EFFECT OF ROW WIDTH AND PLANT POPULATION

ON TWO SOYBEAN CULTIVARS

By

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CHAPTER I

INTRODUCTION

The Agricultural Scientists of the World are being confronted by the challenge of a rapidly-rising world population which must be fed on constant, even diminishing resources of land, water, and nutrients. A major part of this effort to meet the world's needs for increased food and oil production is the development of better management techniques on production of cultivars or basic food crops. Soybean, Glycine max (L.) Merrill, is a major food crop the world over; therefore, it will be needed in larger amounts to help feed more and more people. Both yield and quality must be improved to meet this challenge. The soybean has many important uses. It is a highly efficient producer of protein and oil, both of which are well adapted to the nourishment of animals and humans (1). The two main products derived from soybeans are soybean oil and soybean meal. Soybean oil is used in motor fuel, paint, varnish, linoleum, soap compound and vegetable shortenings, oleomargarine, printing ink, lubricant and other edible products (19). Soybean meal is very important for livestock feed and it is used as an ingredient in making cake, candy bars, cookies, baby foods and hypoallergenic milk. Soy protein, as a food additive, is used to increase protein content and to improve nutritive value of food for human and animal consumption (1).

In the United States, the remarkable expansion in soybean production is one of the most relevant agricultural developments in recent years (19). The industrialization of soybeans caused a rapid increase in harvested acres from about 500,000 in 1924 to almost 56 million in 1972, with a total production of more than 1.54 billion bushels by 1973. Oklahoma soybean acreage had increased from 6,000 acres harvested in 1944 to 219,000 acres harvested in 1974 for a total production of 5,037,000 bushels (27). In the United States, the soybean yields increased by approximately 25 to 30 bushels per acre in the late 70's. Still, improved soybean management and production techniques are needed to meet increasing demands.

Any production technique that increases the yield components of soybeans would be considered beneficial. The effect of shattering, lodging, row space, and plant population are factors which have not been investigated adequately.

High yield in soybeans is the result of maximum photosynthesis and optimum photosynthate utilization (23). In order for this to occur, there must be a maximum interaction between the genetic potential of soybean and environmental factors and management practices (32). Management variables, such as row spacing and plant density, are major factors in improving yield in any production regime.

This study dealt with two determinate soybean cultivars, three row spacings and four plant densities. The objectives of this study were to evaluate the behavior of the two soybean cultivars to the interacting effects of row spacings and plant densities and to determine which combination of treatments produced the highest yields.

CHAPTER II

REVIEW OF LITERATURE

Soybeans are the number one agricultural product in the United States export market; consequently, they became the leading cash crop and the leading source of oil and high-quality protein for feed and food industries in the United States (35). The low cost of producing high-quality oil and protein is largely responsible for the soybean success and popularity today.

Representative soybean cultivars grown in the United States are categorized in ten maturity classes from 00 to VIII. Groups 00 and 0 are the earliest-maturing varieties adapted to the northern latitudes of the United States and southern Canada. Groups VII and VIII are the latest-maturing varieties adapted to the southern extremes of this country.

Soubean cultivars grown in the United States are classified as having an indeterminate or determinate growth habit (14). Egli and Leggett (14) stated that determinate soybean stems terminate in an inflorescence, while the indeterminate type do not have a terminal inflorescence. Bernard (3) indicated that a determinate type was one in which the stem growth terminated abruptly at flowering or soon afterward, while in the indeterminate type, the vegetative and reproductive growth continued for a long while after flowering. Bernard also suggested that there are stages in the degree of determinacy. Westerman and Crothers

(40) found that the determinate soybean plant is subject to less competitive stress than the indeterminate plant types at higher plant density. Green et al. (15) found that indeterminate lines produced a significant increase in seed size and in seed yields compared to the determinate types. They also pointed out that this increase is due to the indeterminate growth habit. Egli and Leggett (14) postulated that the competition between vegetative and reproductive growth in indeterminate soybean cultivars may be detrimental to yield. Simultaneous reproductive and vegetative growth result in reduced pod set and potential reduction in grain yield. They also concluded that a determine stem may be desirable for high-yielding varieties in the North Central soybean production areas.

The soybean yield depends on the result of the plant's response to its environment. Yield components of the plant which contribute to yield include plants per unit area, pods per plant, seeds per pod, and seed weight. The yield components are believed to be independent genetically and their contribution to seed yield depends upon the cultivar which may or may not allow the full genetic expression of each component (40).

Soybean yields have increased remarkably in the last decade from 1.17 billion bushels in 1971 to 1.8 billion bushels in 1980 (35). The adoption of improved cultural practices and higher yielding cultivars have made possible this increase in yield (40). Caviness (9) stated that the successful grower is the one who selects the suitable cultivar to be planted and superimposes adequate management practices on this crop throughout the season.

One management technique that has been researched by many investigators is the effect of difference in row spacings. Higher yields have been reported when soybeans were planted in narrow (less than 20 inches) rather than in wide rows (larger than 30 inches). This is substantially documented (2, 4, 8, 9, 21, 23, 24, 26, 28, 31, 33, 36, 41).

Wiggans (41) studied the influence of space and arrangement on the production of soybean plants. He found that the narrower the distance between rows until the distance between rows equals the space between plants in the row, the more uniform distribution of growth and the greater the yield will be. In 1945, Probst (26) concluded that the soybean plant is capable of making wide adjustments to space and that the optimum rates and widths for soybeans should be dictated by the areas and cultivars to be grown. Burwood and Fehr (5) found that yields increased by planting soybeans in narrow rows (less than 20 inches). This was due to improved plant distribution for a given area. They also concluded that planting in narrow rows made the soybean canopy develop more uniformly. In 1969, Shibles and Green (33) suggested that there are several important facts about narrow-row responses that persuade researchers to consider breeding specific morphological types for the narrow row environment. There is evidence of a genotype-row spacing interaction.

