INFLUENCE OF ROW SPACING AND POPULATION DENSITY ON SEVERAL AGRONOMIC CHARACTERS OF TWO CLARK SOYBEAN ISOLINES

by

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Introduction

The increasing demand for vegetable oil and protein has encouraged soybean (Glycine max (L) Merrill), production. Over the past 20 years, farmers in the United States have been stimulated by this demand to increase their acreage of the crop and to employ good farming and management practices to increase production. In the U.S., the acreage of soybean has steadily increased from 5.7 million hectares in 1950 to more than 20 million hectares in 1973.

The high protein content (40%) and oil content (20%) of soybean gives the crop the potential of meeting the problem of protein malnutrition of protein deficient countries. Soybean protein contains all the essential amino acids for human nutrition and is the cheapest source of protein among animal and vegetable proteins though this may not be the case in the very near future due to the market boost the crop is enjoying now. Soybean is used in making low-cost nutritionally balanced protein foods, e.g. soyburgers, Natto, Hamanato, shoyin, and protein drinks. The crop can be used to increase the nutritive value of foods, e.g. the nutritive value of bread made from wheat can be doubled by fortifying it with 5% soyflour, soymilk which is rated at 81% efficiency of cow's milk and costs only one-sixth as much as cow's milk. The above enumerated uses indicate the future the crop has in developing nations such as my country, Nigeria.

Generally soybeans are adapted to areas in which corn is adapted but will also grow on acid soils where alfalfa and red clover can not be raised.

In Kansas, soybeans are adapted to the eastern part of the state. Drought and rabbits are the principal hinderances to growing the crop

farther west. However the drought problem can be overcome by growing the crop under irrigation.

In order to raise a successful crop, an adapted variety must be selected and good agronomic practices followed. With these things in mind, two soybean isolines, Clark 63 and semi-determinate Clark Dt_2 were chosen for this study with the following objectives:

(a) To determine the influence of five row widths - 75, 37.5, 25, 18.75 and 15 cm on the yield and other agronomic characteristics of the two plant types.

(b) To determine the influence of two population densities - 450 sq. cm/plant and 225 sq. cm/plant on yield and yield components.

Review of Literature

According to Hanway (10), successful production of any crop depends on accomplishing a number of things. One of these is the optimum row width for the crop. He reported highest yields from 21 inch rows and that the consequences of close spacing are taller plants with fewer branches and pods farther from the ground.

As early as 1939 Wiggans (28) reported that highest yields were obtained by planting soybeans in a uniform pattern. With other things being equal, higher yield was realized with equidistant spacing of the plants. He also found the soybean plant, like any other plant, has the ability to adapt to space and that each variety has an optimum number of plants per unit area for maximum net increase in yield.

A study by Camper (3) indicated that higher yields could be obtained on 12 and 24 inch row widths than from 36 inch row spacing. Weber, Shibles and Byth (6) reported highest seed yields from 10 inch rows. Kilgore (15) observed higher yields, higher pod set, fewer seeds

per plant, and fewer branches per plant when row widths were reduced from 40 inches to 20 inches.

Hinson and Hanson (14) reported that plants in wider row spacings had a higher yield per plant through the production of additional branches. This is in line with the findings of Kilgore (15). They also observed a decrease in protein content and an increase in oil content as row spacing increased.

Hicks, Pendleton, Bernard and Johnson (11) using four plant types to evaluate responses to planting patterns, found plant height increased with narrower row spacing, lodging increased as population increased, short determinate types did not lodge and row spacing did not affect seed yield. Buttery (2); Johnson and Harris (13); Nelson and Roberts (22) and other earlier workers reported that plant height increased as plant population increased.

Lehman and Lambert (16) observed higher seed yields from narrow spacing between rows but the effects of within row spacing were variable. In their study, the relative importance of branches was not the same for all spacings in terms of seed and pod number per plant but had little or no effect on seed weight and seeds per pod. They obtained highest yields from 20 inch row spacing.

Working in Florida with three southern soybean varieties, Smith (27) reported highest yields from 12 and 6 inch row widths.

Madder (18) reported that in eastern Kansas 20 inch row spacing produced higher yields than 40 inch row spacing.

