square feet) by an experimental plot harvester at harvest maturity and then at regular intervals (second harvest - three to four weeks after first harvest; third harvest - two to three weeks after second harvest; fourth harvest - two to three weeks after third harvest) at each station. Tables I and II show the exact harvest dates at both locations in both years.

2. EXPERIMENTAL DESIGN

The experimental design for maturity group IV was a split-plot design with the main plot in a randomized complete block design with three replication. Cultivars were the main plot treatments and harvest dates were subplots. The four rows in each main plot were randomly selected and assigned a harvest date. The same design was applied for maturity group V.

Five cultivars in MG IV and five cultivars in MG V were evaluated:

Cultivars/ Germplasm

MG IV	MG V
1. Manokin	1. Holiday
2. Chesapeake	2. Hutcheson
3. Delsoy 4710	3. Graham
4. Stressland	4. Delsoy 5500
5. OK 916005, Essex/Oksoy	5. OK 896001, Essex/Gail

3. DATA OBTAINED AND METHOD OF ANALYSIS

After harvest all samples were threshed and cleaned. A total weight (g/plot) and 100 seed weight (g/100 seed) of each sample were taken. Standard germination tests for seed viability and speed of germination and accelerated-aging germination tests for seedling vigor were conducted. General seed quality and condition were determined by visual observation.

Standard germination:

This germination test was conducted according to the "Rules for Testing Seeds" published by the Association of Official Seed Analysts (AOSA) (Volume 16, Number 3, 1993).

Four 50 seed replications of each sample were planted in rolled paper towels (Towel Method) and kept in a germination chamber at 20-30°C for seven days. Sixteen paper towels were prepared for each sample. They were kept in water for a few minutes for soaking. Two of the paper towels were placed on a wax paper. Fifty seeds were spread evenly on the paper towels. Then the seeds were covered with another two paper towels. The seeds and towels were rolled keeping the wax paper as the outer layer. The wax paper was folded to cover the bottom portion of each roll. This process was repeated four times for each sample. The four rolls for each sample were tied together and labeled. The bundle of rolls was placed erectly in a three-partition container, with three bundles in each partition and were placed into the germination chamber at 20 to 30°C.

Seedling counts were conducted at four (first count) and seven (final count) days after planting. Seedlings were evaluated for normal ("seedlings possessing the essential structures that are indicative of their ability to produce plants under favorable conditions", as defined by AOSA), abnormal ("all seedlings that cannot be classified as normal seedlings", as defined by AOSA), and dormant ("viable seeds, other than hard seeds, which fail to germinate when provided the specified germination conditions for the kind of seed in question", as defined by AOSA) seedlings.

Speed of germination:

This test was conducted according to Tecrony et al. (1984).

At the first count (after 4 days) of the standard germination test, strong (no primary root missing; no breaking, lesions, necrosis, twisting or curling on hypocotyl; no cotyledon missing or no necrosis in one or both cotyledons; no partial decay on epicotyl or one primary leaf missing; no spindly, poorly developed or short overall length of total seedling, as defined by AOSA) and long (more than 3.75 cm) seedlings were counted separately to determine the speed of germination.

Accelerated-aging germination:

This test was conducted according to "Seed Vigor Testing Handbook" published by the Association of Official Seed Analysts (1993) with some modification.

The concept of the "Tray method" (McDonald and Phaneendranath, 1978) was used with modifications depending upon the availability of materials. A plastic box of 5 .625 cm X 12.5 cm X 3.125 cm was used for each sample. Sixty ml of water was added to the box. Inside the plastic box was placed a 12.8 cm X 12.5 cm plastic net, which was held, above the water by small pieces of Styrofoam. The net was placed above the water surface in such a way that it did not touch the water. Approximately 40 g of seed was placed on the net in the plastic box, one layer deep. Then the sealed box was placed into an incubator at 41°C and high relative humidity (100%) for 72 hours. Care was taken during the operation to keep the seeds from touching the water layer. The thermostat (temperature sensor) was kept at the same level as the seeds in the aging chamber to insure temperature regulation. The incubator was not opened during the aging period. After the aging period, standard germination tests were conducted with these aged seed samples.

All data were subjected to analysis of variance and mean separation by LSD. One-way analyses were conducted with the twenty means (at each location each year) which represented combinations of harvest dates and cultivars.

CHAPTER IV

RESULTS AND DISCUSSION

Analyses of variance (ANOVA) with mean separation by LSD were conducted on the data including yield, 100 seed weight, germination, speed of germination, and germination after accelerated aging. An ANOVA was conducted separately for each maturity group at each research station each year.

Table III identifies cultivar X harvest date interactions for all the data. No cultivar X harvest date interactions were observed for yield except MG IV at Chickasha in 1998. So, the combined effects of cultivar and harvest dates were considered at all other locations.

Table IV shows the mean yield data combining all four harvest dates of MG IV cultivars from each location each year except at Chickasha in 1998. In 1997 at Bixby, Manokin produced the highest yield (1516 g/plot) followed by OK916005 (1413 g/plot) and Delsoy 4710 (1240 g/plot). However, the yield difference between Manokin and OK916005 was not significant. Delsoy 4710 yielded significantly lower than Manokin and OK 916005. There was no significant yield difference between Stressland (978 g/plot) and Chesapeake (919 g/plot) but they yielded significantly lower than the other three cultivars. In 1997 at Chickasha, Manokin produced the highest yield (983 g/plot) followed by Delsoy 4710 (760 g/plot), OK916005 (691 g/plot), Chesapeake (597 g/plot), and Stressland (580 g/plot). There was no significant yield difference between Manokin and Delsoy 4710. The yield of OK916005 was significantly lower than Manokin but not different from the other cultivars. In 1998 at Bixby, Manokin produced a significantly higher yield (731 g/plot) than OK916005 (498 g/plot), Chesapeake (368 g/plot),

Delsoy4710 (355 g/plot), and Stressland (341 g/plot). The yield of OK916005 was significantly greater than the other three cultivars. These results show that Manokin was the superior MG IV cultivar since it produced the highest yields in all experiments. Delsoy 4710 and OK916005 were in top significance group in only one of the three experiments. Stressland and Chesapeake were always in the lowest yielding groups.

Table V shows the mean yield data combining all MG IV cultivars in each harvest date from each location each year except at Chickasha in 1998. In 1997 at Bixby, the yield of harvest date one (1342 g/plot) was significantly better than harvest date four (1151 g/plot) and two (1113 g/plot) but not different from harvest date three (1246 g/plot). Harvest date three gave a significantly better yield than harvest date two but it was not significantly different from harvest date four. There was no significant yield difference between harvest dates four and two. In 1997 at Chickasha, the yield of harvest date one (841 g/plot) was significantly better than harvest date two (698 g/plot) and four (609 g/plot) but not different from harvest date three (741 g/plot). Harvest date three gave a significantly better yield than harvest date four but it was not significantly different from harvest date two. There was no significant yield difference between harvest dates four and two. In 1998 at Bixby, harvest date one (530 g/plot) gave the best results followed by two (512 g/plot), three (427 g/plot), and four (365 g/plot). Yields of harvest dates one and two were significantly better than harvest dates three and four. The yield of harvest date three was significantly better than harvest date four. These results show that harvest date one was better than the other dates since it produced the highest yield in each experiment. Harvest two was in the top significance group once and harvest date three twice. Harvest date four was always in the lowest yielding group.