In 1969, Shibles and Green (33) obtained an average yield advantage of about 35-45% for 12-inch rows as compared to 40-inch rows with 87 lines. Carter and Hartwig (8) noted that optimum row spacings for soybeans should be determined not only for the producing areas, but also for the cultivars to be grown. Long-growing season, late-maturing cultivars do not require the same row spacing for maximum yield as short-growing season, early-maturing varieties. Boquet (4) suggested that the agronomic performance of soybeans in different row spacings depended on factors such as cultivar, climate, soil type, growth habit, and day length, and because these factors differ with location. In the northcentral part of the United States, higher yields have been reported when soybeans were planted in narrow (30 or less inches) rather than in wide rows (40 or more inches) with the greatest increase when early-maturity indeterminate cultivars were used. However, in the southern areas of the United States, determinate soybeans have not responded consistently to planting in narrow rows (24). In a series of research projects initiated in 1971, Spilde, Whited, and Shettland (36) pointed out that soybean cultivars generally produce greater yields in narrow row spacings than in wide row spacings. They showed that 12-inch rows yielded 25% higher than 24-inch rows and 40% more than 36-inch rows. Their results lead to the conclusion that a 12-inch row spacing may produce the highest soybean seed yield. Safo-Kantaka and Lawson (31) showed that there was a decrease in yield as row width increased or as rectangularity departed from the square arrangement. They concluded that changes in inter-row width are more detrimental to soybean yield than changes in plant arrangement. Weber, Shibles, and Byth (39) showed that as row width increased, leaf area index decreased. However, in narrow rows the leaf area index increased, originating greater photosynthetically-active radiation interception and higher yield. In 1976 Boquet (4) conducted a row spacing experiment with five soybean cultivars and three row widths of 10, 20, and 40 inches. His results showed that all five cultivars yielded higher when planted in row spaces of 20 inches. He also pointed out that response to row spacing was not always consistent. The magnitude of response was often variable and depended on plant density.

Weed control is a major consideration when planting soybeans in narrow rows. Aldrich and Scott (1) stated that the poor acceptance of narrow row spacing by the farmer is due mainly to the problem in controlling weeds. In 1977, Burnside and Moomar (7) suggested that planting soybeans in wide rows (90 to 105 cm) would aid in weed control. They continued to suggest that there is a need for planting soybeans in wide rows rather than in narrow rows in order to make the cultivation process more suitable for weed control. However, they indicated that the use of good herbicides can decrease the dependence on the cultivation process for weed control. Spilde, Whited, and Shettland (36) stated that chemical or mechanical weed control may be more effective in narrow rows than in 40-inch rows because the herbicide needs to be effective only for a short period of time before the soybean canopy covers weeds between and within the rows. They continued that narrow rows need a good early control of weeds because of the inability to cultivate after soybean emergence. Soybeans are most susceptible to weeds' competition during their early growth stages (7). Soybeans kept weed-free for the first four weeks after planting showed little yield loss from later-emerging weeds (6). Burnside (6) and Wax (38) found that the leaf canopy of narrow row soybeans covers the area between rows more quickly than that of soybeans in 36- to 40-inch rows. After the canopy is developed, the shade is quite defensive against weed competition.

The amount of evapotranspiration from any area is governed primarily by those factors affecting water and heat supply to the soil and plant surface. High rates of water loss by evaporation could be reduced as suggested by Denmead, Fritschein, and Shaw (12) with closer rows. Narrower rows will reduce the energy available for water evaporation from the soil surface, and a considerable increase in water-use efficiency could be obtained under conditions where the soil surface is frequently wet. Taylor (37) suggested that yield of soybeans are influenced by an interaction between row spacing and seasonal water supply. Soybeans planted in narrow rows yielded higher than those planted in wider rows (102 cm) when water supply availability was optimum. But during dry seasons, the row width pattern had no effect on yields. Early canopy closure due to planting in narrow spacings tended to use water at a greater rate early in the season, and less water was available for the pod-filling. Water stress effects on soybeans depend on the stages of reproductive development. Runge and Odell (29) concluded that stress during mid-flowering and early-podding resulted in substantial pod loss from lower nodes. Doss, Pearson, and Rogers (13) and Runge and Odell (29) concluded that insufficient water during the pod-filling period was the major barrier to high soybean yields.

Harvesting losses of soybeans are due to: soil slope, preharvested shattering, shattering by cutter action, beans remaining in pods, beans remaining on the stubble, lodged bean loss or beans in pods on stalk not cut (unthreshed beans). Wax (38) noted that soybeans grown in wider rows generated greater losses during harvesting period due to ridged soil by cultivation than soybeans grown in narrow rows where cultivation was not needed. A better and lower cutting height is required with flatter soil surface between rows. Parker, Narchant, and Mullinix (24) suggested that, generally, plant height increased as row spacing decreased. The lower pods were higher above the soil surface resulting in a decrease in losses during harvesting operation. However, Probst (26) stated that row spacing had little effect on the height of soybean plants. Safo-Kantanka and Lawson (31) in 1980 studied the effect of different row spacing and plant arrangements on soybeans. They suggested that, in general, lodging increased as row width decreased.

Aldrich and Scott (1) suggested that earlier and shorter varieties had shown an advantage in narrow rows over taller, later-maturing varieties. Cavines (9) stated that determinate varieties usually will not canopy the middles when planted after June 15 (late). Therefore, yields are increased by narrow rows when planted late (after June 15).

Another important management technique studied by many researchers is the effect of variation in plant population density within the row. Lueschen and Hicks (22) found that, as plant density is increased, the yield components of soybeans are changed. The number of seeds, pods and branches produced per plant showed a decrease linearly as plant population increases. Shifts within these parameters accounted for the ability of soybeans to adjust to a wide range of intra-row spacings. Pendleton and Hartwig (25) and Wiggins (41) suggested that in determining the optimum plant population density for soybeans several factors should be considered. These include producing areas, cultivars, location, row width, date of planting, seed germination, seed size and weed species. Also they stated that the optimum number of plants per unit area for the maximum net increases was six plants per square foot for the row widths of 12 or 16 inches. According to Boquet (4), optimum plant populations per acre range from 90,000 for 40-inch rows to 130,000 for 10 or 20-inch rows. Westermann and Crothers (40) studied indeterminate and determinate bean varieties. They concluded that determinate plants produced less vegetative growth during the flowering period and pod formation than indeterminate types. The potential for competition between the vegetative and reproductive stages for photosynthate could be less in the determinate than in the indeterminate plants. The ratio of interplant to intraplant competition for assimilates could be increased at greater plant densities. As the plant population increased, the harvest index (dry weight of seed per total plant dry weight) decreased for indeterminate, but remained constant for the determinate cultivars. This was an indication that more photosynthates went to seed production instead of vegetative production as the area per plant increased (decreasing plant population) for the indeterminate, but not for the determined types. This explained the increase of seeds per pod, grams per seed and pods per plant as area per plant increased for the indeterminate types.

Lodging has been one of the major factors affecting yield response to increased plant populations. Boquet (4) stated that proper plant population (34,000, 63,000, and 50,000 plants per acre for 10-, 20-, and 40-inch rows) increased yields, minimized lodging and soil moisture depletion. Safo-Kantanka and Lawson (31) showed that plant height, height of the lowest pod lodging increased with increasing plant density. Height of the pods is important for avoiding harvesting difficulties and losses.

Ryder and Beuerlein (30) stated that plant mortality increased rapidly with an increase in seeding rate. The mortality between emergence and harvest period was greater in 30-inch wide rows than in narrow rows. Their results showed that natural mortality due to intra-row competition at higher plant populations reduced yields as much as 30%.

