PRODUCTIVITY OF SHORT-SEASON SOYBEAN CULTIVARS IN KANSAS

by

METIN BABAOGLU

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Approved by:

W. T. Schapaugh Jr.

Major professor

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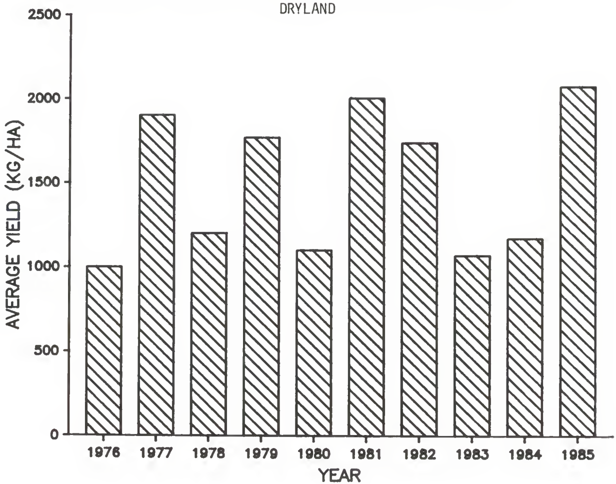
INTRODUCTION

Dryland soybean production predominates in Kansas. Almost three-fourths of the total production area is not irrigated (4). In these areas, the seed yield is dependent on moisture level of the soil during the growing season. Soybeans are sensitive to the lack of moisture at germination and early seedling growth and at the reproductive stage, especially at pod-filling (R5)(23)(42). Any interference in the availability of water at these two stages will adversely affect the soybean yields (42). In eastern and central Kansas, moisture requirements for the germination and early seedling growth are usually adequately supplied by rainfall (8). However, the soil often fails to meet the moisture requirements of the crop for optimum yield due to hot, dry weather during pod fill. In Kansas, the average temperature (30-year average, 1951-1980) is 18.1 C in May, 23.6 C in June, 26.5 C in July, 25.5 C in August, and 20.6 C in September. In addition, average precipitation in July and August of 85 mm and 76mm, respectively, tends to be the lowest of the summer months (4).

The cultivars best adapted to Kansas are in maturity groups III, IV, and V (43). Typically these cultivars are planted from mid-May until early June (32, 41). Double crop soybeans are planted from late June until mid-July if adequate soil moisture is available for germination of seeds and early seedling growth (8, 32). The pod-filling period (R5)(23) of these cultivars usually takes place from late July until mid-August. At this stage, availability of the moisture in the soil is essential for optimum seed yield (42). Due to high temperatures and insufficient rainfall in July and August, these full-season cultivars often undergo drought and heat stress during the seed-filling period. As a consequence, yields are reduced. Because of erratic growing conditions from unstable weather, soybean yields in Kansas fluctuate markedly (Figure 1).

The farmers in southeast Kansas have attempted to minimize the effect of drought by planting late-maturing cultivars (group V). These cultivars accumulate seed dry matter throughout August and September. If environmental conditions in late August and September are more favorable than July and early August for soybean growth, the late-maturing cultivars may produce higher yields than earlier maturing cultivars. Due to the length of growing season, these late-maturing (group V) cultivars are used in production only in east central and southeast Kansas (43). However, growing late-maturing cultivars to escape drought stress has not consistently paid off. Another solution to avoid or at least reduce drought stress may be to produce a soybean crop prior to the onset of

Figure 1. Average soybean yield in Kansas (1976-1985).



stress. Because of its photoperiodic response, when a cultivar adapted to higher latitudes is moved to lower latitudes where daylength is shorter, flowering and maturity are hastened (14, 18, 24, 30, 47). This could possibly allow the crop to be produced in a more favorable environment. In a study in central Missouri, Brown et al.(10) have shown that short-season cultivars reached maturity in mid-July before they were affected by drought and were harvested in early August. Their data have also indicated that in a dry year, short-season cultivars might escape a portion of the drought stress. However, certain detrimental plant responses are anticipated due to photoperiodism (14, 30, 45, 47, 51). Because soybeans are photoperiod sensitive (24), vegetative growth period of most cultivars is reduced, i.e plants are forced to flower prematurely and reach maturity earlier (14, 24, 30, 45, 51). As a result, plants become shorter and produce lower yields since the growing period is reduced (44). While plants become shorter, they tend to set the pods close to the ground (45, 51). This situation may create a harvest problem. The pods close to the ground may also contain seeds of lower quality (25, 45). There usually is a positive relation between the length of the growing season and seed yield. The cultivars that take advantage of all or most of the growing season tend to produce higher yields than those that flower prematurely and reach maturity earlier (45, 47, 48).

Some cultural practices may overcome these problems resulted from photoperiodism. Numerous investigations have shown that soybeans respond well to row spacing. When the row spacing is decreased, seed yield is increased (2, 9, 12, 17, 28, 29, 33, 35, 37, 38, 46, 50, 53, 54). The seed yield in many regions in the U.S is increased by planting in narrow rows (14, 50). Using rows narrower than the traditional 90 to 102 centimeters have led to increases in yields in northern areas of the U.S (14). Narrow rows are widely used in the northern areas since these areas have a shorter growing season than southern areas. In southern areas, greater yields may be obtained from narrow rows when early-maturing cultivars are planted early (47). At narrower row spacings, plants grow taller, develop fewer branches and greater pod numbers per plant (2, 6, 12, 21, 28, 38, 54). The lowest pods develop higher up the stems as row width decreased since plants grow taller in narrow rows (2, 6, 15, 38). However, while plants become taller in narrow rows, they tend to develop larger internodes and slender stems on the plant. As a consequence, the ability of plants to stand decreases and lodging may occur (15, 16, 29, 33, 35, 45). Lodging is one of the factors that may reduce the seed yield. If lodging occurs early, it will reduce the light interception which is essential for photosynthesis. Reduced photosynthate may result in pod abortion or reduced seed size, and hence in reduced seed yield (16). Lodging also makes the harvest difficult and contributes to the harvest losses (16, 50, 51). When the plant population is increased, plant height and height of the lowest pod from the ground increase (6, 15, 21, 31, 36). However, lodging may become a problem at higher plant populations (11, 28, 31, 36, 50). On the other hand, at lower populations, plants tend to produce excessive branches, become shorter, and set the pods lower.

The unique yield advantage exhibited by narrow rows over wide rows is due to the amount of solar energy intercepted by the plants in narrow rows (37, 45, 46, 54). The canopy closes earlier in narrow rows and leaves shade the entire soil surface during seed development period. The closed canopy may help plants to intercept a larger percentage ot the solar energy (46, 54), thereby increase the rate of photosynthesis and reduce the moisture loss from the soil surface by evaporation.