Table VI shows the mean yield data combining all four harvest dates of MG V cultivars from each location each year. In 1997 at Bixby, there was no significant difference in yield among the cultivars. However, Delsoy 5500 produced the highest yield (1263 g/plot). In 1997 at Chickasha, OK896001 produced the highest yield (1308 g/plot) followed by Graham (1182 g/plot) and Holiday (1154 g/plot). However, the yield was not significantly different among those three cultivars. Yields of Hutcheson (1063 g/plot) and Delsoy 5500 (1053 g/plot) were significantly lower than OK 896001 but not different from Holiday and Graham. In 1998 at Bixby, Hutcheson (849 g/plot) and Delsoy 5500 (849 g/plot) produced significantly better yields than the other three cultivars. There was no significant yield difference among the other three cultivars. In 1998 at Chickasha, there was no significant difference in yield among all the cultivars. These results show that all the cultivars produced more or less good yields at all locations and each was in the top significance group in three of the four experiments.

Table VII shows the mean yield data combining all MG V cultivars in each harvest date from each location each year. In 1997 at Bixby, harvest date two (1417 g/plot) gave the best yield followed by harvest date one (1377 g/plot), three (1338 g/plot), and four (803 g/plot). However, yields of harvest date one and two were not significantly different. Also, the yields of harvest date one and three were not significantly different. The yield of harvest date four was significantly inferior compared to the yields of the other three dates. In 1997 at Chickasha, there was no significant difference in yield betwen any harvest dates. In 1998 at Bixby, harvest date four (787 g/plot) produced the best yield followed by harvest date three (786 g/plot) and one (742 g/plot). However, yields of those harvest dates were not significantly different. The yield of harvest date

two (719 g/plot) was significantly lower than the yields of harvest date three and four but not different from harvest date one. In 1998 at Chickasha, harvest date one (1335 g/plot) produced the highest yield followed by three (1108 g/plot), two (1050 g/plot), and four (892 g/plot). The yield of harvest date one was significantly superior and yield of harvest date four was significantly inferior compared to the others. These results show that harvest date one was better since it was in the top significance group in all experiments. The other three dates were in the top significance group in two of the four experiments. Harvest date four was in the lowest yielding group in two experiments.

Yield of MG IV at Chickasha in 1998 shows a cultivar X harvest interaction (Table III). Table VIII shows the mean yield data of each MG IV cultivar at each harvest date at Chickasha in 1998. The yield of Manokin at all harvest dates, OK916005 at harvest dates one and two, and Stressland and Chesapeake at harvest date one were in the top significance group. At Harvest date one, the yield of Delsoy 4710 (897 g/plot) was significantly lower than the other four cultivars. There was no significant yield difference among the other cultivars. At harvest date two, Manokin (1467 g/plot) and OK916005 (1404 g/plot) produced significantly better yields than the other three cultivars. At harvest date three and four, Manokin produced significantly better yields (1268 g/plot and 1338 g/plot, respectively) than the other cultivars. These results show that Manokin was the superior MG IV cultivar since it was in the top significance group at all harvest dates. OK916005 was in the top significance group at harvest dates one and two. Stressland and Chesapeake were in the top significance group only at harvest date one. Delsoy 4710 was never in the top significance group for yield. Though yield of MG IV at Chickasha in

1998 shows a cultivar X harvest dates interaction, the trend is the same as the combined data from the other experiments.

No cultivar X harvest date interaction was observed for 100 seed weight except MG IV at Chickasha in 1998 and MG V at Chickasha in 1997 (Table III). So, the combined effects of cultivar and harvest dates were considered at all other locations.

Table IX shows the mean 100 seed weight data combining all four harvest dates of MG IV cultivars from each location each year except at Chickasha in 1998. In 1997 at Bixby, Delsoy 4710 (15.4 g) gave a significantly greater 100 seed weight compared to the other four cultivars. OK916005 (13.7 g) gave a significantly greater seed weight than Manokin (13.1 g), Stressland (12.2 g), and Chesapeake (12.1 g). There was no significant seed weight difference between Stressland and Chesapeake but they gave significantly lower seed weights than the other three cultivars. In the same year at Chickasha, Delsoy 4710 (14.1 g) gave a significantly greater seed weight than the other four cultivars. But contrary to Bixby, smaller seed weights were observed for Manokin (11.6 g) and OK916005 (11.4 g). There was not a significant difference between these two, but each was significantly lower than Delsoy 4710, Stressland (12.9 g), and Chesapeake (12.9 g). In 1998 at Bixby, Delsoy 4710 (13.7 g) gave the greatest 100 seed weight but it was not significantly better than Manokin (13.0 g) and OK916005 (12.8 g). The seed weight of Stressland (11.2 g) and Chesapeake (11.3 g) were significantly lower than Delsoy 4710 but not different from Manokin and OK916005. These results show that Delsoy 4710 produced the greatest 100 seed weight in all the experiments. Manokin and OK916005 were in the top significance group in only one of the three experiments.

Table X shows the mean 100 seed weight data combining all MG IV cultivars in each harvest date from each location each year except at Chickasha in 1998. In 1997 at Bixby, harvest date one (14.0 g) gave a significantly larger100 seed weight than harvest date two (12.7 g), three (13.3 g), and four (13.2 g). Harvest date three and four was not significantly different but they were significantly greater than harvest date two. In 1997 at Chickasha, harvest date one (13.0 g) gave a significantly greater 100 seed weight than two (12.5 g), three (12.2 g), and four (12.7g). The 100 seed weight of harvest date four and two were not significantly different. The 100 seed weight of harvest date three was not significantly different than harvest date two but significantly lower than harvest date four. In 1998 at Bixby, there was no significant difference in seed weight among any of the harvest dates. These results show that harvest date one was in the top significance group in all these experiments. The other three dates were in the top significance group in only one of the three experiments.

Table XI shows the mean 100 seed weight data combining all four harvest dates of MG V cultivars from each location each year except at Chickasha in 1997. In 1997 at Bixby, OK896001 (17.8 g) gave a significantly greater 100 seed weight than each of the other cultivars. The 100 seed weights of all other cultivars were not significantly different. In 1998 at Bixby, OK896001 (18.0 g) also produced a significantly greater 100 seed weight than all other cultivars. Holiday (13.1 g) gave the lowest 100 seed weight. The 100 seed weight of Holiday was not significantly different than Delsoy 5500 (14.0 g) and Graham (13.9 g) but was significantly lower than Hutcheson (14.7 g). In 1998 at Chickasha, there was no significant difference in 100 seed weight among any cultivars. However, OK896001 gave the highest seed weight. These results shows that OK896001

produced the greatest 100 seed weight of the MG V cultivars in all experiments. All other cultivars were in the top significance group in only one of the three experiments. Overall Hutcheson produced the second heaviest seeds.