CHAPTER III

MATERIALS AND METHODS

In order to evaluate the effect of row width and plant density, an experiment consisting of two soybean varieties, three row spacings and four plant densities was conducted at two different locations in the 1981 growing season.

Cultivars

The two varieties used were 'Essex' and 'Forrest.' Essex originated as an F_7 line selected at Virginia Agricultural Experiment station, and released by Virginia, Delaware, Maryland, Georgia, Kentucky, and Louisiana from the cross 'Lee' X S5-7075 (34). Essex is characterized by high seed yields, excellent standing ability and good seed quality. Maturity is three to five days earlier than 'York' and 'Dare' and four days later than 'Hill.' Mature plant height is normally four to six inches shorter than York and Dare. Pods are produced well off the ground on upright branches. Seed is equal to Dare in size with oil content equal to York, but below Dare and Hill. Protein content is above York, Dare, and Hill. Essex is resistant to bacterial pustule. Several races of downy mildew, freeze and moderately resistant to phytophthora rot. Seeds are free from mottling and the cultivar has resistance to purple seed stain. Plants have purple flowers and gray pubescence. Seeds have buff hila, yellow cotyledons and yellow seed coat. Essex has a determinate growth type and belongs to maturity Group V. Forrest originated as an F_5 line tracing to a cross of 'Dyer' X 'Bragg' cultivars (16). Forrest was developed in a cooperative program of the Agriculture Research service of the United States Department of Agriculture, Mississippi, Tennessee, Oklahoma, Kentucky, Arkansas, and Missouri Agricultural Experiment stations. Forrest has white flowers, brown pubescence, black hilum, and shiny, light greenish seed coat. It is highly resistant to races 1 and 3 of the soybean cyst nematode, moderately resistant to phytophthora rot, and has excellent resistance to seed shattering. Forrest has a determinate growth habit and is a representative of maturity Group V.

Row Widths

The row spacings used at both locations were 25, 50, and 75-cm row widths. These widths were the distance between rows of plants. The 25-cm row width is generally considered a narrow row width and the 75-cm row width is a wide row width. Each plot was 3.6 m long and 3.05 m wide. The number of rows per plot was not constant, but varied with the row spacing of the treatment from three to 12 for row widths from 75 to 25 cm, respectively.

Plant Densities

At both locations, the plant densities used were 110,000, 220,000, 330,000, and 440,000 plants per hectare (11, 22, 33, and 44 plants per square meter). The number of plants needed to define the desired population densities was established by thinning when plants were at the height of 12 to 15 cms.

Design and Field Layout

The study was conducted at the Agronomy Research station near Perkins, Oklahoma on a Teller loam soil (Location 2) and at the Oklahoma Vegetable Research station, Bixby, Oklahoma on a Wynona silt loam soil (Location 1) with slopes of 0 to 1% at both locations. The soybeans were planted at Perkins on June 8, 1981, and at Bixby on June 23, 1981. A four-cone belt planter was used at both locations. Nitrogen-fixing bacteria, Rhizobium japonicum, were applied to seed prior to planting. Hitbold et al. (17) suggested that effective inoculation with Rhizobium japonicum is indispensable for nitrogen fixation and profitable yield of soybeans at both locations, levels of available P and K were adequate according to soil tests. Variables were varieties (Essex, Forrest), plant densities (11,000, 22,000, 33,000, and 44,000 plants per hectare), and row width (25, 50, 75 cm between rows). All combinations of two varieties, three row spacings and four plant densities gave a factorial arrangement of 24 treatment combinations. A randomized complete block design with four replications at each location was used. Each replication consisted of 24 entries.

At Perkins, the study was irrigated three times between the planting and harvest period with a total amount of 37.2 cm of water applied by the sprinkler irrigation system. At Bixby, irrigation was not needed because of sufficient rainfall moisture.

During the growing season the study was searched for diseases, insects and weeds at both locations. Each plot was hand hoed as required for weed control. Also Treflan was used for grass control at preplant. No significant insect or disease damage was registered.

Characters Evaluated

At Bixby and Perkins, the following parameters were observed and measured on each plot: grain yield, plant height, 100-seed weight, and seeds per plant.

Grain Yield

In advance of harvest, each plot was shortened by hand to 2.4 meter to eliminate end-of-plot bias. The grain was harvested by hand. Harvested area per plot was 3.72 m^2. The number of rows harvested varied with the row spacing from one and a half to six for row spacings from 75 to 25 cm, respectively. The number of plants harvested per plot varied from 42 to 180 for population from 110,000 to 440,000 plants per hectare. At both locations, Essex and Forrest were harvested and threshed on October 20, 1981 and November 19, 1981, respectively. The threshed soybeans were cleaned and weighed after they dried to a uniform moisture content. The weight was recorded as grams per plot and converted to kilograms per hectare.

Plant Height

For each plot, plant heights were taken at maturity and matched to the distance in centimeters from the soil surface to the top of the main stem. This parameter was expressed as an average over the entire plot.

100-Seed Weight

The 100-seed weight was determined by weighing 100 clean, undamaged seeds from each plot. This character was expressed in grams per 100 seeds.

Seeds per Plant

The quantity of seeds per plant was estimated for each plot by dividing the number of seeds per plot by the number of harvested plants per plot. The number of seeds per plot was determined by dividing the number of grams per plot by the 100-seed weight and multiplying the quotient by 100.

Statistical Analyses

At the Oklahoma State computer center, all data collected in this study were analyzed by the statistical analysis system. An analysis of variance was computed for each character. The LSD was used to compare the means.

CHAPTER IV

RESULTS AND DISCUSSION

Table I shows the analyses of variance for the characters evaluated at location 1. This table indicates a significant difference due to cultivars at the 0.01 level of probability for grain yield, height, 100-seed weight, and seeds per plant. Significant differences due to plant population occurred for grain yield, height, 100-seed weight, and seeds per plant at the 0.01 level. In addition, cultivar X plant population interactions were significant for height and seeds per plant at the 0.01 level. Row width X plant population interactions were significant for yield at the 0.05 level and for height and 100-seed weight at the 0.01 level.