Results of a 5-year study on soybean date of planting and row widths conducted by Mader (18) show variable responses to different row widths depending upon the location. At Columbus in southeast Kansas, he

obtained highest average yields in 30 inch rows whereas at Newton, yields were higher from 20 and 30 inch than from the 40 inch row width. At Garden City, Colby and Scandia results show highest average yields in 10, 20 and 30 inch row widths. At Powhattan and Manhattan, the 20 inch row width gave higher yields than the 30 and 40 inch row width and at Ottawa yields were higher in 20 inch row width than in 30 and 40 inch row widths.

Oswalt, Arnold and Matlock (26) in Oklahoma observed highest yields in 21 inch row spacing as compared to 14 and 28 inch row spacing.

Reddy (21) in his study of the effect of spacing on two soybean plant types, 'Clark 63' and 'Clark Dt_2', at Manhattan found no differences in yield due to plant types or densities. He, however, noted significant differences in yield due to spacing--the equidistant spacing (6" x 6") resulted in the highest yields. Lowest yields were obtained from the 30 inch rows where the plants were spaced 3 inches apart. He also noted that the determinate plant type may produce higher yields at wider within row spacings.

Some workers (6, 15) have reported that maturity date is not affected by row width. They noted that plants grown at higher densities were taller, branched less, lodged more, and set fewer pods and seeds than those at lower densities.

Hartwig and Edwards (9) studied two soybean plant types and reported that the only characters that influenced yield were indeterminate growth and glabrousness. The lower yield from the indeterminate variety was due to increased lodging.

Reiss and Sherwood (24) observed best soybean performance in 24 inch row spacing. (30) in a row width and rate of planting study in

southern states concluded that there is no yield advantage for planting soybeans in rows more closely spaced than 36-40 inches.

Another factor that is important in raising a successful crop is how far or close the plants are spaced within the row. This is important because it determines the level of competition between the plants for moisture, nutrients, and light which in turn affects yield. Close spacing will produce a very high level of competition and too wide a spacing will produce a very low level of competition, both of which are not condusive for high yields. Hence an optimum density should be provided for the plants if maximum yields are to be obtained.

Nelson and Roberts (22) reported that highest yields were obtained from 1-inch spacing within the row and that yields decreased at wider spacing between plants. They also observed decreased lodging and increased seed size with increased plant spacing.

On the other hand Probst (23) using 5 within row spacings of 1, 2, 3, 4 and 5 inches reported highest yields were obtained when plants were spaced 2 or 3 inches apart. He also concluded that thick planting (i.e. narrow within row spacing) is condusive to lodging and delayed maturity. However, Probst reported that spacing has little effect on the height of plants and seed size.

Matson (19) obtained greater seed yields with plants spaced 1.5 inches apart than spaced 3 inches apart. Buttery (2) using four plant populations in a 12 inch row width reported that high plant population (32 plants/m^2) resulted in small plants with high dry weight per unit area and that low plant population (4 plants/m^2) produced larger plants with smaller dry weight per unit area. Intermediate densities (16 and 18 plants/m^2) produced intermediate plant sizes and yields.

One other major factor considered as a barrier to higher yields is lodging. Luellen (17) reported lodging affects yields by reducing light use efficiency of the crop because of increased mutual shading. He also believes that lodging might stimulate vegetative growth over pod set.

As reported by earlier workers (7, 21), within row spacing of the plants determines the amount of lodging. Delayed planting can reduce lodging (7). Cooper (5) has demonstrated under highly productive environments that early lodging is a major barrier to higher soybean yields. He also found that seed yield was generally unaffected by seeding rate where no lodging differential occurred but seed yield was lower where the higher seeding rates caused early lodging.

Lodging can reduce yield through the stimulation of terminal growth and excessive branching at the expense of seed set. Bernelin, Pendleton, Berner and Ghovasky (1) reported greater lodging in plants with branches than in plants without branches. Also seed weight was greater in plants without branches. In Virginia, Camper (3) reported lodging was heavier with closer spacing of plants in the row and closer spacing between rows.

Gopani, Kabaria (8) and Saxena, Pandey (20) observed that there is a positive correlation between seed yield and plant height, number of branches, number of pods and seeds per plant.

Materials and Methods

Soybean isolines, 'Clark 63', an indeterminate type in which the terminal bud continues vegetative activity during most of the growing season, and 'Clark Dt_2', a semi-determinate type which has a dominant gene Dt_2 causing a moderately abrupt stem termination, were tested at the

Kansas State University Agronomy Research Farm at Ashland under irrigation for two seasons.