Planting date may also affect the growth and development of soybeans since changes in planting date expose the plants to different daylengths (30, 47). Numerous investigations have shown that grain yield and length of vegetative and reproductive development stages in soybeans are intluenced by planting date (1, 3, 7, 13, 39, 49). May or early June is considered to be the more convenient planting date in most areas in the U.S (32, 40, 41). Early plantings have not resulted in any favorable increases in yields (26, 40). When cultivars are planted early, they tend to flower too early to maximize vegetative growth. As a result, plants become shorter, set pods lower on the plant, and produce lower yields than those planted in May (26, 30, 40, 44). Late plantings have also led to lower yields, shorter plants, and lower pods on the plant (1, 3, 7, 9, 13, 26, 39, 40, 47, 49). However, the yield may be increased if early-maturing cultivars are planted early in narrow rows (13, 22).

Planting date also affects seed quality. The seed quality tends to be the highest from late plantings (1, 22, 25, 26, 49). However, early maturing cultivars may also produce seeds of good quality when planted early since they flower and mature before they are affected by the hot and dry weather (25).

The objectives of this study were to investigate the influence of various production practices on the productivity of short-season soybean cultivars and compare the productivity of these cultivars to full-season types in dryland production areas in Kansas.

MATERIALS AND METHODS

The experiment was conducted at five Kansas dryland locations: Parsons, Powhattan, Ottawa, Hesston, and the Ashland Agronomy farm at Manhattan in 1986. Four cultivars from different maturity groups were tested. These cultivars were: McCall (maturity group 00), Evans and Dawson (maturity group 0), and Hodgson-78 (maturity group I).

The Manhattan plots were planted in a Muir silt loam classified as Pachic Haplustolls, fine silty, mixed mesic; the Ottawa plots, in a Woodson silt loam (Typic Abruptic Argiaguolls, fine, Montmorillonitic, thermic); the Powhattan plots, in a Grundy silty clay loam classified as Aquic Argiustolls, fine, Montmorillonitic, mesic; the Parsons plots, in a Parsons silt loam (Typic Mallic Albaqualf, fine, mixed, thermic); and the Hesston plots, in a Ladysmith silty clay loam classified as Pachic Argiustolls, fine, Montmorillonitic, mesic. A summary of soil tests information collected at planting is given in Table 1. No plots were irrigated or fertilized. Weed control was accomplished using herbicides and by hand weeding when needed. At the Hesston location, 2-chloro-N-(2,6-diethylphenyl)-N- (methoxymethyl) acetamide (Lasso) (2.2 kg/ha) and 4-amino-6- (1,1- dimethylethyl)-3-(methylthio) - 1,2,4 - triazin - 5 (4H)-one (Lexone) (0.43 kg/ha), and at the Ottawa and Powhattan locations, 2,6 -

Table 1. Soil test results at all locations.

Location	Soil type	Organic matter	Soil pH	Available P	Available K
		%		-------kg/ha------	
MANHATTAN	Silt loam	2.3	7.3	85.3	870.1
HESSTON	Silty clay loam	2.4	6.6	125.2	73.0
OTTAWA	Silt loam	2.6	6.9	79.2	370.5
PARSONS	Silt loam	1.8	7.0	47.2	224.5
POWHATTAN	Silty clay loam	2.5	5.4	69.6	342.4

dinitro - N ,N - dipropyl -4-(trifluoromethyl) benzenamine (Treflan) (1.12 and 0.84 kg/ha, respectively) were incorporated before planting. At the Powhattan and Parsons locations, 3 - (1 - methylethyl) - (1H) - 2,1,3-benzothiadiazin-4 (3H)-one 2,2- dioxide (Basagran) (1.12 and 2.34 kg/ha, respectively) was sprayed after planting. At Parsons, 2 - chloro - N - (2,6 - diethylphenyl) - N - (methoxymethyl) acetamide (Lasso) (1.75 kg/ha) was also incorporated prior to planting. At the Manhattan location, no herbicide was used. The seeds were treated with a fungicide (Thiram) before planting. Plantings were made on April 24 at Parsons and Ottawa; April 30 at Powhattan; May 1 at Manhattan; and May 2 at Hesston. A second planting was made on May 16 at the Manhattan location to compare the yields from two planting dates.

Two row widths, 25 and 76 cm, and two seeding rates, 13 and 20 seeds per meter in 25-cm rows and 27 and 40 seeds per meter in 76-cm rows, were used to produce combinations of narrow row-high population (N H=775,000 seeds /ha), narrow row-low population (N L=516,000 seeds /ha), wide row-high population (W H=516,000 seeds /ha) and wide row-low population (W L=344,000, seeds /ha). The 25-cm plots contained 10 rows and the 76-cm plots consisted of 4 rows, 6.3 meters long.

Environmental conditions during the growing season were as follows: at the Manhattan location, precipitation in June and August was greater than average (30-year average, 1951-1980). May and July received less precipitation than the average. At Hesston, the precipitation throughout the growing season was above average. At the Ottawa location, precipitation was above average in April and July, but below average in June and August. An average amount of precipitation was received in May. At the Parsons location, all months except for April received less precipitation than the average. The Powhattan location received less precipitation in April, June, and July than the average. The temperatures during the growing season were close to the average at all locations (Table 2).

The experimental design was a randomized, complete block design with three replications. The plots were end-trimmed at maturity to 4.7 meters. The center 2 rows in 4-row plots and the center 6 rows in 10-row plots were machine harvested on July 29 at Parsons; August 14 at Ottawa; August 18 at Powhattan; August 22 at Manhattan (first date); and August 25 at Hesston. The late planted (May 16) plots at the Manhattan location were harvested on August 28.

Plant traits measured were seed yield, mature plant height, maturity, lodging, seed quality, seed weight, and height of the lowest pod from the ground at all

Table 2. Monthly average temperatures and precipitation during the growing season at all locations in 1986 and 30-year mean.