Table II shows the analyses of variance for the characters evaluated at location 2. This table indicates a significant difference due to cultivars at the 0.01 level of probability for height and 100-seed weight. No significant difference due to cultivars is shown for yield or the number of seeds per plant. Significant differences due to row width are shown for grain yield, 100-seed weight, and the number of seeds per plant at the 0.01 level. Significant differences due to plant population occurred for height, 100-seed weight, and seeds per plant at the 0.01 level. No significant difference due to plant population is shown for yield. The only interactions which were significant involved the effects of row width X plant population and of cultivar X row width

TABLE I

MEAN SQUARES FOR GRAIN YIELD, PLANT HEIGHT, 100-SEED WEIGHT, AND SEEDS PER PLANT (LOCATION 1)

Source of Variation	df	Grain Yield	Height	100-Seed Weight	Seeds per Plant
Cultivars	1	207762.04**	8740.20**	981.76**	8531.51**
Row Width	2	1721.29	4.45	17.95	214.34
Cultivar X Row Width	2	31872.67	34.82	14.82	502.07
Plant Population	3	278477.64**	381.46**	65.51**	89968.87**
Cultivar X Plant Population	3	40249.12	74.36**	27.04	2557.26**
Row Width X Plant Population	6	82817.76*	67.49**	58.11**	571.29
Cultivar X Row Width X Population	6	21861.75	9.98	26.60	310.24
Error	69	27791.84	16.94	15.93	296.20

*Significant at the 0.05 level of probability.
**Significant at the 0.01 level of probability.

TABLE II

MEAN SQUARES FOR GRAIN YIELD, PLANT HEIGHT, 100-SEED WEIGHT, AND SEEDS PER PLANT (LOCATION 2)

Source of Variation	df	Grain Yield	Height	100-Seed Weight	Seeds per Plant
Cultivar	1	43435.04	12927.04**	787.76**	1.50
Row Width	2	388089.57**	3.22	154.14**	5251.45**
Cultivar X Row Width	2	45031.89	23.89*	153.64**	1850.72*
Plant Population	3	11312.82	265.51**	122.95**	151466.58**
Cultivar X Plant Population	3	18139.71	9.18	3.62	76.75
Row Width X Plant Population	6	26069.43	14.73*	23.62	559.95
Cultivar X Row Width X Population	6	29875.14	42.89**	7.62	888.05
Error	69	24502.81	5.55	27.18	454.95

*Significant at the 0.05 level of probability.
**Significant at the 0.01 level of probability.

X plant population on height.

Grain Yield (Location 1)

In Table I the analyses of variance shows that the effects of cultivars and plant population on grain yield were statistically significant at the 0.01 level of probability. Also the interaction of row width X plant population was significant at the 0.05 level of probability. Row width did not significantly affect yield at this location. Forrest outyielded Essex with a mean yield of 3444.3 kg/ha while the mean yield for Essex was 3193.9 kg/ha (Table III). The LSD at the 0.05 level of probability for comparing grain yield means at the various plant populations was 258.6 kg/ha. The lowest plant population of 11 plants/m^2 produced significantly lower yields than any other population. The population of 22 plants/m^2 produced a significantly higher yield than the 11 plants/m^2 population but significantly lower than the 33 plants/m^2 population. There was no significant difference in yield between the 33 plants/m^2 and the 44 plants/m^2 populations. Other investigators (4, 11, 18, 20, 22, 39, 40) also found that higher population densities were associated with higher grain yields.

There was a row width X plant population interaction which was significant at the 0.05 level of probability (Table I). This interaction can be explained by using data on Table IV. This table shows that for the 25-cm row width, there was a significant difference for grain yield between populations of 11 and 44, and 22 and 33 plants/m^2, but there was no significant difference in yield as the population increased from 11 to 22 or 33 to 44 plants/m^2. At the 50-cm row width, yields increased as populations increased from 11 to 22 plants/m^2. There was no

TABLE III

AVERAGE EFFECT OF PLANT POPULATION AND CULTIVAR ON GRAIN YIELD (LOCATION 1)

Cultivar	Plant Population (Plants/m^2) 11	22	33	44	Mean Grain Yield (kg/ha)
Forrest	3162.6	3475.4	3449.4	3689.8	3444.3
Essex	2680.9	3126.2	3482.3	3486.2	3193.9
Mean Grain Yield (kg/ha)	2921.7	3200.8	3465.9	3588.0	

LSD 0.05 (Cultivar) = 182.9 kg/ha.

LSD 0.05 (Population) = 258.6 kg/ha.

TABLE IV

AVERAGE EFFECT OF PLANT POPULATION AND ROW WIDTH ON THE GRAIN YIELD (LOCATION 1)

Row Width (cm)	Plant Population (Plants/m^2)				Mean Grain Yield (kg/ha)
	11	22	33	44	
25	2816.1	3228.2	3745.5	3576.9	3341.7
50	2889.4	3425.9	3583.7	3321.7	3315.2
75	3059.6	3248.3	3068.4	3865.2	3310.4
Mean Grain Yield (kg/ha)	2921.7	3300.8	3465.9	3587.9	

LSD 0.05 (Row) = 223.9 kg/ha.

LSD 0.05 (Population) = 258.6 kg/ha.

LSD 0.05 (Row - Population) = 447.9 kg/ha.

significant difference in yield between populations of 22 and 33, 33 and 44 or 22 and 44 plants/m^2. Table IV also indicates that in the 75-cm row width, the grain yield increased as plant population increased from 33 to 44 plants/m^2, but there was no significant difference in yield between populations of 11 and 22, 22 and 33, or 11 and 33 plants/m^2. This data indicates that at location 1 the best yields were produced by the 50-cm row combined with the population of 22 plants/m^2. The optimum population for a 75-cm row width was 44 plants/m^2. For the 50-cm row, the optimum population would not be more than 33 plants/m^2 and could be as low as 22 plants/m^2. However, at the 25-cm row width, the optimum population appears to be no less than 33 plants/m^2.

Grain Yield (Location 2)

The result of the analyses of variance for the variables measured at location 2 are presented in Table II. There was no difference in yield due to cultivars, plant populations or interactions at this location. There was a significant difference due to row width for grain yield at the 0.01 level of probability. The average effects of row width and cultivar on grain yield is represented in Table V. The LSD at the 0.05 level of probability for comparing grain yield means at the various row widths was 210.0 kg/ha. The shortest row width of 25 cm produced significantly higher yield than any other row width. The 50-cm row produced significantly lower yield than 25-cm row, but significantly higher than 75-cm row. The optimum row width at this location was 25 cms. Other researchers (3, 4, 9, 21, 26, 31, 36, 37) have also found that narrow rows (less than 50-cm) tend to outyield wider rows (more than 50-cm).

TABLE V

AVERAGE EFFECT OF ROW WIDTH AND CULTIVAR ON GRAIN YIELD (LOCATION 2)

Cultivar	Row Width (cm) 25	50	75	Mean Grain Yield (kg/ha)
Forrest	3521.1	3020.1	2987.5	3176.2
Essex	3577.5	3359.2	2935.5	3290.7
Mean Grain Yield (kg/ha)	3549.3	3189.7	2961.5	

LSD 0.05 (Cultivar) = 171.7 kg/ha.