Table XII shows the mean 100 seed weight data combining all MG V cultivars in each harvest date from each location each year except at Chickasha in 1997. In 1997 at Bixby, there was no significance difference in 100 seed weight among any harvest dates. In 1998 at Bixby, harvest date one (15.0 g) gave a significantly greater 100 seed weight than harvest date two (14.6 g) and three (14.4 g) but it was not significantly different from harvest date four (15.0 g). In 1998 at Chickasha, there was no significant difference in seed weight among the harvest dates. These results show that harvest date one and four were associated with the heaviest seeds since they were in the top significance group in all experiments. The other two dates were in the top significance group in two of the three experiments.

The 100 seed weight of MG IV cultivars at Chickasha in 1998 shows a cultivar X harvest interaction (Table III). Table XIII shows the mean 100 seed weight data of all MG IV cultivars in each harvest date at Chickasha in 1998. Delsoy4710 (16.8 g) and OK916005 (16.0 g) at harvest date two produced the heaviest seeds and were in the top significance group. Delsoy 4710 was in the second heaviest group at harvest dates one (15.3 g), three (15.7 g), and four (15.5 g). These results agree with the combined data over all harvest dates (Table IX), i.e. Delsoy 4710 produced the heaviest seeds. Harvest date does not appear to adversely affect seed weight since harvest date one appears to be superior (Table X) in combined data but harvest date two for Delsoy 4710 and OK916005.

The 100 seed weight of MG V cultivars at Chickasha in 1997 shows a cultivar X harvest interaction (Table III). Table XIV shows the mean 100 seed weight data of all MG V cultivars at each harvest date at Chickasha in 1997. OK896001 at harvest date one (16.7 g), two (16.8 g), and four (17.2 g) produced the heaviest seeds and were in the top significance group. OK896001 was in the second heaviest group at harvest date three (15.7 g). These results agree with the combined data over all harvest dates (Table XI) i.e. OK896001 produced the heaviest seeds. Harvest date does not appear to adversely affect seed weight.

Germination percentage, speed of germination, and accelerated aging test showed cultivar X harvest date interactions in most cases (Table III). They will be discussed individually.

Table XV shows the germination percentage of all MG IV cultivars at each harvest date at each location each year. In 1997 at Bixby, OK916005 gave the highest germination percentage (more than 80%) at each harvest date. Even the germination percentage of OK916005 at harvest date three (93.2%) was significantly better than the germination percentage of Manokin at harvest date one (81.3%). Manokin gave the second best result (more than 80% germination at harvest dates one and three). Chesapeake exhibited more than 80% germination at harvest date one but not at the other dates. Stressland and Delsoy 4710 did not reach 80% germination at any of the dates. For all five cultivars there was a big drop at harvest date two. At harvest date three, there was some recovery with a decline at harvest date four. This phenomenon may be explained by the weather conditions prior to harvest. At the first, third, and fourth harvest date, the Bixby Research Station did not experience any rain during the previous seven days. The

mean temperatures were 15.16°C, 13.16°C, and 6°C, on harvest days one, three, and four, respectively. Conversely, there was 1.075 cm of rain during the last two days before the second harvest date. The mean temperature on harvest day two was 1°C. Rainfall just prior to harvest and/or low temperatures at harvest may have affected germination of the harvested seeds. In 1997 at Chickasha, all five cultivars gave more than 80% germination at harvest date one. The biggest drop in germination percentage was observed at harvest date three for all cultivars except Manokin. In the case of Manokin, the biggest drop was observed at harvest date two. Manokin's harvest date two was closer to the other cultivars' harvest date three (Manokin is a late MG IV). Except for harvest date one, Delsoy4710 and Stressland gave poor results (less than 80% germination). Chesapeake gave more than 80% germination at harvest date two but not in three or four. Manokin showed more than 80% germination in all cases except harvest date two. OK916005 did not reach 80% germination at harvest dates two and three. There was a rainfall before the second harvest date for Manokin and third harvest date for the other cultivars but no rainfall before the fourth one. Again, rainfall just prior to harvest appears to be associated with a large drop in germination percentage. In 1998 at Bixby, there was no significant difference in germination percentage among all the cultivars at harvest date one. However, only Delsoy 4710 gave more than 80% germination. OK916005 was in the high significance group for germination percentage in each of its four harvest dates. However, only harvest date four gave more than 80% germination. OK916005, Delsoy 4710, and Cheasepeake showed a gradual decrease until harvest date three and then slightly recovered at harvest date four. Manokin and Stressland showed a gradual decrease until harvest date four. At this location, rainfall was observed before each

harvest date. In 1998 at Chickasha, all the cultivars germinated more than 80% at harvest date one except Delsoy 4710. Stressland and Chesapeake germinated more than 80% at each of the first three harvest dates. OK916005 germinated more than 80% at all dates except harvest date two. Manokin did not germinate above 80% at harvest dates two and four. Delsoy 4710 did not germinate above 80% at any harvest date. Also, at this location rainfall was observed before each harvest date. These results indicate that OK916005 and Manokin were superior MG IV cultivars since they germinated more than 80% in most cases, even at the later harvest dates. In most cases, Delsoy 4710 was in the lowest significance group. Except at Chickasha in 1998, Stressland and Chesapeake gave acceptable germination only at the first harvest date. Harvest date one always gave the best germination percentage. But harvest date four did not always show the lowest germination percentage as expected. In most cases, the drop in germination percentage was the result of weather conditions rather than delay in harvest dates.

Table XVI shows the germination percentage of all MG V cultivars at each harvest date at each location each year. In Bixby in 1997, all the cultivars germinated more than 80% through harvest date three. Germination percentages sharply declined at harvest date four. Holiday germinated best though it was not significantly superior to the other cultivars (except Hutcheson). No rainfall was received during the seven days preceding the first three harvest dates but fifteen cm of rain occurred before the last harvest date. This appeared to cause the sharp decline in germination percentage at the fourth harvest date. In the same year at Chickasha, different results were observed. There was a gradual decrease in germination percentage until harvest date three and then some recovery at four. However, Delsoy5500 germinated 93.8% at harvest date three and

declined at harvest date four. It also germinated more than 80% at harvest dates one and two. Hutcheson germinated more than 80% at harvest dates one and two but not in three and four. Graham germinated about 60% at harvest dates two and three but more than 80% at harvest dates one and four. OK896001 and Holiday germinated more than 80% at harvest dates one, two, and four. Two days before the third harvest, a .05 cm rainfall occurred. There was a 2.175 cm rainfall five days before the first harvest date. In 1998 at Bixby, germination of all cultivars except OK896001 gradually declined until harvest date three and then increased at harvest date four. All cultivars at all harvest dates germinated more than 80%. Rainfall was observed before the second harvest date. In 1998 at Chickasha, germination of all cultivars gradually declined until harvest date three and then increased at harvest date four (except Graham). Except Hutcheson, Delsoy 5500 and OK896001 at harvest date three and Hutcheson at harvest date four, all cultivars germinated more than 80% at all harvest dates. Graham and Holiday germinated better than the other cultivars. Rainfall was observed before the third harvest date. All the MG V cultivars germinated more than 80% in most tests. However, Holiday gave the best overall results. Harvest date one always gave the best germination percentage. Harvest date four did not always show the worst results as expected. In most cases, the drop in germination percentage was the result of weather conditions rather than delays in harvest dates.