LOCATION		APRIL	MAY	JUNE	JULY	AUGUST	APRIL	MAY	JUNE	JULY	AUGUST
		Rainfall					Temperature				
		mm					C				
MANHATTAN	1986	44.5	14.2	145.0	51.8	125.9	14.0	17.4	23.8	27.6	24.8
	Average#	39.4	91.1	80.8	69.6	66.3	13.2	18.5	24.1	27.1	26.2
HESSTON	1986	67.0	135.0	83.0	143.0	156.0	14.4	18.9	25.8	28.0	23.9
	Average	66.0	113.8	47.0	90.7	77.2	13.6	18.8	24.3	27.3	26.4
OTTAWA	1986	102.1	122.4	61.7	134.1	103.1	15.5	19.3	25.2	27.8	23.4
	Average	81.8	122.2	137.2	108.2	106.7	13.7	18.9	23.8	26.5	25.6
PARSONS	1986	98.8	123.7	79.0	31.5	83.0	14.8	18.9	24.8	27.9	23.6
	Average	94.5	131.6	122.0	92.7	87.1	15.0	19.8	24.5	27.4	26.6
POWHATTAN	1986	79.0	178.0	66.0	58.0	135.9	13.0	18.0	24.7	26.4	21.7
	Average	84.3	112.0	141.0	113.3	107.4	12.6	18.0	23.0	25.7	24.6

30-year average (1951-1980).

locations. A scoring system of 1 to 5 with 1=all plants erect and 5=all plants down was used for lodging. Seed weight was measured and recorded as grams from 100 randomly selected seeds sampled after harvest. Seed quality was visually assessed by evaluating the number of green, etching, wrinkling, and moldy or rotten seeds in a sample. Again the scoring system was 1 to 5 with 1 being good and 5 being poor for the seed quality. In addition, standard germination and accelerated aging tests were run on the seeds from the two different planting dates at Manhattan and Hesston. Standard warm germination test was conducted by the rolled towel method and accelerated aging test was run after the seeds were exposed to 100 % relative humidity at 40 C for 72 hours as outlined in the AOSA rules for testing seeds (5).

For the analyses, the data on the seed yield, plant height, lodging, seed quality, seed weight, height of the lowest pod, maturity, warm germination, and accelerated aging tests results were used as dependent variables with locations, planting date, seeding rate, and row widths were independent variables in a fixed model. All means were statistically separated by using the Fisher's least significant difference (LSD) at 5 % probability level.

RESULTS AND DISCUSSION

The results of this study will be presented under two main headings, namely the production of short-season soybean cultivars across Kansas and effects of planting date on the productivity of these cultivars.

PRODUCTION OF SHORT-SEASON SOYBEAN CULTIVARS ACROSS KANSAS

A summary of analyses of variance for some agronomic characters of soybeans is given in Table 3. Seed weight and seed quality data (visual rating) are not discussed since they were not influenced by the treatment combinations evaluated in this study. The performance among cultivars and locations differed significantly in terms of yield, maturity, plant height, lowest pod height, lodging score, accelerated aging, and warm germination percentages. Row spacing influenced yield and plant height. Plant population significantly affected yield, and maturity. The relative performance of the cultivars significantly changed across locations for most agronomic traits measured. Another significant, two-way interaction, location x row width, was also observed for yield and plant height. Although there was a significant cultivar x location interaction for lodging scores, they were not presented since lodging was observed only at the Manhattan location.

Hodgson 78 was the highest average yielding cultivar tested in the study (Table 4). It produced a yield of 1631 kg/ha. McCall, the lowest yielding cultivar, had a 362 kg/ha lower average yield than Hodgson 78. Dawson and Evans were intermediate in yield between Hodgson 78 and McCall.

The Manhattan and Hesston locations produced the highest yields among five locations tested (Table 4). The Ottawa and Parsons locations had the lowest yields. Yield at Powhattan was higher than those at Ottawa and Parsons, but lower than yields at the Manhattan and Hesston locations.

The relative yield performance of the cultivars at each location tended to follow the pattern indicated with the mean yields. McCall tended to be the lowest yielding cultivar and Hodgson 78 tended to produce the highest yields. Some exceptions to that trend were seen, the most noteworthy is the relatively poor performance of Dawson and Evans at the Manhattan and Parsons locations, respectively.

The differences in yield among the cultivars can be mainly attributed to their different response to daylength. The later maturing cultivars tended to produce the highest yields. The correlation coefficient (r) between yield and maturity was 0.68 (Table 5). In terms of maturity, McCall was the earliest among the four cultivars. It matured 6 days earlier than Evans, 10 days earlier than Dawson, and 15 days earlier than Hodgson 78 across all five locations (Table 4). When these maturity dates were converted to total growing season, McCall had a 90-day growing season; Evans 96 days; Dawson 100 days; and Hodgson 78 had a 105-day total growing season. Although the range in maturity among the four cultivars differed by an average of 15 days, environments significantly influenced the relative maturity of the cultivars. In the more productive environments at Manhattan, Hesston, and Powhattan, the range in maturity, from the earliest cultivar, McCall, to the latest cultivar Hodgson 78, tended to be the greatest. In the more stressed environments of Ottawa and Parsons, McCall and Hodgson 78 differed in maturity by only 11 days.

The differences in yield across locations were due primarily to precipitation received during the growing season. At the Ottawa, Parsons, and Powhattan locations, plants were subjected to drought stress due to a lack of rainfall in June, July or both months (Table 2). At the Ottawa and Powhattan locations, plants also competed with weeds throughout the vegetative growth period. At the Parsons location, the drought brought on the development of charcoal rot. The combined stresses of the drought and disease resulted in the plants at the Parsons location maturing prematurely. When the maturity dates were converted to total growing season, the differences among the locations became obvious. The Parsons location had a 84-day growing season which was the shortest among the five locations. It was 101 days at both Ottawa and Powhattan. The Manhattan location had a 104-day total growing season while Hesston had a 102-day growing season.

Hodgson 78 produced the tallest plants among the four cultivars averaged across all locations (Table 4). McCall and Evans were the shortest. Dawson tended to grow taller than McCall and Evans, but shorter than Hodgson 78. Plant height reached a maximum at the Manhattan and the minimum at the Powhattan location. There was a 15-cm difference in the average plant height between these two locations. The correlation between plant height and maturity was 0.22, however it was not significant (Table 5). Plant heights of all cultivars at the Manhattan, Ottawa, and Powhattan locations followed a similar pattern to the one indicated with the mean plant heights. Hodgson 78 was the tallest and McCall and Evans were the shortest cultivars. At the Parsons location, McCall tended to grow taller than Evans. At Hesston, while Hodgson 78 was the tallest cultivar, McCall, Evans, and Dawson did not significantly differ.

The average height of the lowest pod was the highest for Hodgson 78. Evans and Dawson tended to set the pods lower on the plant than McCall and Hodgson 78. A correlation between lowest pod height and maturity gave a correlation coefficient (r) of 0.16. The later-maturing cultivars tended to set the pods higher up the stem. When the lowest pod heights were averaged for all locations, Hesston produced the highest pods on the plant among the five locations. Plants grown at the Ottawa and Powhattan locations developed the pods lower on the plant than at the other three locations. The relative lowest pod height performance of all cultivars at Ottawa and Powhattan also followed the same pattern indicated with the mean lowest pod heights. At the Manhattan, Hesston, and Parsons locations, McCall and Hodgson 78 did not significantly differ.