LSD 0.05 (Row) = 210.0 kg/ha.

The results from the two locations are somewhat contradictory. Forrest was superior in yield at location 1; whereas, there was no difference in yield due to cultivars at location 2. There was no difference in yield due to row width at location 1; whereas, the difference was highly significant at location 2. The 25-cm row width produced the highest average yield followed by the 50-cm width. The 75-cm width produced the lowest yield. There was a significant difference in yield due to plant population at location 1, but not at location 2. At location 1, the lowest population of 11 plants/m^2 appears to be insufficient for best yields. In general, the higher the population up to 44 plants/m^2, the higher the yield. The row width X plant population interaction at location 1 was the only interaction which significantly affected yield. The best combination of row width and plant population appears to be 50-cm width and 22 plants/m^2.

Plant Height (Location 1)

The effects of cultivars, plant population, cultivar X population and row width X population interactions were highly significant for plant height (Table I). There was no significant difference in plant height due to row width, cultivar X row width and cultivar X row width X population interactions at location 1. Forrest's mean height (86.6 cm) was higher than the Essex's mean height (67.5 cm). The LSD at the 0.05 level of probability for comparing height means at the various plant populations was 2.4 cm (Table VI). The lowest plant population of 11 plants/m^2 produced significantly shorter height than any other population. There was no significant difference in height between populations of 22 and 33, 33 and 44, or 22 and 44 plants/m^2. There was a

TABLE VI

AVERAGE EFFECT OF PLANT POPULATION AND CULTIVARS ON PLANT HEIGHT (LOCATION 1)

Cultivar	Plant Population (Plants/m^2) 11	22	33	44	Mean Plant Height (cm)
Forrest	82.7	89.3	86.8	87.5	86.6
Essex	59.4	68.6	71.3	70.7	67.5
Mean Plant Height (cm)	71.1	78.9	79.0	79.1	

LSD 0.05 (Cultivar) = 1.7 cm.

LSD 0.05 (Population) = 2.4 cm.

LSD 0.05 (Cultivar X Population) = 3.4 cm.

cultivar X plant population interaction which was significant at the 0.01 level of probability (Table I). This interaction was due mainly to the difference in magnitude between cultivars (Table VI). There was a row width X plant population interaction which was significant at the 0.01 level of probability (Table I). The row width X plant population interaction can be explained by using the data in Table VII. This table shows that in 25-cm row width, plant height increased as population increased from 11 to 22 plants/m^2. There was no significant difference in plant height as population increased from 22 to 33 plants/m^2, but there was a significant decrease in height as the population increased from 33 to 44 plants/m^2. At the 50-cm row width, plant height increased as plant population increased from 11 to 22 plants/m^2. There was no significant difference in plant height between populations of 22 and 33, 33 and 44, or 22 and 44 plants/m^2. Table VII also indicates that in 75-cm row width, the plant height increased as plant population increased from 11 to 22 plants/m^2, but there was no significant difference in plant height between populations of 22 and 33, 33 and 44, or 22 and 44 plants/m^2. Mean plant height increased as population increased and remained the same as row width increased. Hoggard, Shannon, and Johnson (18) also suggested that plant height tended to increase as population increased. At location 1 the data indicates that the tallest plant heights were produced by the populations of 33 plants/m^2 combined with the 25-cm row width. For 50-cm row, the tallest plants were when the population was less than 44 plants/m^2. However, at the 75-cm row, the populations that produced the tallest plants were 22 and 44 plants/m^2.

TABLE VII

AVERAGE EFFECT OF PLANT POPULATION AND ROW WIDTH ON PLANT HEIGHT (LOCATION 1)

Row Width (cm)	Plant Population (Plants/m^2)				Mean Plant Height (cm)
	11	22	33	44	
25	68.6	79.0	82.8	78.6	77.3
50	70.1	79.1	79.4	80.1	77.2
75	74.4	78.6	74.9	78.5	76.6
Mean Plant Height (cm)	71.1	78.9	79.0	79.1	

LSD 0.05 (Row) = 2.1

LSD 0.05 (Population) = 2.4

LSD 0.05 (Row Width X Population) = 4.1 cm.

Plant Height (Location 2)

The analyses of variance for height indicates a highly significant difference due to cultivar, plant population and cultivar X row width X plant population interaction (Table II). The cultivar X row width and row width X plant population interactions were significant for plant height at the 0.05 level. No significant difference due to row width was shown for plant height. In Table II the analyses of variance show that the effects of cultivar and plant population were statistically significant on plant height at the 0.01 level of probability. Forrest's mean height (92.7 cm) was higher than the mean height (69.5 cm) for Essex (Table VIII). The LSD at the 0.05 level of probability for comparing plant height means at the various plant populations was 1.4 cm. The lowest plant population of 11 plants/m^2 produced significantly lower height than any other population. The population of 22 plants/m^2 produced significantly higher plant height than the 11 plants/m^2 population, but significantly lower than the 33 and 44 plants/m^2 populations. There was no significant difference in plant height between the 33 plants/m^2 and the 44 plants/m^2 populations. There was a cultivar X row width interaction which was significant at the 0.05 level of probability (Table II). This interaction can be explained by using data in Table IX. This table indicates that Forrest's plant height increased significantly as row width increased from 25 to 50 cm, and decreased significantly from 50 to 75 cm. There was no significant difference in height between row widths of 25- and 75-cm rows. Table IX also indicates that there was no significant difference in Essex's plant height between row width of 25 and 50, 50 and 75, or 25 and 75-cm rows. There was a row width X plant population interaction which was significant at the 0.05 level of

TABLE VIII

AVERAGE EFFECT OF PLANT POPULATIONS AND CULTIVARS
ON PLANT HEIGHT (LOCATION 2)

	Plant Population (Plants/m^2)				Mean Plant Height (cm)
Cultivar	11	22	33	44	
Forrest	87.5	92.3	94.5	96.3	92.7
Essex	65.3	69.6	71.6	71.3	69.5
Mean Plant Height (cm)	76.4	80.9	83.1	83.8	

LSD (Cultivar) 0.05 = 1.0 cm.

LSD (Population) 0.05 = 1.4 cm.

TABLE IX

AVERAGE EFFECT OF CULTIVARS AND ROW WIDTH ON PLANT HEIGHT (LOCATION 2)

Cultivar	Row Width (cm) 25	50	75	Mean Plant Height (cm)
Forrest	92.1	94.0	92.0	92.7
Essex	70.1	68.8	69.5	69.5
Mean Plant Height (cm)	81.1	81.4	80.8	

LSD 0.05 (Cultivar) = 1.0 cm.

LSD 0.05 (Row Width) = 1.2 cm.