Table XVII shows the speed of germination (germination percentage counted at fourth day) of all MG IV cultivars at each harvest date at each location each year. In 1997 at Bixby, OK916005 showed significant superiority at harvest date one and three over the other cultivars. Manokin gave the second best result. In the same year at Chickasha, there

was no significant difference among any cultivar at harvest date one. Manokin showed a large drop in speed of germination percentage at harvest date two. But at the other three dates, the speed of germination percentages were not significantly different. OK916005 showed no significant difference in speed of germination at harvest dates one, two, and three. Somehow harvest date four showed significantly better speed of germination than the other three dates. Delsoy 4710 and Chesapeake gave the best speed of germination percentage at harvest date one. The speed of germination percentages gradually declined until harvest date three and then slightly recovered at harvest date four. Stressland gave the best speed of germination percentage at harvest date one followed by two, three and four. However except for harvest date one, the other three dates were not significantly different. In 1998 at Bixby, on the average harvest date two showed the biggest drop in speed of germination percentage. Altogether Manokin and OK916005 showed better speed of germination percentage than the others. In 1998 at Chickasha, harvest date two showed a drop in speed of germination percentage, then the percentages increased slightly at harvest date three and then dropped again at harvest date four. OK916005 and Manokin showed better speed of germination percentages than the other cultivars. Harvest date one always gave the best speed of germination percentage. Harvest date four did not always show the worst results as expected. In most cases, the drop in speed of germination percentage was the result of weather conditions rather than delay in harvest dates.

Table XVIII shows the speed of germination (percentage) of all MG V cultivars at each harvest date at each location each year. In 1997 at Bixby, a trend of gradual decline was observed from harvest date one through harvest date four. Though it declined

gradually, Holiday did not show any significant difference in the first three harvest dates. Graham and Delsoy5500 did not give significantly different speed of germination percentages at harvest dates one and two. Those two dates gave significantly better results than the last two. In the case of OK896001, harvest date one gave a significantly better speed of germination percentage but harvest dates two, three, and four did not show significantly different results. Hutcheson showed no significant differences in speed of germination percentage between harvest dates one and two, two and three, and three and four. In the same year, at Chickasha, a decrease until harvest date three and recovery at four was observed (except Delsoy5500). No cultivar showed any significant difference between harvest date one and four. In most cases harvest dates two and three gave significantly lower results compared to one and four. In the case of Delsoy5500, the second and third harvest dates did significantly better than the fourth. In 1998 at Bixby, both harvest dates two and three gave very poor results for all the cultivars. In all cases, values of germination speed dropped down to zero. Holiday gave significantly better result at harvest date one than any other cultivars at any other dates. In 1998 at Chickasha, both Graham and Holiday gave better speed of germination percentages than the other cultivars. OK896001 gave the worst results. All other cultivars gave similar results. There was a gradual decline from harvest date one through four. Harvest date one always gave the best speed of germination percentage. Here also, harvest date four did not always show the worst results as expected. In most cases, the drop in speed of germination percentage was the result of weather conditions rather than delay in harvest dates.

Table XIX shows the germination percentage after stress of all MG IV cultivars at each harvest date at each location each year. In 1997 at Bixby, OK916005, Manokin, and Chesapeake showed more than 80% germination at harvest date one and three. OK 916005 also showed more than 80% germination at harvest date four. In the same year, at Chickasha, Manokin showed a significant drop at harvest date two. OK916005 showed no significant difference in the second, third, and fourth harvest dates. Harvest date one gave a significantly better germination percentage than the others. Delsoy4710 and Chesapeake gave the best results in harvest date one followed by two, then dropped at harvest date three and slightly recovered at harvest date four. Stressland gave the best results at harvest date one followed by two, three, and four. The results of all four harvest dates were significantly different. In 1998 at Bixby, each cultivar showed a gradual decrease from harvest date one through four. OK916005 and Manokin showed better results than the other cultivars. In 1998 at Chickasha, on average, the highest drop was observed at harvest date four. On average, OK916005 did better than the other cultivars. Stressland showed good results at harvest date one and two. Like germination percentage and speed of germination, OK916005 and Manokin gave better results compared to the other cultivars. Harvest date one always gave the best germination percentage. Harvest date four did not always show the worst results as expected. In most cases, the drop in germination percentage was the result of weather conditions rather than delay in harvest dates.

Table XX shows the germination percentage after stress of all MG V cultivars at each harvest date at each location each year. In 1997 at Bixby, all the cultivars showed an acceptable germination percentage until harvest date three. Germination percentages

declined sharply at harvest date four. All cultivars gave more than 80% germination at harvest dates one and two. Holiday gave more than 80% germination even at harvest date three. In 1997 at Chickasha, the results showed a gradual decrease until harvest date three and recovery at four. Here, each cultivar produced more than 80% germination only at harvest date one. In 1998 at Bixby, harvest dates one and two gave better results compared to harvest dates three and four. Delsoy 5500 and Holiday at harvest date one and two, and Hutcheson and Graham at harvest date one gave more than 70% germination with no significant difference among them. In 1998 at Chickasha, very erratic results were found. All the cultivars gave more or less similar results. However, Graham germinated better than the other cultivars. Except Chickasha in 1998, harvest date one always gave the best germination percentage. However, harvest date four did not always show the worst results as expected. In most cases, the drop in germination percentage was the result of weather conditions rather than delay in harvest dates.

The visual observation of seeds did not show any noticeable difference in seed quality at the different harvest dates.

CHAPTER V

SUMMARY AND CONCLUSION

Among MG IV cultivars, Manokin and OK916005 produced better yields at both locations each year than the other three cultivars at all harvest dates. Though, Delsoy4710 gave the heaviest 100 seed weight, Manokin and OK916005 gave second or third heaviest weights (except Chickasha, 1997). OK916005 and Manokin produced better viability and vigor than the other cultivars especially at the later harvest dates.

Among MG V, all cultivars produced more or less good yields in all cases. OK 896001 gave the heaviest 100 seed weight in all cases. However, there was no big difference among all the other cultivars. In the case of viability and vigor, all the cultivars showed similar results. These results agree with the results of Tecrony et al., (1980). Late maturing cultivars gave better vigor and viability than early maturing cultivars.