The combination of high temperature and below normal precipitation may be encountered under field conditions and these conditions occurred in 1974 as indicated in table 1 below.

Table 1. Weather data showing precipitation and temperature from May thru September 1973 and 1974

Month	Precipitation (cm)	Deviation from normal	Temperature °F Max	Min	Av
	1973				
May	15.58	4.65	75.1	50.6	62.9
June	7.23	-5.55	87.9	64.9	76.4
July	14.73	4.73	89.8	67.3	78.6
August	5.70	-4.75	89.9	68.8	79.4
September	24.73	15.45	75.4	59.3	67.4
	1974				
May	5.43	-5.45	79.6	55.9	67.8
June	14.60	-0.00	83.2	60.6	71.9
July	6.48	-4.48	96.5	71.0	83.8
August	7.25	-1.75	83.9	64.4	74.2
September	4.03	-5.88	74.9	51.2	63.1

The plant spacing treatments used in the study were: 75 cm by 3 and 6 cm, 37.5 cm by 6 and 12 cm, 25 cm by 9 and 18 cm, 18.75 cm by 12 and 24 cm, and 15 cm by 15 and 30 cm.

The two population densities were 450 sq. cm per plant or 218,800 plants/hectare (87,120 plants/acre) and 225 sq. cm per plant or 435,000

plants/hectare (174,240 plants/acre).

Experimental plots were laid out in a randomized complete block arrangement replicated four times. All plots were irrigated but the frequency of irrigation depended upon the prevailing weather conditions. Plots were irrigated through furrows 3 times both years - on July 7, 15 and August 24 in 1973 and on July 8, 17 and August 24 in 1974. At each irrigation, 3 inches of irrigation water was applied.

Each plot had 2 beds, with 6 rows (15 x 15 cm, 15 x 30 cm); 5 rows (18.75 x 12 cm 18.75 x 24 cm); 4 rows (25 x 9 cm, 25 x 18 cm); 3 rows (37.5 x 6, 37.5 x 12); or 2 rows (75 cm x 30 cm, and 75 x 6 cm) respectively.

The experiment was planted on a Eudora silt loam soil with a hand planter on May 17 both years. By May 21 the seedlings had emerged and reached the unifoliate stage by May 25. In 1973, the plots were gap filled but this was not necessary in 1974 due to good emergence and stand of the two plant types. Plots were thinned to the desired within row spacing approximately two weeks after emergence. Good weed control was achieved by hand weeding during the growing season.

Field Data

Plant height (cm) was measured in the field by averaging three readings in each plot. Lodging scores were assigned to each plot from visual observation on a scale of 1 to 5 in which: 1 - all plants erect; 2 - few plants lodged; 3 - 25-50 percent of the plants lodged; 4 - 50-80 percent of the plants lodged; 5 - all plants lodged.

Maturity

Plants were said to be mature on the date when 95% of their pods ripened. Three weeks before plants reached physiological maturity, the

plots were trimmed to a harvest length of 4.9 meters. Two rows were harvested from 75 cm row width; three rows from 37.5 cm row width; four rows from 25 cm row width; five rows from 18.75 cm row width and six rows were harvested from 15 cm row width. Seed yield (Kg/ha) was determined by weighing the threshed samples after they had been air dried to a uniform moisture percent. Seed quality was determined on a scale of 1 to 5 in which 1 = very good; 2 = good; 3 = fair; 4 = poor and 5 = very poor. Factors considered in determining seed quality were wrinkling, defective seed-coats (i.e. growth cracks) moldy or rotten seeds and greenishness. Seed size was determined by weighing samples of 100 seeds from each plot.

Individual Plant Data

At maturity samples of 5 plants were taken from each row on beds that had 2, 4 and 6 rows in 1973. On beds that had 3 and 5 rows, 10 plants were taken from the center row while 5 plants were taken from the other rows. In 1973, the 10 plants from the two outside rows and adjacent rows were combined. However in 1974, samples of 5 plants were taken from each row irrespective of the number of rows per bed and kept separate to facilitate comparisons between plants on the outside rows and inner rows on the same bed. The yield components, pods per plant, seed yield per plant, number of seeds per plant and seeds per pod, were computed from these plant samples. Also ancillary plant characteristics - height to first pod, number of branches per plant, plant height and number of nodes per plant were determined from the plant samples.