LSD 0.05 (Cultivar X Row Width) = 1.7 cm.

probability (Table II). This interaction can be explained by using the data in Table X. This table shows that in 25-cm row width, the plant height increased as plant population increased from 11 to 22, but there was no significant difference in plant height as the population increased from 22 to 33 or 33 to 44 plants/m^2. At the 50-cm row width, the plant height increased as population increased from 11 to 22 and from 22 to 33 plants/m^2, but there was no significant difference in plant height as the population increased from 33 to 44 plants/m^2. Table X also indicates that in the 75-cm row width, the plant height increased as plant population increased from 11 to 22 plants/m^2. There was no significant difference in plant height between populations of 22 and 33, 33 and 44, or 22 and 44 plants/m^2. There was a cultivar X row width X plant population interaction which was significant at the 0.01 level of probability (Table II). This interaction can be explained by using the data in Table XI. This table indicates that within 25-cm row width there was a significant difference in Forrest's plant height between population of 11 and 44 plants/m^2, but there was no significant difference in Forrest's plant height between any other two populations. Table XI indicates that within 50-cm row width, there was a significant difference in Forrest's plant height between populations of 11 and 33, 11 and 44, 22 and 33, or 22 and 44 plants/m^2, but there was no significant differences in Forrest's plant height between populations of 11 and 22, or 33 and 44 plants/m^2. Table XI also indicates that within the 75-cm row width, the lowest plant population of 11 plants/m^2 produced significantly shorter plant height than any other population. There was no significant difference in Forrest's plant height between populations of 22 and 33, or 22 and 44 plants/m^2, but there was a significant difference in Forrest's plant height between

TABLE X

AVERAGE EFFECT OF PLANT POPULATION AND ROW WIDTH ON PLANT HEIGHT (LOCATION 2)

Row Width (cm)	Plant Population (Plants/m^2)				Mean Plant Height (cm)
	11	22	33	44	
25	77.3	80.5	82.9	83.9	81.1
50	76.8	79.6	84.4	84.6	81.4
75	75.3	82.8	81.9	83.0	80.7
Mean Plant Height (cm)	76.4	81.0	83.0	83.8	

LSD 0.05 (Row) = 1.2 cm.

LSD 0.05 (Population) = 1.4 cm.

LSD 0.05 (Row X Population) = 2.4 cm.

TABLE XI

AVERAGE OF ROW WIDTH AND PLANT POPULATION ON THE HEIGHT OF TWO SOYBEAN CULTIVARS (LOCATION 2)

Cultivar	Row Width (cm)	Plant Population (Plants/m^2)	Plant Height (cm)	Mean Plant Height (cm)
Forrest	25	11	90.50	
		22	91.50	92.13
		33	92.25	
		44	94.25	
	50	11	89.25	
		22	90.50	93.94
		33	98.25	
		44	97.75	
	75	11	82.75	
		22	95.00	91.94
		33	93.00	
		44	97.00	
Essex	25	11	64.00	
		22	69.50	70.13
		33	73.50	
		44	73.60	
	50	11	64.25	
		22	68.75	68.75
		33	70.50	
		44	71.50	
	75	11	67.75	
		22	70.50	69.50
		33	70.75	
		44	69.00	

LSD 0.05 (Cultivar X Row X Population) = 3.33 cm.

populations of 33 and 44 plants/m^2. Table XI shows that in 25-cm row width, the Essex's plant height increased as plant population increased. from 11 to 22 and from 22 to 33 plants/m^2. There was no significant difference in Essex's plant height as the population increased from 33 to 44 plants/m^2. At the 50-cm row width, the Essex's plant height increased as plant population increased from 11 to 22 plants/m^2. There was no significant difference in Essex's plant height between populations of 22 and 33, 33 and 44, or 22 and 44 plants/m^2. Table XI also shows that in the 75-cm row width, the various plant populations did not significantly affect the Essex's plant height at this location. At both locations, Forrest was significantly taller than Essex. There were significant effects on cultivar's plant height due to plant population at both locations. In general, plant height increased as plant population increased and row width decreased. At location 1, the data indicates that the tallest plant heights were produced by the population of 33 plants/m^2 combined with the narrowest row width, but at location 2 the data shows that the tallest plant heights were produced by the population of 44 plants/m^2 combined with the 50-cm row width.

100-Seed Weight (Location 1)

Table I shows that the cultivars, plant population and row width X plant population interaction effects on 100-seed weight was significant at the 0.01 level of probability. There was no significant difference on 100-seed weight due to row width, cultivar X row width, cultivar X plant population, and cultivar X row width X plant population interaction at this location. Table XII contains the average effect of plant population and cultivar on 100-seed weight. The LSD at the 0.05 level

TABLE XII

AVERAGE EFFECT OF PLANT POPULATION AND CULTIVAR ON 100-SEED WEIGHT (LOCATION 1)

Cultivar	Plant Population (Plants/m^2) 11	22	33	44	Mean 100-Seed Weight (g/100 seeds)
Forrest	12.4	12.3	12.2	12.3	12.3
Essex	13.3	12.8	12.7	13.0	13.0
Mean 100-seed Weight (g/100 seeds)	12.9	12.6	12.5	12.7	

LSD 0.05 (Cultivar) = 0.2 g/100 seeds.

LSD 0.05 (Population) = 0.3 g/100 seeds.

of probability for cultivar was 0.2 g/100 seeds. There was a significant difference between the two cultivars. Essex's 100-seed weight (13.0 g) was significantly higher than Forrest's 100-seed weight (12.3 g). The LSD at the 0.05 level of probability for comparing the 100-seed weight means at the various plant population was 0.3 g/100 seeds. The lowest plant population of 11 plants/m^2 produced significantly higher 100-seed weight than the 33 plants/m^2 populations. There was no significant difference in 100-seed weight between populations of 11 and 22, 11 and 44, 22 and 33, 22 and 44, or 33 and 44 plants/m^2. There was a row width X plant population interaction which was significant at the 0.01 level of probability (Table I). This interaction can be explained by using data in Table XIII. This table indicates that in 25-cm row width, the 100-seed weight decreased as plant population increased from 33 to 44 plants/m^2, but there was no significant difference in the 100-seed weight between populations of 11 and 22, 22 and 33, or 11 and 33 plants/m^2. At the 50-cm row width, the 100-seed weight decreased as the plant population increased from 11 to 22 plants/m^2. There was no significant difference in the 100-seed weight between populations of 22 and 33, 33 and 44, or 22 and 44 plants/m^2. Table XIII also shows that in the 75-cm row width, the 100-seed weight decreased significantly as population increased from 11 to 22 plants/m^2, and there was a significant increase in 100-seed weight when the population increased from 33 to 44 plants/m^2. There was no significant difference in the 100-seed weight between populations of 11 and 44 plants/m^2. This data indicates that at location 1, the highest 100-seed weight were produced by the lowest plant population of 11 plants/m^2 combined with the wider rows (50 and 75-cm). The optimum population for all row widths was 11 plants/m^2.