The experiments also proved that soybean seed attains its highest potential quality at physiological maturity and remains high until harvest maturity. Harvest date one (harvest at maturity) always gave the best results. However, harvest date four did not always show the worst results as expected. Gradual decline was observed in most cases. Sudden drops in germination percentage happened mostly due to weather conditions during the previous seven days. These results also agree with the result of Tecrony et al., (1980). Soybean seed quality at harvest is determined by environmental conditions both before and after the seed reaches a harvestable moisture level. In most cases, a decrease in germination percentage was the result of the weather conditions rather than delay in harvest dates.

Results indicate that it is better not to harvest just after a rain. If there is no rain prior to harvest, even late harvest may give acceptable seed quality.

Table I

HARVEST DATES OF MG IV & MG V AT CHICKASHA AND BIXBY IN 1997

		CHICKASHA		
MG IV	Harvest date1	Harvest date2	Harvest date 3	Harvest date4
Manokin	31-Oct	25-Nov	4-Dec	19-Dec
Chesapeake	3-Oct	31-Oct	12-Nov	28-Nov
Delsoy 4710	3-Oct	31-Oct	12-Nov	28-Nov
Stressland	3-Oct	31-Oct	12-Nov	28-Nov
OK 916005	3-Oct	31-Oct	12-Nov	28-Nov
MG V				
Holiday	31-Oct	25-Nov	4-Dec	19-Dec
Hutcheson	31-Oct	25-Nov	4-Dec	19-Dec
Graham	31-Oct	25-Nov	4-Dec	19-Dec
Delsoy 5500	31-Oct	25-Nov	4-Dec	19-Dec
OK 896001	31-Oct	25-Nov	4-Dec	19-Dec
MG IV		**BIXBY**		
Manokin	20-Oct	11-Nov	24-Nov	15-Dec
Chesapeake	20-Oct	11-Nov	24-Nov	15-Dec
Delsoy 4710	20-Oct	11-Nov	24-Nov	15-Dec
Stressland	20-Oct	11-Nov	24-Nov	15-Dec
OK 916005	20-Oct	11-Nov	24-Nov	15-Dec
MG V				
Holiday	4-Nov	24-Nov	15-Dec	5-Jan
Hutcheson	4-Nov	24-Nov	15-Dec	5-Jan
Graham	4-Nov	24-Nov	15-Dec	5-Jan
Delsoy 5500	4-Nov	24-Nov	15-Dec	5-Jan
OK 896001	4-Nov	24-Nov	15-Dec	5-Jan

TABLE II

HARVEST DATES OF MG IV & MG V AT CHICKASHA AND BIXBY IN 1998

		CHICKASHA		
MG IV	Harvest date1	Harvest date2	Harvest date 3	Harvest date4
Manokin	23-Oct	5-Nov	16-Nov	30-Nov
Chesapeake	28-Sep	23-Oct	5-Nov	16-Nov
Delsoy 4710	23-Oct	5-Nov	16-Nov	30-Nov
Stressland	28-Sep	23-Oct	5-Nov	16-Nov
OK 916005	23-Oct	5-Nov	16-Nov	30-Nov
MG V				
Holiday	24-Nov	16-Dec	29-Dec	12-Jan
Hutcheson	24-Nov	16-Dec	29-Dec	12-Jan
Graham	24-Nov	16-Dec	29-Dec	12-Jan
Delsoy 5500	24-Nov	16-Dec	29-Dec	12-Jan
OK 896001	24-Nov	16-Dec	29-Dec	12-Jan
MG IV		**BIXBY**		
Manokin	20-Oct	6-Nov	18-Nov	2-Dec
Chesapeake	29-Sep	20-Oct	6-Nov	18-Nov
Delsoy 4710	29-Sep	20-Oct	6-Nov	18-Nov
Stressland	29-Sep	20-Oct	6-Nov	18-Nov
OK 916005	20-Oct	6-Nov	18-Nov	2-Dec
MG V				
Holiday	18-Nov	9-Dec	30-Dec	13-Jan
Hutcheson	18-Nov	9-Dec	30-Dec	13-Jan
Graham	18-Nov	9-Dec	30-Dec	13-Jan
Delsoy 5500	18-Nov	9-Dec	30-Dec	13-Jan
OK 896001	18-Nov	9-Dec	30-Dec	13-Jan

TABLE III

PROBABILITIES OF F VALUE OF CULTIVAR X HARVEST DATE INTERACTION

Year	Location	MG	Germ	Long	Acc	Yield	Wt
97	Bixby	IV	**0.0094**	**0.0430**	**0.0001**	0.4377	0.6694
97	Chick	IV	**0.0001**	**0.0001**	**0.0008**	0.3851	0.0785
98	Bixby	IV	**0.0002**	**0.0001**	**0.1268**	0.1752	0.6170
98	Chick	IV	**0.0060**	**0.0045**	**0.0362**	**0.0002**	**0.0328**
97	Bixby	V	**0.0021**	0.2771	0.5415	0.0620	0.3572
97	Chick	V	**0.0001**	**0.0037**	**0.0010**	0.1348	**0.0264**
98	Bixby	V	0.4018	**0.0001**	**0.0120**	0.1725	0.9202
98	Chick	V	0.6474	0.0525	0.1291	0.9676	0.8782

Bold = significant cultivar X harvest date interaction (.05 or less)

TABLE IV

MEAN YIELDS (G/PLOT) OF MG IV CULTIVARS COMBINED OVER HARVET DATES AT EACH LOCATION

	Manokin	Delsoy 4710	Stressland	Chesapeake	OK 916005	LSD
Bixby, 1997	1516 **a***	1240 **b**	978 **c**	919 **c**	1413 **a**	165
Chick, 1997	983 **a**	760 **ab**	580 **b**	597 **b**	691 **b**	105
Bixby, 1998	731 **a**	355 **c**	341 **c**	368 **c**	498 **b**	48

*Means at each row with the same letter are not significantly different at the 5% level of probability according to LSD.

TABLE V

MEAN YIELDS (G/PLOT) AT EACH HARVEST DATE COMBINED OVER MG IV CULTIVARS AT EACH LOCATION

	Harvest date one	Harvest date two	Harvest date three	Harvest date four	LSD
Bixby, 1997	1342 **a***	1113 **c**	1246 **ab**	1151 **bc**	101
Chick, 1997	841 **a**	698 **bc**	741 **ab**	609 **c**	105
Bixby, 1998	530 **a**	512 **a**	427 **b**	365 **c**	48

*Means at each row with the same letter are not significantly different at the 5% level of probability according to LSD

TABLE VI

MEAN YIELDS (G/PLOT) OF MG V CULTIVARS COMBINED OVER HARVEST DATES AT EACH LOCATION

	Hutcheson	Delsoy 5500	Holiday	Graham	OK 896001	LSD
Bixby, 1997	1251 **a***	1263 **a**	1246 **a**	1204 **a**	1200 **a**	119
Chick, 1997	1063 **b**	1053 **b**	1154 **ab**	1182 **ab**	1308 **a**	200
Bixby, 1998	849 **a**	849 **a**	714 **b**	723 **b**	656 **b**	120
Chick, 1998	1072 **a**	1148 **a**	972 **a**	1213 **a**	1075**a**	262