RESULTS AND DISCUSSION

Plant Height

In 1973 and 1974, row width did not influence the height of either

plant type significantly (table 2). However Clark 63 was significantly taller than Clark Dt_2 for all row widths. In 1973 and 1974 population density did not alter the height of Clark Dt_2 (table 3) but in 1973 Clark 63 was significantly taller at the lower density. Row width x density interaction was not significant in both years.

The difference in height between the two isolines is due to their growth patterns and genetic differences. Clark Dt_2 a semi-determinate type has a dominant gene, Dt_2, which causes a moderately abrupt stem termination whereas Clark 63 is an indeterminate type in which the terminal bud continues vegetative activity during most of the growing season.

There was a marked reduction in height of both plant types in 1974 as compared to 1973. Clark 63 was taller in 1973 by 14.6 cm and Clark Dt_2 by 12.9 cm than in 1974. The reduction in height could possibly have been due to a red spider mite attack early in July 1974 and soil variability within the experimental plots. Other contributing factor may have been the intense hot dry weather that prevailed in July of 1974. Some plots were under moisture stress prior to the first irrigation in 1974.

Seed Yield - Kg/ha

In 1973, no significant yield differences were found among the five row widths of Clark Dt_2 (table 2, fig 1). Clark 63 produced significantly higher yields from the 75 and 37.5 cm row widths than from the narrower row widths. On the average Clark 63 produced 567 Kg/ha more on the wider than on the narrowest spacings (table 2, fig 1). The yield of Clark Dt_2 was higher than Clark 63 on all row width except the 37.5 cm row width. Population density did not affect the yields of the two

Table 2. Effect of row spacing on height, seed quality, lodging, seed size and the yield of two soybean isolines in 1973 and 1974

Row width (cm)	Plant height (cm)		Seed quality		Wt/100 seeds (gms)		Yield Kg/ha		Lodging score	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
					1973					
75	90	127	1.5	1.7	17.4	16.8	3154	3003		3.2
37.5	90	130	1.5	1.8	17.2	16.6	2926	2989		3.4
25	90	130	1.5	1.7	17.2	16.5	3040	2580		3.7
18.75	91	130	1.5	1.7	16.9	16.8	3057	2609		3.5
15	90	129	1.5	1.6	17.1	16.9	3090	2436		2.3
Average	90	129	1.5	1.7	17.2	16.7	3053	2723		3.2
L.S.D. .05										
RW	NS		0.1		NS		183.0			0.5
Plant type	2.3		0.1		0.2		119.0			
RWX type	NS		NS		NS		259.2			
					1974					
75	78	117	1.5	1.5	16.7	15.6	2092	2081	2.0	2.4
37.5	75	115	1.5	1.7	16.6	16.2	2180	2223	2.0	2.3
25	81	113	1.7	1.5	16.5	15.9	2082	2091	1.8	2.2
18.75	75	107	1.6	1.6	16.9	15.8	2198	1985	1.8	2.1
15	77	121	1.7	1.8	16.5	16.7	2010	2174	1.9	2.2
Average	77	115	1.6	1.6	16.6	16.6	2112	2111	1.9	2.2
L.S.D. .05										
RW	NS		0.2		NS		NS		0.3	
Plant type	5.6		NS		NS		NS		0.1	
RWX type	NS		NS		NS		NS		NS	

isolines (table 3). At both densities Clark Dt_2 gave significantly higher yields than Clark 63. The row width x population density interaction did not influence the yield of Clark Dt_2 but it influenced the yield of the indeterminate type significantly. Clark 63 produced higher yields on the wider rows at the lower population density while at the higher density its yields were higher on the narrower rows (Appendix table 26).

In 1974, row width did not influence the yields of both isolines (table 2, fig 1). The yields of the two plant types on the average are the same. Clark Dt_2 gave a higher yield than Clark 63 at the higher density and the opposite was true at the lower population. The yield depression at the higher density may have been due to the fact that Clark 63 lodged more than Clark Dt_2 and some earlier workers (6) have reported that lodging could reduce soybean yields by as much as 23%. Row width x population density interaction was not significant.