TABLE XIII

AVERAGE EFFECT OF PLANT POPULATION AND ROW WIDTH ON 100-SEED WEIGHT (LOCATION 1)

Row Width (cm)	Plant Population (Plants/m^2) 11	22	33	44	Mean 100-Seed Weight (g/100 seeds)
25	12.8	12.7	12.9	12.4	12.7
50	12.9	12.5	12.6	12.8	12.7
75	12.9	12.4	12.0	12.8	12.5
Mean 100-Seed Weight (g/100 seeds)	12.9	12.5	12.5	12.6	

LSD 0.05 (Row) = 0.2 g/100 seeds.

LSD 0.05 (Population) = 0.3 g/100 seeds.

LSD 0.05 (Row Width X Population) = 0.4 g/100 seeds.

100-Seed Weight (Location 2)

In Table II the analysis of variance shows that the effects of cultivars, row width, plant population, and cultivar X row width interaction were statistically significant on the 100-seed weight at the 0.01 level of probability. There was no significant difference in the 100-seed weight due to cultivar X plant population, row width X plant population, and cultivar X row width X plant population interactions. Table XIV contains the average effects of cultivar and plant population on the 100-seed weight. The LSD at the 0.05 level of probability for comparing the 100-seed weight for both cultivars was 0.2 g/100 seeds. There was a significant difference between the two cultivars. Essex's 100-seed weight (12.1 g) was higher than Forrest's 100-seed weight (11.6 g). The LSD at the 0.05 level of probability for comparing the 100-seed weight means at the various plant populations was 0.3 g/100 seeds. The highest plant population of 44 plants/m^2 produced a significantly lower 100-seed weight than any other population except the 33 plants/m^2 population. There was no significant difference in the 100-seed weight between populations of 11 and 22, 22 and 33, or 33 and 44 plants/m^2. The effect of row width on the 100-seed weight was significant at the 0.01 level of probability (Table II). Table XV shows the effects of row width and cultivar on the 100-seed weight. The LSD at the 0.05 level of probability for comparing the 100-seed weight means at the various row widths was 0.3 g/100 seeds. The 75-cm row produced significantly higher 100-seed weight than 25-cm or 50-cm rows. There was no significant difference in the 100-seed weight between The 25- and 50-cm or the 50- and 75-cm row widths. There was a cultivar X row width interaction which

TABLE XIV

AVERAGE EFFECT OF PLANT POPULATION AND CULTIVAR ON 100-SEED WEIGHT (LOCATION 2)

Cultivar	Plant Population ($Plants/m^2$) 11	22	33	44	Mean 100-Seed Weight (g/100 seeds)
Forrest	11.8	11.7	11.6	11.3	11.6
Essex	12.4	12.3	12.2	11.8	12.1
Mean 100-seed Weight (g/100 seeds)	12.1	12.0	11.9	11.6	

LSD 0.05 (Cultivar) = 0.2 g/100 seeds.

LSD 0.05 (Population) = 0.3 g/100 seeds.

TABLE XV

AVERAGE EFFECT OF ROW WIDTH AND CULTIVAR ON 100-SEED WEIGHT (LOCATION 2)

Cultivar	Row Width 25	50	75	Mean 100-Seed Weight (g/100 seeds)
Forrest	11.5	11.7	11.6	11.6
Essex	11.9	11.9	12.6	12.1
Mean 100-Seed Weight (g/100 seeds)	11.7	11.8	12.1	

LSD 0.05 (Cultivar) = 0.2 g/100 seeds.

LSD 0.05 (Row Width) = 0.3 g/100 seeds.

LSD 0.05 (Cultivar X Row Width) = 0.4 g/100 seeds.

was significant at the 0.01 level of probability (Table II). This interaction can be explained by using data on Table XV. Row widths did not significantly affect Forrest's 100-seed weight. The 75-cm row width produced significantly higher Essex's 100-seed weight than the 25- and 50-cm rows. This data indicates that at location 2, the largest seeds for Essex were produced at the lowest plant population of 11 plants/m^2 and the wider rows of 75-cm. At both locations, the cultivars' 100-seed weight was increased at the lowest plant population of 11 plants/m^2 and the 75-cm row widths.

Seeds per Plant (Location 1)

The cultivar, plant population, and cultivar X plant population interaction effects on the number of seeds per plant was highly significant at the 0.01 level of probability (Table I). There was no significant effect on the number of seeds per plant due to row width, cultivar X row width X plant population interactions. Forrest's mean seeds per plant (127.1 g) was higher than Essex's mean seeds per plant (108.3 g) (Table XVI). The LSD at the 0.05 level of probability for comparing the number of seeds per plant means at the various plant populations was 10.0 seeds/plant. The lowest plant population of 11 plants/m^2 produced significantly higher numbers of seeds per plant than any other population. The population of 22 plants/m^2 produced significantly lower numbers of seeds per plant than the 11 plants/m^2 population, but significantly higher than the 33 or 44 plants/m^2 populations. The 44 plants/m^2 produced the lowest number of seeds per plant than any other population. There was a cultivar X plant population interaction which was significant at the 0.01 level of probability (Table I). This interaction

TABLE XVI

AVERAGE EFFECT OF PLANT POPULATION AND CULTIVAR ON THE NUMBER OF SEEDS PER PLANT (LOCATION 1)

Cultivar	Plant Population ($Plant/m^2$)				Mean Seeds per Plant
	11	22	33	44	
Forrest	227.1	127.4	87.0	66.8	127.1
Essex	178.7	110.2	84.5	59.6	108.3
Mean Seeds per Plant	202.9	118.8	85.8	63.2	

LSD 0.05 (Cultivar) = 7.0 seeds/plant

LSD 0.05 (Population) = 10.0 seeds/plant.

LSD 0.05 (Cultivar X Plant Population) = 14.0 seeds/plant.

was due mainly to the effects of plant population which were more pronounced on Forrest than on Essex (Table XVI). This data indicates that at location 1 the number of seeds per plant for both cultivars decreased as population increased.

Seeds per Plant (Location 2)

In Table II the analyses of variance show that the effects of row width and plant population were statistically significant on the number of seeds per plant at the 0.01 level of probability. Also the interaction of cultivar X row width was significant at the 0.05 level of probability (location 2). There was no significant effect on the number of seeds per plant due to cultivar, cultivar X plant population, row width X plant population and cultivar X row width X plant population interactions.