Row spacing had an effect on the average seed yield and plant height averaged across all cultivars and locations (Table 6). The yield in 25-cm rows exceeded the yield in 76-cm rows by 257 kg/ha. On the other hand, average plant height was the highest in 76-cm rows. However, the difference was only 2.6 cm. Maturity, height of the lowest pod, and lodging score were not affected by the row spacing.

A significant location x row width interaction was observed for yield and plant height (Table 7). The plots with 25-cm rows produced higher yields than the plots with 76-cm rows at the Manhattan and Ottawa locations. At the Hesston, Parsons, and Powhattan locations, the yields from

25 and 76-cm rows were similar. The highest average yield was obtained at the Manhattan location in 25-cm rows. The lowest yields were harvested in 76-cm rows at the Ottawa and Parsons locations. There was a 47 % yield increase in 25-cm rows over 76-cm rows at the Manhattan location; 5 % at Hesston; 24 % at Ottawa; 15 % at Parsons; and 9 % at the Powhattan location. These results agree with other workers (2, 12, 28, 37, 46, 54) who report that yield increases in narrow rows due to early canopy closure and larger amount of light interception by the plants in narrow rows.

The average plant height was the highest in 76-cm rows at all locations except Manhattan and Parsons. At these two locations, the plant heights in 25 and 76-cm rows were not significantly different. The tallest plants were at the Manhattan location in both 25 and 76-cm rows. The shortest plants were in 25-cm rows at the Powhattan location. These results disagree with those (2, 6, 12, 21, 28, 38, 54) who have reported that at narrow row spacings, plants grow taller. While the average plant population was higher in 25-cm rows than in 76-cm rows, the plant population along a row in 76-cm row plots of 18 plants/m was greater than the 10 plants per meter in the 25-cm row plots. This higher density of plants could have accounted for the taller plants in the 76-cm rows. Row spacing did not influence the lowest pod height at any location. Within each location, both row widths produced the same pod height. However, the Hesston location had the highest pod height in both row widths among the five locations.

The plant populations at harvest were much less than the seeding rates at planting. The seeding rates were 775,000 and 516,000 seeds/ha in 25-cm rows and 516,000 and 344,000 seeds/ha in 76-cm rows. However, only 432,000 and 334,000 plants/ha in 25-cm rows and 287,000 and 190,000 plants/ha in 76-cm rows were harvested. The average stand establishment was 58 %. This low stand establishment might have resulted from low soil temperatures, and/or inadequate soil moisture during the germination process. The average soil temperatures (at 5 cm depth) at the time of planting were as follows: 14.4 C at Parsons, 20.5 C at Ottawa, 16.4 C at Powhattan, 19.4 C at Hesston, and 16.2 C at the Manhattan location. These are slightly higher than the treshold temperatures for soybeans to germinate. However, germination percentage and hypocotyl elongation will be higher at 30 C (20, 27, 45). Although emergence and establishment of plants averaged only 58 % of the seeding rates, plant populations nested within two row widths significantly affected the average yield and maturity (Table 8). Higher populations within the both row widths increased yields. The highest yield, 1661 kg/ha, was obtained in 25-cm rows with a population of 432,000 plants/ha (11 plants/m). Seventy-six-cm rows with a population of 190,000 plants/ha (14.4 plants/m) produced the lowest yield. The correlation between yield and plant population was 0.50 (Table 5). These results agree with other workers (2, 11, 21, 28, 31, 50) who report that yield is increased with increased plant density.

Within the same row width, plant population had no effect on the average plant height (Table 8). Lowest pod height and lodging scores were also not affected by the plant populations within two row widths. High populations resulted in a 1-day hastening of maturity within each row width.

Response of each cultivar to plant populations within two row spacings was also different (Table 9). However, cultivars produced their highest yields in 25-cm rows with higher populations. Lower populations reduced the yield in all cultivars. For instance, in Evans, while 25-cm rows with a population of 421,000 plants/ha produced 1583 kg/ha, seventy-six-cm rows with a population of 192,000 plants/ha produced only 1073 kg/ha. The highest yield averaged across locations, 1945 kg/ha, was produced by Hodgson 78 in 25-cm rows with a population of 395,000 plants/ha (10 plants/m). This was the best treatment combination that produced the highest yields. Plant population did not affect the plant height of any cultivars within the same row width. The lowest pod height of all cultivars except for Dawson was also not influenced by the plant population. In Dawson, low population in 25-cm rows resulted in lower pod set on the plant.

In summary, the results of this experiment showed that the cultivars in maturity group I had a better performance than the cultivars in group 00. The four cultivars tested differed in yield. Later-maturing cultivars such as Hodgson 78 tended to produce higher yields and taller plants than early-maturing cultivars such as McCall. This was because late-maturing cultivars took advantage of more of the growing season.

Narrow rows (25-cm) produced the highest yields due to larger percentage of light interception by the plants in 25-cm rows. On the other hand, the average plant height was the highest 76-cm rows because of the competition among the plants along a row in 76-cm row plots rather than the competition between rows since while the average plant population was higher in 25-cm row plots than in 76-cm row plots, the plant density along a row was higher in 76-cm row plots than in 25-cm row plots. Although the average plant height was the highest in 76-cm rows, height of the lowest pod was not affected by the row spacing. All cultivars responded well to high plant populations in terms of yield. However, plant height and height of the lowest pod were not influenced by plant population. The plant population achieved in this study was not high enough to maximize the yields of short-season soybean cultivars and the yield might be increased using 25-cm rows with high populations since a correlation between yield and plant population gave a significant positive correlation coefficient (r) of 0.50 (Table 5) and no lodging was observed.

The average yield of four cultivars across Kansas was 1430 kg/ha. In 1986, the state's average in dryland production areas from full-season cultivars was 1987 kg/ha. None of the short-season soybean cultivars' average yield equalled, or exceeded the state's average. The closest cultivar to the state's average was Hodgson 78 with a yield of 1631 kg/ha. As has been indicated previously, the best treatment combination was Hodgson 78, 25-cm rows with higher plant population. When the average yield of Hodgson 78 across all locations, 1945 kg/ha, was compared with the crop reporting districts' average yield, 2298 kg/ha, full-season cultivars outyielded short-season cultivars (Table 10). However, the yield of Hodgson 78 at Manhattan and Hesston exceeded the districts' average. At the Ottawa, Parsons, and Powhattan locations, full-season cultivars outyielded the best treatment combination. These comparisons have shown that the farmers in Kansas may not benefit from growing short-season soybean cultivars instead of full-season types. However, these are the results of a one-year study. The same study on the productivity of short-season soybean cultivars in Kansas should be conducted at least one more year to make the final decision. Perhaps, the growing season in 1986 was not dry enough to show the benefits of growing short-season soybean cultivars. These cultivars need to be compared to full-season types in a dry year. In a dry year, short-season soybean cultivars may be a benefit for Kansas farmers.