The yields were considerably lower in 1974 as compared to 1973. Clark Dt_2 gave a higher yield (30.8 percent more) in 1973 and Clark 63 produced 22.4 percent more in 1973 than in 1974. The yield reductions may have been due to a red spider mite attack early in the growing season, adverse weather conditions and lodging of both isolines caused partially by strong winds in early August.

Yields of different rows per bed

Data showing the average yields for both years of individual rows on each bed has been presented on table 4. The data was not

Table 3. Effect of population density on height, seed quality, lodging, seed size and yield of two soybean isolines in 1973 and 1974

Population density	Plant height cm		Seed quality		Wt/100 seeds (gms)		Yield Kg/ha		Lodging score	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
					1973					
450 sq. cm per plant	90	132	1.5	1.7	17.1	16.9	3006	2728		3.0
225 sq. cm per plant	90	126	1.5	1.7	17.1	16.6	3100	2719		3.5
L.S.D. 0.05										
Density		2.3		NS		NS		NS		
Plant types		2.3		0.1		0.2		119		
Density x types		5.1		NS		NS		NS		
					1974					
450 sq. cm per plant	75	111	1.6	1.6	16.6	15.8	2077	2095	1.9	2.1
225 sq. cm per plant	79	118	1.6	1.6	16.7	16.3	2148	2127	1.9	2.4
L.S.D. 0.05										
Density		NS		NS		NS		NS		NS
Plant types		5.6		NS		NS		NS		0.1
Density x types		NS		NS		NS		NS		0.9

Table 4. Average yields of individual rows per bed in 1973 and 1974

Number of rows per bed (cm between rows)	Clark 63 Yields-Kg/ha 450 cm^2	225 cm^2	Average	Clark Dt_2 Yields-Kg/ha 450 cm^2	225 cm^2	Average
2 (75 cm)	2552	2526	2539	2476	2676	2576
3 (37.5 cm)						
1	3018	2928	2973	3042	2958	3000
2	1986	1758	1872	1722	1836	1779
4 (25 cm)						
1	2996	3152	3074	3056	3136	3096
2	1876	1316	1596	2144	1916	2030
5 (18.75 cm)						
1	3485	3035	3260	2600	3290	2945
2	1775	1870	1823	2070	2225	2148
3	1140	1605	1373	2230	2595	2413
6 (15 cm)						
1	2832	3768	3300	3516	3780	3648
2	1944	2214	2079	2766	2688	2727
3	1458	1632	1545	1950	1974	1962

statistically analyzed to determine significant differences. This is due to the fact that plants from two rows were combined and threshed together - hence it is difficult to know the exact yield of each row. On beds that had 3 and 5 rows, the two outside rows were combined while the center row was harvested alone. Thus we have one yield figure on 2 row beds, two yield figures on 3 and 4 row beds and three yield figures on 5 and 6 row beds. However the values in the table represent average of the two combined rows.

On three row beds Clark 63 produced 366 Kg/ha more on the outside rows than in the center rows and on 4 row beds the difference between the outer rows and the inner rows was 69 Kg/ha. On 5 and 6 row beds, yields decreased gradually from the outside rows to the center rows. The yield differences on 6 row beds were not as high as those on 5 row beds. Clark Dt_2 and Clark 63 demonstrated a gradual decrease in yield from the outside rows to the center rows (table 4). On 5 row beds, the yield from the outside rows was higher than the yield from the center row but the next two inside rows produced lower yields than the center row. On 6 row beds Clark Dt_2 followed the same yield pattern as Clark 63.

Seed quality

Both plant types produced good quality seeds. Row width did not influence the quality of Clark Dt_2 in 1973 (table 2, fig 2), however, row spacing influenced Clark 63 quality. Seeds produced on 37.5 cm rows were significantly better than seeds from 25, 18.75 and 15 cm rows. Clark Dt_2 produced better quality seeds than Clark 63 on all row widths and the differences are significant. Row width x density interaction was not significant (Appendix table 17 and 18).

In 1974, row spacing influenced seed quality significantly

(table 2, fig 2). Seeds on the wider row widths (75 and 37.5 cm) of Clark Dt_2 were significantly better than seeds produced on the 25 and 15 cm rows. Clark 63 produced its best seeds on 75 and 25 cm rows and were significantly better than seeds produced on 37.5 and 15 cm rows. There are no significant differences in seed quality between the two isolines. Population density did not influence seed quality (table 3). Row width x density interaction was not significant.