Table XVII shows the average effects of row width and cultivar on number of seeds per plant. The LSD at the 0.05 level of probability for comparing the number of seeds per plant means at the various row widths was 10.7 seeds/plant. The 25-cm row produced significantly higher numbers of seeds per plant than any other row width. There was no significant difference on the number of seeds per plant between the 50- and 75-cm rows. There was a cultivar X row width interaction which was significant at the 0.05 level of probability (Table II). This interaction can be explained by using data on Table XVII. Forrest's number of seeds per plant was significantly higher at 25-cm rows than at 50- or 75-cm rows. There was no significant difference on the number of seeds per plant between the 50- and 75-cm rows. Essex's number of seeds per plant was significantly lower at 75-cm rows than at 25- or 50-cm rows. There

TABLE XVII

AVERAGE EFFECT OF ROW WIDTH AND CULTIVAR ON NUMBER OF SEEDS PER PLANT (LOCATION 2)

	Row Width (cm)			Mean Seeds per Plant
Cultivar	25	50	75	
Forrest	143.9	113.6	122.9	126.8
Essex	138.4	130.4	110.8	126.5
Mean Seeds per Plant (g)	141.2	122.0	116.9	

LSD 0.05 (Cultivar) = 8.7 seeds/plant.

LSD 0.05 (Row Width) = 10.7 seeds/plant.

LSD 0.05 (Cultivar X Row Width) = 15.1 seeds/plant.

was no significant difference on Essex's number of seeds per plant between the 25- and 50-cm rows. There was a significant difference due to plant population for the number of seeds per plant at the 0.01 level of probability (Table II). Table XVIII shows the average effect of plant population and cultivar on the number of seeds per plant. The LSD at the 0.05 level of probability for comparing the number of seeds per plant means at the various plant populations was 12.3 seeds/plant. The LSD at the 0.05 level of probability indicates that cultivars mean seeds per plant decreased significantly as plant population increased. This data indicates that at location 2 the highest number of seeds per plant was produced by the lowest plant population of 11 plants/m^2 and by the narrowest row of 25-cm. The results from the two locations are somewhat contradictory. Forrest was superior in the number of seeds per plant at location 1; while, there was no significant difference in the number of seeds per plant due to cultivar at location 2. There was no significant difference in the number of seeds per plant due to row width at location 1, whereas, the difference was highly significant at location 2. The 25-cm row width produced the highest number of seeds per plant followed by the 50-cm row width. The 75-cm row produced the lowest number of seeds per plant. The lowest population of 11 plants/m^2 produced the highest number of seeds per plant at both locations. In general, the higher the population the lower the number of seeds per plant. The cultivar X plant population interaction at location 1 was the only interaction which significantly affected the number of seeds per plant. The best combination of plant population and row width for the number of seeds per plant was 11 plants/m^2 combined with the 25-cm width.

TABLE XVIII

AVERAGE EFFECT OF PLANT POPULATION AND CULTIVAR ON THE NUMBER OF SEEDS PER PLANT (LOCATION 2)

Cultivar	Plant Population ($Plant/m^2$)				Mean Seeds per Plant
	11	22	33	44	
Forrest	239.0	119.8	84.3	64.1	126.8
Essex	242.3	117.2	86.5	60.2	126.5
Mean Seeds per Plant (g)	240.7	118.5	85.4	62.2	

LSD 0.05 (Cultivar) = 8.7 seeds/plant.

LSD 0.05 (Population) = 12.3 seeds/plant.

CHAPTER V

SUMMARY AND CONCLUSIONS

A field experiment was conducted at Bixby and Perkins in 1981 to evaluate the response of two soybean cultivars to three row widths and four plant populations and to determine which combination of treatments yielded highest. All combinations of the two cultivars (Forrest and Essex), three row widths (25 cm, 50 cm, and 75 cm), and four plant populations (11, 22, 33, and 44 plants/m^2) gave a factorial arrangement of 24 treatment combinations. A randomized complete-block design with four replications was used at each location (Bixby and Perkins).

At both locations, the characters investigated were grain yield, plant height, 100-seed weight and number of seeds per plant. Analyses of variance were performed for each variable and an LSD at the 0.05 level of probability was used to compare means.

Analyses of variance indicated that significant differences due to cultivars were present at both locations for all characteristics except for grain yield and the number of seeds per plant at location 2. At location 1, the cultivars' effects on grain yield was significant at the 0.01 level of probability. Forrest outyielded Essex with a mean yield of 3444.3 kg/ha while the mean yield for Essex was 3193.9 kg/ha. The row width effects on grain yield was significant at the 0.01 level or probability at location 2. There was no significant difference due to plant population for grain yield at the 0.01 level of probability at location 1. There was no significant effect due to plant population at location 2. There was an effect on grain yield due to the row width X plant population interaction which was significant at the 0.05 level of probability of location 1. The best combination of row width and plant population appears to be 50-cm width and 22 plants/m^2.

The effects of cultivar, plant population, cultivar X plant population and row width X population interactions were highly significant on plant height at location 1. At location 2 the analyses of variance for plant height indicates highly significant differences due to cultivar, plant population and cultivar X row width X plant population interaction. The cultivar X row width and row width X plant population interactions were significant for height at the 0.05 level. At both locations, Forrest was significantly taller (86.6 cm and 92.7 cm) than Essex (67.5 cm and 69.5 cm). There were significant effects on plant height due to plant population at both locations. In general, plant height increased as plant population increased and row width decreased.

The cultivar, plant population and row width X population interaction effects on 100-seed weight were significant at the 0.01 level of probability at location 1. The analyses of variance for 100-seed weight show that the effects of cultivar, row width, plant population and cultivar X row width interaction were statistically significant at the 0.01 level of probability at location 2. At both locations Essex's 100-seed weight (13.0 and 12.1 g/100 seeds) was significantly higher than Forrest's 100-seed weight (12.3 and 11.6 g/100 seeds). The cultivar's 100-seed weight was significantly increased at the lowest plant population of 11 plants/m^2 combined with the 75-cm row widths at both locations.

A highly significant difference was found between cultivars, plant populations and cultivar X plant population interactions for the number of seeds per plant. Forrest averaged 127.1 seeds per plant, whereas Essex averaged 108.3 seeds per plant at location 1. The number of seeds per plant decreased as population increased. The analyses of variance for location 2 show that the effects of row width and plant population were significant on the number of seeds per plant at the 0.01 level of probability. Also the interaction of cultivar X row width was significant at the 0.05 level. Mean seeds per plant decreased as population and row width increased.

In conclusion, the results of this study indicated that grain yield was affected by cultivars, row widths and plant populations. The higher the population, the higher the grain yield per unit area; the shorter the distance between rows (less than 50 cm), the higher the grain yield per hectare. These results are from a one-year study only. Further study is necessary to determine the optimum row width and plant population for soybean cultivars grown in Oklahoma.

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