*Means at each row with the same letter are not significantly different at the 5% level of probability according to LSD

TABLE VII

MEAN YIELDS (G/PLOT) AT EACH HARVEST DATE COMBINED OVER MG V CULTIVARS AT EACH LOCATION

	Harvest date one	Harvest date two	Harvest date three	Harvest date four	**LSD**
Bixby, 1997	1377 **ab***	1417 **a**	1338 **b**	803 **c**	76
Chick, 1997	1200 **a**	1102 **a**	1128 **a**	1178 **a**	105
Bixby, 1998	742 **ab**	719 **b**	786 a	787 a	64
Chick, 1998	1335 **a**	1050 **b**	1108 b	892 **c**	155

*Means at each row with the same letter are not significantly different at the 5% level of probability according to LSD

TABLE VIII

MEAN YIELDS (G/PLOT) OF MG IV CULTIVARS AT CHICKASHA IN 1998

	Manokin	Delsoy4710	Stressland	Chesapeake	OK916005
Harvest I	1377 **a***	897 **c**	1270 **ab**	1306 **ab**	1215 **ab**
Harvest II	1467 **a**	939 **c**	808 **c**	901 **c**	1404 **a**
Harvest III	1268 **ab**	930 **c**	821 **c**	940 **c**	889 **c**
Harvest IV	1338 **a**	324 **d**	379 **d**	540 **c**	1051 **bc**

*Means with the same letter (all comparisons) are not significantly different at the 5% level of probability according to LSD

TABLE IX

MEAN 100 SEED WEIGHTS (G) OF MG IV CULTIVARS COMBINED OVER HARVEST DATES AT EACH LOCATION

	Manokin	Delsoy 4710	Stressland	Chesapeake	OK 916005	LSD
Bixby, 1997	13.1 **c***	15.4 **a**	12.2 **d**	12.1 **d**	13.7 **b**	0.5
Chick, 1997	11.6 **c**	14.1 **a**	12.9 **b**	12.9 **b**	11.4 **c**	0.4
Bixby, 1998	13.0 **ab**	13.7 **a**	11.2 **b**	11.3 **b**	12.8 **ab**	1.8

*Means at each row with the same letter are not significantly different at the 5% level of probability according to LSD

TABLE X

MEAN 100 SEED WEIGHTS AT EACH HARVEST DATE COMBINED OVER MG IV CULTIVARS AT EACH LOCATION

	Harvest date one	Harvest date two	Harvest date three	Harvest date four	LSD
Bixby, 1997	14.0 **a***	12.7 **c**	13.3 **b**	13.2 **b**	0.3
Chick, 1997	13.0 **a**	12.5 **cb**	12.2 **c**	12.7 **b**	0.3
Bixby, 1998	12.4 **a**	12.1 **a**	12.3 **a**	12.8 **a**	0.7

*Means at each row with the same letter are not significantly different at the 5% level of probability according to LSD

TABLE XI

MEAN 100 SEED WEIGHTS (G) OF MG V CULTIVARS COMBINED OVER HARVEST DATES AT EACH LOCATION

	Hutcheson	Delsoy 5500	Holiday	Graham	OK 896001	LSD
Bixby, 1997	15.1 **b***	13.7 **b**	15.0 **b**	13.7 **b**	17.8 **a**	2.0
Bixby, 1998	14.7 **b**	14.0 **bc**	13.1 **c**	13.9 **bc**	18.0 **a**	1.0
Chick, 1998	13.9 **a**	14.0 **a**	13.3 **a**	13.9 **a**	16.6 **a**	3.7

*Means at each row with the same letter are not significantly different at the 5% level of probability according to LSD

TABLE XII

MEAN 100 SEED WEIGHTS (G) AT EACH HARVSET DATE COMBINED OVER MG V CULTIVARS AT EACH LOCATION

	Harvest date one	Harvest date two	Harvest date three	Harvest date four	**LSD**
Bixby, 1997	15.0 **a***	14.8 **a**	15.7 **a**	14.7 **a**	1.4
Bixby, 1998	15.0 **a**	14.6 **bc**	14.4 **c**	15.0 **ab**	0.4
Chick, 1998	14.6 **a**	14.4 **a**	14.1 **a**	14.2 **a**	0.7

*Means at each row with the same letter are not significantly different at the 5% level of probability according to LSD

TABLE XIII

MEAN 100 SEED WEIGHTS (G) OF MG IV CULTIVARS AT CHICKASHA IN 1998

	Manokin	Delsoy4710	Stressland	Chesapeake	OK916005
Harvest I	14.0 **efgh***	15.3 **bcd**	14.5 **def**	13.8 **efgh**	14.7 **cdef**
Harvest II	14.7 **cdef**	16.8 **a**	13.8 **efgh**	14.1 **efgh**	16.0 **ab**
Harvest III	13.8 **efgh**	15.7 **bc**	14.5 **defg**	14.8 **cde**	13.9 **efgh**
Harvest IV	13.4 **gh**	15.5 **bcd**	13.7 **fgh**	13.4 **h**	13.9 **efgh**

*Means with the same letter (all comparisons) are not significantly different at the 5% level of probability according to LSD

TABLE XIV

MEAN 100 SEED WEIGHTS (G) OF MG V CULTIVARS AT CHICKASHA IN 1997

	Hutcheson	Delsoy 5500	Holiday	Graham	OK 896001
Harvest I	12.4 **fgh***	12.7 **efg**	13.7 **c**	13.1 **cde**	16.7 **a**
Harvest II	12.1 **gh**	12.0 **h**	12.2 **gh**	12.4 **fgh**	16.8 **a**
Harvest III	12.1 **gh**	12.3 **fgh**	12.6 **efgh**	12.5 **efgh**	15.7 **b**
Harvest IV	12.2 **gh**	12.6 **efgh**	13.0 **def**	13.4 **cd**	17.2 **a**

*Means with the same letter (all comparisons) are not significantly different at the 5% level of probability according to LSD