Table 3. Summary of analysis of variance for some agronomic characters of short-season soybean cultivars in Kansas.

	Yield	Mat.	Plant ht.	Pod ht.	Lodg.	Stand count.	Accel. aging	Warm germ.
C#	*	*	*	*	*	*	*	*
R	*	ns	ns	ns	*	ns	ns	*
L	*	*	*	*	*	*	*	*
RW	*	ns	*	ns	ns	*	ns	ns
PPL(RW)	*	*	ns	ns	ns	*	ns	ns
C*L	*	*	*	*	*	ns	*	*
C*RW	ns	ns	ns	ns	ns	*	*	ns
C*PPL(RW)	ns	ns	ns	ns	ns	ns	ns	ns
L*RW	*	ns	*	ns	ns	*	ns	ns
L*PPL(RW)	ns	ns	ns	ns	ns	*	ns	ns
C*L*RW	ns	ns	ns	ns	*	ns	ns	ns
C*L*PPL(RW)	ns	ns	ns	ns	ns	ns	ns	ns

* Significant at 5 % probability level.

C= Cultivar, R= Replication, L= Location, RW= Row width, and PPL= Plant population.

Table 4. Performance of short-season soybean cultivars at five locations in Kansas.

CULTIVAR	MANHTN.	HESSTON	OTTAWA	PARSONS	POWHATTAN	Mean
			Yield			
	---kg/ha---					
MCCALL	1652fg+	1870def	791m	928jkm	1103ijk	1269c#
EVANS	2193ab	1912b-e	886km	730m	1156ij	1376b
DAWSON	1855ef	2096bcd	1036ijk	961jkm	1268hi	1443b
HODGSON 78	2112ab	2332a	1118ijk	1096ijk	1494gh	1631a
Mean	1953a#	2053a	958c	929c	1255b	
			Maturity			
	---mo/day---					
MCCALL	8/2 h	8/4 g	7/31i	7/12m	7/31i	7/28d
EVANS	8/13d	8/11e	7/31i	7/13m	8/7 f	8/3 c
DAWSON	8/18ab	8/15c	8/2 h	7/18k	8/11e	8/7 b
HODGSON 78	8/19a	8/19a	8/11e	7/23j	8/17b	8/12a
Mean	8/13a	8/12b	8/3 d	7/17e	8/9 c	
			Plant height			
	---cm---					
MCCALL	50.4e-h	49.1e-h	44.0ijk	54.4cd	38.5m	47.3c
EVANS	58.2bc	47.4g-j	42.8k	50.8e-h	39.6km	47.8c
DAWSON	60.0b	48.9fgh	47.0hij	52.0def	44.0jk	50.4b
HODGSON 78	67.0a	58.4b	53.6de	58.0bc	51.6def	57.7a
Mean	58.9a	51.0c	46.9d	53.8b	43.4e	
			Lowest pod height			
	---cm---					
MCCALL	6.8e-h	9.8ab	6.8e-h	9.7b	6.6f-i	7.9b
EVANS	7.4def	9.1bc	5.5hi	7.3def	5.5hi	7.0c
DAWSON	8.0c-f	9.8ab	5.3i	6.6f-i	5.6ghi	7.0c
HODGSON 78	8.2cde	11.2a	7.0efg	8.7bcd	8.2cde	8.7a
Mean	7.6b	10.0a	6.2c	8.1b	6.5c	

+ The means with the same letter within the same row and column are not significantly different at p= 0.05 (LSD).

The means with the same letter within the same row or column do not differ at p= 0.05 (LSD).

Table 5. Correlation coefficients between yield, plant population, maturity, plant height, and lowest pod height (N= 80).

Characteristic	Yield	Maturity	Plant popl.	Plant ht.	Lowest pod ht.
			r		
Yield	____	0.68*	0.50*	0.44*	0.50*
Maturity		____	0.08	0.22	0.16
Plant population			____	-0.14	0.35*
Plant height				____	0.46*
Lowest pod height					____

* Indicates significance at the 0.05 level of probability.

Table 6. Effect of row spacing on average seed yield, maturity, plant height, lowest pod height, and lodging score.

ROW WIDTH	YIELD	MATURITY	PLANT HEIGHT	POD HEIGHT	LODGING
cm	kg/ha	mo/day	------cm------		score#
25	1558a+	8/5a	49.5b	7.5a	1.0a
76	1301b	8/5a	52.1a	7.8a	1.0a

Table 7. Influence of row width on soybean seed yield, plant height, and lowest pod height at five locations.

LOCATION	ROW WIDTH	SEED YIELD	YIELD INCREASE	PLANT HT.	POD HEIGHT
	cm	kg/ha	%	-------cm-------	
MANHATTAN	25	2325a+	47	58.6a	7.5bc
	76	1581c		59.2a	7.7b
HESSTON	25	2105b	5	47.7cd	10.0a
	76	2001b		54.2b	9.8a
OTTAWA	25	1060ef	24	45.4d	6.1d
	76	856g		48.3c	6.2d
PARSONS	25	995fg	15	53.9b	7.8b
	76	863g		53.8b	8.3b
POWHATTAN	25	1308d	9	41.8e	6.2d
	76	1203de		45.1d	6.7cd

+ The means with the same letter do not differ at p= 0.05 using Fisher's LSD.

Scoring was 1= all plants erect and 5= all plants down.

Table 8. Average seed yield, maturity, plant height, lowest pod height, and lodging score as influenced by the plant population within two row widths.

ROW WIDTH	PLANT POPULATION	YIELD	MATURITY	PLANT HT.	POD HT.	LODGING
cm	plants/ha	kg/ha	mo/day	----cm-----		score#
25	432,000	1661a+	8/4a	49.7b	7.6a	1.0a
	334,000	1456b	8/5b	49.3b	7.4a	1.0a
76	287,000	1387b	8/4a	52.3a	8.0a	1.0a
	190,000	1214c	8/5b	52.0a	7.6a	1.0a

1= all plants erect.