Seed Size

There was little difference in seed size between the five row widths for both plant types in 1973 (table 2). In 75, 37.5 and 25 cm row widths, Clark Dt_2 produced significantly larger seeds than Clark 63. Population density did not affect the seed size of Clark Dt_2. Clark Dt_2 produced larger seeds than Clark 63 at both densities but the difference is significant only at the higher population density. Row width x density interaction was not significant.

In 1974 there were also no significant differences between the five row widths in the seed size of both isolines (table 2). Population density did not influence the seed size of either plant type (table 3). Row width x density interaction was not significant.

Lodging Score

In 1973 only Clark 63 plots were assigned lodging scores (table 2). Plants lodged most on 18.75 cm and least in 15 cm rows. The difference between these row widths was significant while differences between the other row widths were not significant. Population density influenced lodging significantly (table 3). Plants lodged 10.2% more at the higher density. Row width x density interactions were not significant.

In 1974 both plant types were assigned lodging scores. The results show no significant differences in lodging between the row widths for Clark Dt_2 (table 2, fig 3). On the other hand row spacing influenced lodging significantly for Clark 63. This plant type lodged most in 75 cm rows and least in 18.75 cm rows. The difference between these two row widths is significant but differences between the other row widths are not significant. Clark 63 lodged more than Clark Dt_2 on all row widths but differences are not significant. Population density did not influence lodging for Clark Dt_2. Clark 63 lodged more at the higher density than at the lower density. Clark 63 lodged more than Clark Dt_2 at both densities and the differences were significant. Row width x density interaction was significant for Clark 63. It lodged more in the higher density on four row widths (75, 37.5, 18.75 and 15 cm) but lodged more at the lower population density on 25 cm rows (Appendix table 21).

In both years, Clark 63 lodged more in wider row widths than in narrow row widths. And in 1974, Clark Dt_2 lodged more in wider rows than in narrow rows. The greater degree of lodging occurred on wider rows because plants were spaced more closely within the row whereas on narrow rows they were spaced more widely apart.

THREE ROWS PER BED

Height to first pod

There were no significant differences between the two outer rows and the center row for both plant types on height to first pod (table 5). Population density did not affect the height at which Clark Dt_2 formed its first pods. On the other hand Clark 63 formed its first pods higher in the heavier population than in the lower density and this difference was significant (table 6). At the lower density Clark 63 produced its first pods significantly higher than Clark Dt_2.

Number of branches per plant

Clark 63 (table 5) produced 30% more branches on the outside rows than on the center row. The difference in branching between the two isolines was not significant. Branching was significantly affected by population density (table 6). Clark 63 branched 2.9 times as much and Clark Dt_2 2.8 times as much at the lower density as compared to the higher density. Clark 63 produced 30% more branches at the lower density than Clark Dt_2 and this difference was significant.

Plant height

Differences in plant height between the outside rows and the center row were not significant (table 5). Clark 63 was significantly taller than Clark Dt_2 by as much as 35.6 cm. Population density influenced the height of Clark 63 significantly. It was taller at the higher density by 12.3 cm (table 6). Clark Dt_2 was also taller at the higher density by 2.1 cm than at the lower density.

Table 5. Evaluation of several plant characters on beds with three rows in 1974

Row Number	Height to first pod cm		Number of branches per plant		Plant height cm		Number of nodes per plant		Number of pods per plant		Seed yield/plant (gms)		Number of seeds per plant		Seeds per pod	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
1	3.0	2.7	1.2	1.8	82	113	19.8	22.0	48.2	50.4	19.6	19.0	118.4	121.7	2.5	2.4
2	3.0	2.6	1.1	1.3	77	113	19.3	21.6	42.3	41.0	17.2	15.7	115.0	98.5	2.5	2.4
3	2.9	2.8	1.3	1.6	77	116	19.8	22.2	49.9	52.1	19.8	19.5	121.1	123.5	2.4	2.4
L.S.D. 0.05	NS	NS	NS	0.05	NS	NS	NS	NS	5.3	5.8	2.6	2.9	14.0	17.0	NS	NS

Table 6. Influence of population density on several characters of plants on beds with three rows in 1974