TABLE XV

MEAN GERMINATION PERCENTAGES OF MG IV CULTIVARS

1997			Bixby			LSD
	Manokin	Delsoy 4710	Stressland	Chesapeake	OK916005	
Harvest I	81.3 **bcd***	76.7 **cde**	78.7 **cde**	85.8 **abc**	95.7 **a**	11.2
Harvest II	63.8 **fg**	35.5 **k**	47.3 **hij**	54.7 **ghi**	81.2 **bcd**	
Harvest III	81.3 **bcd**	52.5 **hij**	58.3 **gh**	75.5 **cde**	93.2 **a**	
Harvest IV	74.0 **def**	43.5 **ijk**	43.3 **jk**	69.7 **ef**	90.2 **ab**	
			Chickasha			
Harvest I	88.2 **ab**	92.0 **a**	92.0 **a**	93.0 **a**	91.5 **a**	12.4
Harvest II	41.9 **fg**	58.2 **e**	76.8 **bcd**	82.2 **abcd**	75.7 **cd**	
Harvest III	82.3 **abcd**	29.3 **h**	41.5 **gh**	35.5 **gh**	59.8 **e**	
Harvest IV	81.7 **abcd**	42.7 **fg**	51.5 **ef**	74.8 **d**	87.3 **abc**	
1998			**Bixby**			
Harvest I	79.0 **a**	80.7 **a**	71.3 **abcd**	78.8 **a**	76.7 **ab**	13.3
Harvest II	76.8 **ab**	56.0 **ef**	53.0 **efg**	63.0 **cde**	77.2 **ab**	
Harvest III	78.5 **a**	39.2 **h**	45.0 **fgh**	61.2 **de**	75.7 **abc**	
Harvest IV	63.0 **cde**	41.3 **gh**	24.8 **I**	64.7 **bcde**	81.2 **a**	
			Chickasha			
Harvest I	95.7 **a**	66.7 **hi**	88.8 **abc**	93.2 **ab**	88.7 **abc**	10.2
Harvest II	72.3 **fgh**	49.8 j	85.3 **bcd**	84.3 **bcd**	78.0 **efdg**	
Harvest III	80.7 **cdef**	69.8 **gh**	84.0 **bcde**	80.8 **cdef**	90.5 **abc**	
Harvest IV	76.2 **defgh**	58.8 **ij**	75.5 **defgh**	74.0 **efgh**	92.3 **ab**	

*Means at each location each year with the same letter are not significantly different at the 5% level of probability according to LSD

TABLE XVI

MEAN GERMINATION PERCENTAGES OF MG V CULTIVARS

1997			Bixby			LSD
	Hutcheson	Delsoy 5500	Holiday	Graham	OK 896001	
Harvest I	87.3 **bcd***	89.7 **abc**	97.7 **a**	93.5 **abc**	91.8 **abc**	8.5
Harvest II	86.3 **bcd**	90.2 **abc**	97.2 **a**	93.7 **abc**	94.7 **ab**	
Harvest III	81.0 **d**	89.3 **abcd**	96.3 **a**	89.5 **abc**	85.7 **cd**	
Harvest IV	41.0 **f**	25.9 **g**	57.0 **e**	55.0 **e**	50.2 **e**	
			Chickasha			
Harvest I	96.2 **ab**	95.2 **ab**	96.0 **ab**	96.0 **ab**	97.0 **a**	10.6
Harvest II	80.2 **c**	80.8 **c**	80.0 **c**	62.2 **e**	85.7 **bc**	
Harvest III	66.8 **de**	93.8 **ab**	63.2 **e**	59.0 **e**	64.0 **e**	
Harvest IV	77.2 **cd**	77.2 **cd**	96.5 **a**	97.7 **a**	95.5 **ab**	
1998			**Bixby****			
Harvest I	93.8 **ab**	92.2 **abcde**	94.5 **a**	94.0 **a**	91.7**abcdefg**	3.5
Harvest II	91.0 **abcdefg**	90.2 **cdefg**	93.7 **abc**	92.0 **abcdef**	88.8 **efgh**	
Harvest III	88.2 **gh**	85.7 **h**	90.3 **bcdefg**	88.2 **gh**	89.7 **defg**	
Harvest IV	94.0 **a**	88.5 **fgh**	93.0 **abcd**	94.2 **a**	92.3 **abcde**	
			Chickasha**			
Harvest I	88.3 **bcdef**	86.5 **cdefg**	94.7 **ab**	96.7 **a**	91.0 **abcd**	8.1
Harvest II	82.7 **efghi**	80.3 **fghij**	93.7 **abc**	92.5 **abcd**	85.0 **defgh**	
Harvest III	73.2 **j**	76.8 **ij**	90.5 **abcde**	93.3 **abc**	79.7 **ghij**	
Harvest IV	77.3 **ijh**	82.7 **efghi**	88.7 **abcde**	91.7 **abcd**	85.0 **defgh**	

*Means at each location each year with the same letter are not significantly different at the 5% level of probability according to LSD

**No cultivar X harvest date interactions were observed

TABLE XVII

MEAN GERMINATION SPEEDS (%) OF MG IV CULTIVARS

1997			Bixby			LSD
	Manokin	Delsoy 4710	Stressland	Chesapeake	OK916005	
Harvest I	58.0 **c***	39.0 **efg**	49.8 **cde**	39.8 **efg**	70.3 **ab**	11.2
Harvest II	32.7 **gh**	13.7 j	19.5 **ij**	22.5 **hij**	45.5 **def**	
Harvest III	53.0 **cd**	20.3 **ij**	30.7 **ghi**	36.2 **fg**	79.8 **a**	
Harvest IV	39.2 **efg**	18.2 j	22.7 **hij**	21.8 **hij**	59.7 **bc**	
			Chickasha			
Harvest I	36.3 **ab**	28.5 **b**	38.0 **ab**	31.5 **b**	30.0 **b**	10.3
Harvest II	9.5 **cd**	10.3 **cd**	14.2 **cd**	18.0 **c**	29.0 **b**	
Harvest III	31.2 **b**	5.5 **d**	11.8 **cd**	6.5 **d**	30.0 **b**	
Harvest IV	29.8 **b**	9.3 **cd**	7.8 **cd**	12.5 **cd**	44.5 **a**	
1998			**Bixby**			
Harvest I	28.5 **bc**	7.8 **h**	6.8 **gh**	0.3 **gh**	19.7 **cde**	9.5
Harvest II	7.0 **gh**	12.0 **efg**	8.5 **gh**	9.3 **fgh**	8.8 **fgh**	
Harvest III	48.8 **a**	7.5 **gh**	8.7 **gh**	18.2 **def**	44.7 **a**	
Harvest IV	30.0 **b**	10.8 **efg**	2.7 **gh**	22.2 **bcd**	51.7 **a**	
			Chickasha			
Harvest I	49.0 **ab**	20.3 **defghi**	28.5**bcdefg**	15.2 **efghi**	30.8 **bcdef**	21.8
Harvest II	8.7 **ghi**	3.5 **hi**	47.8 **ab**	24.3**cdefgh**	12.5 **fghi**	
Harvest III	41.8 **abcd**	21.2 **defghi**	36.0 **bcde**	22.0**cdefgh**	59.5 **a**	
Harvest IV	20.8 **defghi**	5.3 **hi**	17.0 **efghi**	0.2 **i**	43.0 **abc**	

*Means at each location each year with the same letter are not significantly different at the 5% level of probability according to LSD