+ The means followed by the same letter within the same column are not significantly different at P=0.05 using Fisher's LSD.

Table 9. The yield, plant height, and lowest pod height of four soybean cultivars as affected by the plant population within two different row widths.

CULTIVAR	ROW WIDTH	PLANT POPULATION	YIELD	PLANT HT.	POD HT.
	cm	plants/ha	kg/ha	--------cm--------	
MCCALL	25	477,000	1462bcd+	46.4ef	7.9a-d
		355,000	1235efg	44.4f	7.6b-f
	76	338,000	1271d-g	49.4de	7.9a-d
		233,000	1107fg	48.9de	8.3abc
EVANS	25	421,000	1583bc	47.4def	6.4fg
		395,000	1534bc	46.4ef	7.6b-f
	76	275,000	1313def	48.0de	7.2c-g
		192,000	1073g	49.0de	6.6d-g
DAWSON	25	461,000	1652b	48.9de	7.7a-f
		293,000	1437cd	49.3de	6.1g
	76	279,000	1436cde	53.0bc	7.8a-e
		190,000	1246efg	50.3cd	6.5efg
HODGSON 78	25	395,000	1945a	56.0ab	8.6ab
		296,000	1619bc	57.0a	8.3abc
	76	256,000	1530bc	58.8a	9.0a
		144,000	1429cde	59.1a	8.8ab

+ The means followed by the same letter within the same column are not significantly different at P=0.05 using Fisher's LSD.

Table 10. Comparison between the yield of the best treatment combination at all locations with the Kansas crop reporting districts' average yields.

LOCATION	HODGSON 78 25-CM ROWS HIGH POPULATION	DISTRICT YIELDS
	--------kg/ha--------	
MANHATTAN	2929	2608
HESSTON	2513	2287
OTTAWA	1558	2341
PARSONS	1225	1647
POWHATTAN	1498	2608
Mean	1945	2298

INFLUENCE OF PLANTING DATE ON THE PRODUCTIVITY OF SHORT-SEASON SOYBEAN CULTIVARS

A summary of analyses of variance concerning the performance of short-season soybean cultivars at two planting dates is given in Table 11. Main effects, cultivars and planting dates, were significant for all agronomic traits measured. Row width and plant population within two row spacings were also significant for yield. The primary significant interactions were cultivar x planting date for maturity, planting date x row width and cultivar x planting date x row width for yield.

Evans produced the highest yield among the four cultivars (Table 12). McCall and Dawson gave the lowest yields. Hodgson 78 had a higher yield than McCall and Dawson, but lower yield than Evans. McCall was 9 days earlier than Evans, 13 days earlier than Dawson, and 14 days earlier than Hodgson 78. Dawson and Hodgson 78 were the latest in maturity. Evans and Dawson are in the same maturity group; however, Evans reached maturity 4 days earlier than Dawson. Hodgson 78 was the tallest cultivar among the four cultivars, McCall the shortest. Evans and Dawson were not significantly different from another. Hodgson 78 set the pods higher up the stem than McCall and Evans. Hodgson 78 and Dawson were not significantly different. Height of the lowest pod was the same for McCall, Evans, and Dawson. Dawson and Hodgson 78 tended to lodge more than McCall and Evans. The difference between McCall and Evans was not significant.

In terms of accelerated aging (AA) and warm germination (WG) scores, McCall, Evans, and Dawson were not significantly different. The difference among Evans, Dawson, and Hodgson 78 was not significant either. However, Hodgson 78 had a higher AA and WG scores than McCall.

Seed yield was also affected by the row spacing (Table 13). The yield was higher in 25-cm rows than 76-cm rows. Average maturity, plant height, lowest pod height, and lodging scores were not influenced by the row spacing. Plant populations within two row widths also had an effect on the average yield. The yield was the highest in 25-cm rows with a population of 461,000 plants/ha (12 plants/m). The yield obtained in 25-cm rows with a population of 355,000 plants/ha was significantly higher than the yield obtained in 76-cm rows with a population of 329,000 plants/ha. However, there was no significant difference between the yields in 76-cm rows with a population of 329,000 and 191,000 plants/ha. Plant population had no effect on maturity, plant height, lowest pod height, and lodging score. There was only a 0.5-cm difference in plant heights at a population of 461,000 and 191,000 plants/ha.

The average yield, maturity, plant height, lowest pod height, lodging, accelerated aging (AA), and warm germination (WG) scores were affected by the date of planting (Table 14). Seed yield was higher in the May 16 planting than the May 1 planting. Plant height also was the highest for the May 16 planting. These results disagree with those (1, 3, 7, 9, 13, 26, 39, 40) who report that when planting is delayed, plants become smaller and produce lower yields. This might have been resulted from the differences in plant populations between two planting dates. While the average harvested plant population for the May 1 planting was 302,000 plants/ha, it was 367,000 plants/ha for the May 16 planting date.

The average total growing season for the May 1 planting was 104 days. The total growing season was 95 days for the May 16 planting date. This result shows that delayed planting reduces the time required from planting to maturity. This response agrees with other workers (1, 9, 24, 30, 49).

A 15-day delay in planting caused the pods to be set higher on the plant. Lodging also tended to increase with late planting. This was because plants were the tallest from the May 16 planting. The average AA and WG scores were the highest from the May 16 planting. This might have resulted from the effects of environmental conditions on the seed quality during the seed maturation period at different planting dates (25).

Except for Dawson and Hodgson 78, all cultivars produced higher yields when planting was delayed 15 days (Table 15). Planting date did not effect the yields of Dawson and Hodgson 78. The highest yield of 2581 kg/ha was produced by Evans when planted May 16. McCall and Dawson produced the lowest yields when planted May 1.

All cultivars reached maturity in less time when planted May 16 than planted May 1. The total growing season is reduced 4 days in McCall; 9 days in Evans; and 11 days in Dawson and Hodgson 78. This shows that the cultivars from maturity group 00 were not affected by the planting date as much as the cultivars from group I.

Plant height was increased with a 15-day delay in planting in all cultivars. Delayed planting also caused McCall, Evans, and Hodgson 78 to set the pods higher on the plant. Planting date had no effect on the lowest pod height of Dawson. Hodgson 78 and Dawson tended to lodge when the planting was delayed 15 days. However, lodging scores of McCall and Evans were not affected by the time of planting. These results disagree with others (1, 3, 7, 9, 13, 30, 47) who report that delayed planting reduce yield, plant height, and height of the lowest pod.

Another significant Planting date x Row width interaction was also observed for the average yield (Table 16). The average yield was the highest in 25-cm rows for both planting dates. However, the yield of the narrow rows exceeded the yield of the wide rows by 47 % and 15 % for the first and second planting, respectively.

In this planting date study, a significant cultivar x row width x planting date interaction was observed for yield (Table 17). While McCall produced its highest yield in 25-cm rows when planted May 16, Hodgson 78 produced its highest yield in 25-cm rows when planted May 1. Planting date had no effect on the yield of Evans and Dawson when planted in 25-cm rows. All cultivars tended to yield less in 76-cm rows when planted May 1. Narrow rows resulted in increases in yields of all cultivars. As has been explained before, this was due to the larger amount of light interception by the plants in narrow rows (37, 46, 54).

The results of accelerated aging (AA) and warm germination (WG) tests are presented in Table 18. Hodgson 78 had the highest AA and WG scores among the four cultivars. The AA and WG scores were the lowest for McCall. Evans and Dawson were not significantly different. When the AA and WG scores were averaged for all locations tested, the Manhattan (May 16 planting) location was the best. The Manhattan (May 1 planting) and Hesston locations were not significantly different from each other.

The AA and WG scores of all cultivars at each location except for the Manhattan (May 16 planting) location tended to follow the pattern indicated with the mean AA and WG scores. At Manhattan (May 16 planting), McCall, Evans, and Hodgson 78 did not significantly differ in AA scores. The WG scores were the same for all cultivars.

In the same table, Table 18, effect of planting date on AA and WG scores are also presented. McCall and Evans had a higher AA and WG scores when planted May 16. Planting date had no effect on the AA and WG scores of Dawson and Hodgson 78. As an average, AA and WG scores were higher for the May 16 planting date.

These results have shown that very short-season cultivars such as McCall (group 00) have had a poor germination percentage when compared to early-season cultivars such as Hodgson 78 (group I). Only McCall and Evans had a better AA and WG scores when the planting was delayed for 15 days. These differences among cultivars might have been resulted from the differences in maturity of cultivars. Some cultivars might have reached maturity during a hot weather and seed quality might have been affected by high temperatures during the seed maturation period. For example, at the Hesston location, temperatures were higher than at the Manhattan location during the growing season. Temperatures also were above the 30-year average at the Hesston location (Table 2). These high temperatures during the growing season might have affected the seed quality and hence the germination percentages. These results have shown that the seeds produced by the farmers on their own land may not be suitable to plant next season since these short-season cultivars have a lower germination percentages. This situation may force the farmers to buy the seeds each year from a suitable dealer.

In summary, a 15-day delay in planting resulted in higher average yields, hastening of maturity by 9 days, taller plants, higher pods on the plant, increased lodging, and higher AA and WG percentages.

The average yield was the highest for the May 16 than for the May 1 planting. Plant population was higher at the second planting date and environmental conditions more favorable for early growth. An increase in lowest pod height and lodging was due to the fact that plant height was the highest in the May 16 planting. Only McCall and Evans tended to produce higher yields when the planting was delayed. Yields of the later-maturing cultivars such as Dawson and Hodgson 78 were not affected by the date of planting. On the other hand, the time required from planting to maturity was reduced in all cultivars. All cultivars tested also tended to grow taller with delayed planting. However, only Dawson and Hodgson 78 lodged when the planting was delayed. Height of the lowest pod was also increased with delayed planting in all cultivars except for Dawson. Higher pod set on the plant and increased lodging were due to taller plants from late planting. Delayed planting also increased AA and WG scores because seed maturation period took place in a more favorable environment in the May 16 planting than in the May 1 planting.

Table 11. Analysis of variance table for some agronomic characters of soybeans in the planting date study.

	Yield	Mat.	Plant ht.	Pod ht.	Lodg.	Stand count	Accel. aging	Warm germ.
C#	*	*	*	*	*	*	*	*
R	*	ns	ns	ns	*	*	ns	ns
D	*	*	*	*	*	*	*	*
RW	*	ns	ns	ns	ns	*	ns	ns
PPL(RW)	*	ns	ns	ns	ns	*	ns	ns
C*D	ns	*	ns	ns	*	*	*	*
C*RW	ns	ns	ns	ns	ns	ns	ns	ns
C*PPL(RW)	ns	ns	ns	ns	ns	ns	ns	ns
D*RW	*	ns	ns	ns	ns	*	ns	ns
D*PPL(RW)	ns	ns	ns	ns	ns	ns	ns	ns
C*D*RW	*	ns	ns	ns	ns	ns	ns	ns
C*D*PPL(RW)	ns	ns	ns	ns	ns	ns	ns	ns

* Significant at P=0.05.

C= Cultivar, R= Replication, D= Date of planting, RW= Row width, and PPL= Plant population.

Table 12. Average seed yield, maturity, plant height, lowest pod height, lodging score, accelerated aging, and warm germination percentages from two planting dates at the Manhattan location.

CULTIVAR	YIELD	MATURITY	PLANT HT.	POD HT.	LODG.	ACCEL. AGING	WARM GERM.
	kg/ha	mo/day	----cm----		score#	-----%-------	
MCCALL	1861c+	8/7 c	63.0c	8.0b	1.1b	72.0b	82.5b
EVANS	2356a	8/16b	69.9b	8.5b	1.1b	76.2ab	85.1ab
DAWSON	1945c	8/20a	68.9b	8.6ab	1.7a	75.3ab	87.0ab
HODGSON 78	2166b	8/21a	76.3a	9.4a	1.9a	83.5a	90.3a

Scoring was 1= all plants erect and 5= all plants down.

+ The means followed by the same letter within the same column are not significantly different at P=0.05 using Fisher's LSD.

Table 13. Influence of plant population and row spacing on average yield, maturity, plant height, lowest pod height, and lodging score.

ROW WIDTH	PLANT POPULATION	YIELD	MATURITY	PLANT HT.	POD HT.	LODGING
cm	plants/ha	kg/ha	mo/day	-----cm-----		score#
25	461,000	2492a+	8/16a	70.0a	8.3a	1.4a
	355,000	2195b	8/16a	68.2a	8.5a	1.3a
Mean		2343a‡	8/16a	69.1a	8.4a	1.4a
76	329,000	1873c	8/15a	70.3a	9.1a	1.5a
	191,000	1768c	8/16a	69.5a	8.7a	1.5a
Mean		1821b	8/16a	69.9a	8.9a	1.5a

Scoring was 1= all plants erect and 5= all plants down.

\+ The means followed by the same letter within the same column are not significantly different at P=0.05 using Fisher's LSD.

‡ The means followed by the same letter within the same column are not significantly different at P=0.05 using Fisher's LSD (comparison between two means of row widths).