TABLE XVIII

MEAN GERMINATION SPEEDS (%) OF MG V CULTIVARS

1997			Bixby**			LSD
	Hutcheson	Delsoy 5500	Holiday	Graham	OK 896001	
Harvest I	68.2 **ab***	68.8 **ab**	84.0 **a**	79.8 **a**	66.5 **ab**	25.2
Harvest II	46.8 **bcd**	75.2 **a**	65.5 **ab**	62.7 **abc**	30.8 **defg**	
Harvest III	36.7 **def**	34.0 **defg**	62.3 **abc**	36.8 **def**	39.7 **cde**	
Harvest IV	13.8 **fgh**	4.2 **h**	28.8 **defgh**	10.8 **gh**	14.5 **efgh**	
			Chickasha			
Harvest I	66.0 **abc**	60.7 **abcde**	74.7 **a**	65.2 **abc**	62.8 **abcd**	21.5
Harvest II	47.7 **cdefg**	64.8 **abc**	41.2 **efg**	30.3 **fgh**	29.3 **fgh**	
Harvest III	31.5 **fgh**	66.5 **abc**	34.3 **fgh**	26.2 **gh**	18.5 **h**	
Harvest IV	63.5 **abc**	41.5 **defg**	69.3 **ab**	71.7 **ab**	50.3 **bcdef**	
1998			**Bixby**			
Harvest I	15.5 **bc**	19.7 **bc**	48.8 **a**	23.0 **b**	11.8 **cd**	8.8
Harvest II	0.0 **e**	0.2 **e**	2.0 **e**	0.0 **e**	0.0 **e**	
Harvest III	0.0 **e**	0.0 **e**	1.5 **e**	0.0 **e**	0.0 **e**	
Harvest IV	5.8 **de**	3.7 **de**	22.0 **b**	20.0 **bc**	3.3 **de**	
			Chickasha**			
Harvest I	17.7 **defg**	17.3 **defgh**	30.3 **b**	24.2 **bcd**	10.7 **fghi**	8.3
Harvest II	15.0 **efgh**	12.3 **fghi**	28.2 **b**	23.0 **bcde**	10.5 **ghi**	
Harvest III	14.7 **fgh**	16.5 **defgh**	26.2 bc	39.2 **a**	11.7 **fghi**	
Harvest IV	9.3 **hi**	11.5 **fghi**	18.8 **cdef**	14.8 **efgh**	6.2 **i**	

*Means at each location each year with the same letter are not significantly different at the 5% level of probability according to LSD

**No cultivar X harvest date interactions were observed

TABLE XIX

MEAN GERMINATION PERCENTAGES (AFTER STRESS) OF MG IV CULTIVARS

1997			Bixby			LSD
	Manokin	Delsoy 4710	Stressland	Chesapeake	OK916005	
Harvest I	89.5 **ab***	70.8 **cd**	82.8 **abc**	89.8 **ab**	96.0 **a**	14.7
Harvest II	59.5 **de**	37.7 **g**	43.0 **fg**	40.3 **g**	76.5 **bc**	
Harvest III	82.8 **abc**	50.3 **efg**	56.8 **def**	85.0 **abc**	93.8 **a**	
Harvest IV	76.0 **bc**	37.7 **g**	16.5 **h**	76.8 **bc**	93.3 **a**	
			Chickasha			
Harvest I	71.8 **abc**	60.5 **bcde**	86.5 **a**	80.5 **ab**	88.8 **a**	20.1
Harvest II	24.8 **ghi**	33.2 **fgh**	43.0 **efg**	45.8 **def**	59.7 **cde**	
Harvest III	61.8 **bcde**	11.7 **I**	17.2 **hi**	15.7 **hi**	54.3 **cde**	
Harvest IV	45.0 **def**	14.8 **hi**	12.3 **I**	22.7 **hi**	63.2 **bcd**	
1998			**Bixby**			
Harvest I	66.0 **ab**	54.8 **bc**	36.3 **defg**	67.0 **ab**	72.2 **a**	16.6
Harvest II	61.2 **abc**	33.0 **efg**	27.5 **fgh**	45.8 **cde**	68.3 **ab**	
Harvest III	37.5 **def**	15.0 **hi**	10.8 **I**	20.5 **ghi**	64.7 **ab**	
Harvest IV	21.5 **fghi**	13.2 **hi**	9.9 **I**	22.2 **fghi**	52.3 **bcd**	
			Chickasha			
Harvest I	74.8 **abc**	45.3 **def**	81.2 **ab**	68.3 **abc**	88.2 **a**	20.4
Harvest II	39.8 **efg**	34.8 **gf**	75.3 **abc**	64.5 **bcd**	58.7 **cde**	
Harvest III	40.0 **efg**	20.8 **g**	28.8 **gf**	31.0 **gf**	66.8 **bc**	
Harvest IV	29.7 **gf**	22.3 **g**	45.7 **def**	23.5 **g**	56.0 **cde**	

*Means at each location each year with the same letter are not significantly different at the 5% level of probability according to LSD

TABLE XX

MEAN GERMINATION PERCENTAGES (AFTER STRESS) OF MG V CULTIVARS

1997			Bixby**			LSD
	Hutcheson	Delsoy 5500	Holiday	Graham	OK 896001	
Harvest I	94.8 **ab***	92.2 **abcd**	95.3 **a**	96.0 **a**	93.2 **abc**	16.3
Harvest II	85.2 **abcd**	89.7 **abcd**	93.2 **abc**	92.8 **abc**	88.0 **abcd**	
Harvest III	76.2 **de**	67.3 **e**	86.2 **abcd**	78.2 **cde**	78.8 **bcde**	
Harvest IV	27.7 **g**	38.2 **fg**	49.7 **f**	32.3 **g**	23.7 **g**	
			Chickasha			
Harvest I	84.7 **abc**	91.2 **ab**	92.2 **a**	92.5 **a**	92.3 **a**	11.9
Harvest II	39.3 **gh**	55.8 **de**	60.0 **d**	40.0 **gh**	53.5 **def**	
Harvest III	16.0 **i**	44.5 **efg**	40.3 **gh**	40.7 **gh**	31.0 **h**	
Harvest IV	42.7 **fgh**	58.2 **d**	74.3 **c**	79.7 **bc**	77.5 **c**	
1998			**Bixby**			
Harvest I	72.5 **a**	74.0 **a**	71.3 **ab**	70.0 **abc**	58.0 **bcd**	13.5
Harvest II	55.8 **de**	72.3 **a**	70.0 abc	57.0 **cde**	62.3 **abcd**	
Harvest III	39.7 **fg**	29.8 **g**	44.0 **ef**	28.8 **g**	35.8 **fg**	
Harvest IV	34.7 **fg**	40.0 **fg**	36.2 **fg**	28.7 **g**	54.7 **de**	
			Chickasha**			
Harvest I	43.7 **abc**	21.5 **d**	19.8 **d**	51.5 **ab**	19.5 **d**	20.5
Harvest II	44.8 **abc**	31.0 **bcd**	55.7 **a**	56.2 **a**	44.3 **abc**	
Harvest III	39.5 **abcd**	24.3 **cd**	37.5 **abcd**	44.7 **abc**	43.7 **abc**	
Harvest IV	21.2 **d**	32.5 **bcd**	21.5 **d**	45.2 **ab**	36.4 **abcd**	

*Means at each location each year with the same letter are not significantly different at the 5% level of probability according to LSD

**No cultivar X harvest date interactions were observed

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