Table 14. Planting date effect on average yield, maturity, plant height, lowest pod height, lodging score, accelerated aging, and warm germination percentages.

PLANTING DATE	YIELD	MAT.	TOTAL GRW.S.	PLANT HT.	POD HT.	LODG.	ACCEL. AGING	WARM GERM.
	kg/ha	mo/day	day	----cm----		score#	------%-----	
May 1	1953b+	8/13b	104	58.9b	7.6b	1.2b	66.3b	80.3b
May 16	2211a	8/19a	95	80.0a	9.6a	1.6a	87.2a	92.2a

+ The means followed by the same letter within the same column are not significantly different at P=0.05 using Fisher's LSD.

Table 15. Planting date effect on some agronomic characters of four soybean cultivars.

CULTIVAR	PLANTING DATE	YIELD	MAT.	TOTL. GRW.S.	PLANT HT.	POD HT.	LODGING
		kg/ha	mo/day	day	----cm----		score#
MCCALL	May 1	1652d+	8/2 e	93	50.4f	6.8f	1.2c
	May 16	2069bc	8/13d	89	75.6c	9.3bc	1.0c
EVANS	May 1	2193b	8/13d	104	58.2e	7.4ef	1.1c
	May 16	2518a	8/19c	95	81.5ab	9.5ab	1.1c
DAWSON	May 1	1855cd	8/18c	109	59.9e	8.0def	1.2c
	May 16	2035bc	8/22b	98	77.9bc	9.1bcd	2.3a
HODGSON 78	May 1	2112bc	8/19c	110	67.0d	8.3cde	1.6b
	May 16	2221b	8/23a	99	85.5a	10.6a	2.2a

\# Scoring was 1= all plants erect and 5= all plants down.

\+ The means followed by the same letter within the same column are not significantly different at P=0.05 using Fisher's LSD.

Table 16. Effect of row width on average soybean yield at two different planting dates.

PLANTING DATE	ROW WIDTH	YIELD
	cm	kg/ha
May 1	25	2325a+
	76	1580c
May 16	25	2362a
	76	2060b

+ The means followed by the same letter within the same column are not significantly different at P=0.05 using Fisher's LSD.

Table 17. The yields of four soybean cultivars as affected by row spacing and planting date.

CULTIVAR	ROW WIDTH	PLANTING DATE MAY 1	MAY 16	Mean
		Yield		
	cm	----------kg/ha---------		
MCCALL	25	1829def+	2322bc	2076bc#
	76	1475f	1816def	1646d
Mean		1652d#	2069bc	
EVANS	25	2630ab	2718a	2674a
	76	1756ef	2319bc	2038bc
Mean		2193b	2518a	
DAWSON	25	2151cd	2101cde	2126b
	76	1558f	1970cde	1764cd
Mean		1855cd	2035bc	
HODGSON 78	25	2690a	2306c	2498a
	76	1534f	2136cd	1835cd
Mean		2112bc	2221b	

\+ The means followed by the same letter within the same row and column are not significantly different at P=0.05 using Fisher's LSD.

The means followed by the same letter within the same row or column are not significantly different at P=0.05 using Fisher's LSD.

Table 18. Accelerated aging and warm germination tests results of four soybean cultivars at three environments and two different planting dates.

CULTIVAR	MANHATTAN (May 1)	MANHATTAN (May 16)	HESSTON	Mean
	LOCATION			
	Accelerated aging			
	---------------%---------------			
MCCALL	52.9f+	91.3a	36.8g	60.3c#
EVANS	62.6ef	89.8ab	59.7f	70.7b
DAWSON	72.1de	78.4bcd	61.7ef	70.7b
HODGSON 78	77.7cd	89.3abc	89.8ab	85.6a
Mean	66.3b#	87.2a	62.0b	
	Warm germination			
	---------------%---------------			
MCCALL	69.5e	95.5a	65.7e	76.9c
EVANS	77.3d	92.8a	78.7d	82.9b
DAWSON	84.4bcd	89.5abc	83.2cd	85.7b
HODGSON 78	89.8abc	90.8ab	94.0a	91.5a
Mean	80.3b	92.2a	80.4b	

+ The means followed by the same letter within the same row and column are not significantly different at P=0.05 using Fisher's LSD.

The means followed by the same letter within the same row or column are not significantly different at P=0.05 using Fisher's LSD.

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A P P E N D I X

A1. Reproductive growth stages of four soybean cultivars at two different dates of planting at Manhattan, Kansas (1986).

CULTIVAR	REPRODUCTIVE GROWTH STAGE							
	R1	R2	R3	R4	R5	R6	R7	R8
	-----------------------			day/mo	-----------------------			
McCall	__	__	__	6/25+	7/5	7/14	7/25	8/2
	__	6/26	__	7/5	7/14	7/22	8/1	8/13
Evans	__	__	__	6/25	7/5	7/14	8/1	8/13
	__	6/26	__	7/5	7/14	7/26	8/5	8/19
Dawson	__	__	6/25	7/2	7/11	7/22	8/7	8/18
	__	6/26	7/5	7/11	7/18	7/27	8/13	8/22
Hodgson 78	__	__	6/25	7/3	7/13	7/25	8/11	8/19
	__	6/26	7/5	7/14	7/22	8/7	8/16	8/23

+ Upper values for the May 1 planting and bottom values for the May 16 planting date.

PRODUCTIVITY OF SHORT-SEASON SOYBEAN CULTIVARS IN KANSAS

by

METIN BABAOGLU

B.Sc. University of Cukurova, Adana, Turkey, 1983.

AN ABSTRACT OF

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ABSTRACT

Four short-season soybean cultivars from different maturity groups, ranging from 00 to I, were tested at five Kansas dryland locations in 25 and 76-cm rows with two different seeding rates within each row width to investigate the possibilities of producing short-season soybean cultivars and effects of cultural practices on the productivity of these cultivars in dryland production areas in Kansas. The later-maturing cultivars (group I) tended to perform better than the early-maturing cultivars (group 00). Hodgson 78 (goup I) was the highest-yielding cultivar among the four cultivars tested. It also grew taller and set the pods higher up the stem than McCall, Evans, and Dawson. While the average seed yield was the highest in 25-cm rows, plant height reached a maximum in 76-cm rows. Lowest pod height and lodging scores were not affected by the row spacing. All cultivars tended to produce higher yields at higher plant populations. A 15-day delay in planting resulted in higher yields in early maturing cultivars, hastening of maturity, taller plants, higher pods on the plant in all cultivars, increased lodging in late maturing cultivars, and higher accelerated aging and warm germination scores in early maturing cultivars (group 00).