Population Density	Height to first pod cm		Number of branches per plant		Plant height cm		Number of nodes per plant		Number of pods per plant		Seed yield/plant (gms)		Number of seeds per plant		Seeds per pod	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
450 sq. cm per plant	2.9	2.5	1.8	2.3	77	108	19.9	22.0	51.7	52.1	21.0	19.0	127.0	123.2	2.5	2.4
225 sq. cm per plant	3.0	3.0	0.6	0.8	80	120	19.4	21.9	41.9	43.6	16.7	17.1	102.6	105.9	2.4	2.4
L.S.D. 0.05	NS	0.2	0.3	0.4	NS	8.5	NS	NS	4.4	4.7	2.2	NS	11.5	13.9	NS	NS

Number of nodes per plant

Clark 63 on the average had 2.2 nodes more than Clark Dt_2 and this difference was significant (table 5). No significant differences were observed between the two population densities (table 5).

Pods per plant

There were some significant differences between the center row and the two outside rows for number of pods per plant (table 5). On the average Clark 63 produced 10.3 pods more and Clark Dt_2 produced 6.7 pods more on the outside rows than on the center row. The difference between the two plant types was not significant. Population density also influenced this yield component significantly (table 6). Clark 63 produced 8.5 pods more and Clark Dt_2 produced 9.8 pods more at the lower density than at the higher density. Thus higher plant population resulted in a decrease in the number of pods produced by each isoline.

Seed yield per plant

Seed yields were higher for plants in the outside rows than for those in the center row but the difference was significant only for Clark 63. Clark 63 produced 3.6 gms more on the outside rows as compared to the center row (table 5). Population density influenced the yield of Clark Dt_2 significantly. Clark Dt_2 produced 4.3 gms more at the lower density than at the higher density. Differences in yield between the two plant types were not significant (table 6).

Seeds per plant

Both isolines produced a significantly larger number of seeds from the two outside rows than on the center row (table 5). Clark 63 produced 24.1 seeds more and Clark Dt_2 produced 14.9 seeds more on the

outside rows than on the center row. The two plant types produced almost the same number of seeds on the average (Clark Dt_2 - 114.8; Clark 63 - 114.6). Both isolines produced significantly larger number of seeds at the lower population density (table 6). Clark Dt_2 produced 24.4 more seeds and Clark 63 17.3 more seeds at the lower density than at the higher density. At the lower density Clark Dt_2 produced 3.8 seeds more than Clark 63 and Clark 63 had 3.3 seeds more than Clark Dt_2 at the higher density.

Seeds per pod

There were no differences in seeds per pod between the outside rows and the center row or between the two plant types (table 5). Population density did not influence this yield component (table 6).

FOUR ROWS PER BED - 1974

Height to 1st pod

Height to first pod was not significantly affected by the number of rows per bed for Clark 63 (table 7). Clark Dt_2 produced its first pods significantly higher on the first row as compared to the second row. Clark Dt_2 first pods were produced higher above ground than those of Clark 63 - the difference being 0.20 cm. Population density did not influence height to first pod (table 8).

Number of branches per plant

Both plant types branched more on the two outside rows than on the center rows (table 7, fig 4a). The outside rows of Clark 63 averaged 0.56 branches more than the center rows and this difference was significant but the difference between the outside rows and the center rows for Clark Dt_2 was not significant. Population density affected branching significantly (table 8). Clark 63 branched 2.3 times as much at the lower density and Clark Dt_2 branched 1.7 times as much at the lower density than at the higher density. These findings support the conclusions of Reckly (24) who reported decreased branching at higher densities.

Plant height

There were no significant differences between the four rows in height for both plant types (table 7). Clark 63 was taller than Clark Dt_2 on the average and this difference is highly significant. Population density did not influence plant height (table 8).

Number of nodes per plant

There were little differences between the four rows for both

Table 7. Evaluation of several plant characters on beds with four rows in 1974

Row Number	Height to first pod cm		Number of branches per plant		Plant height cm		Number of nodes per plant		Number of pods per plant		Seed yield/plant (gms)		Number of seeds per plant		Seeds per pod	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
1	3.0	2.7	2.1	2.2	79	114	19.9	22.5	53.2	54.2	20.2	19.4	127.1	128.0	2.4	2.4
2	2.5	2.7	1.6	1.6	81	114	19.4	22.3	43.3	43.3	17.2	16.0	109.8	104.8	2.5	2.4
3	2.9	2.4	1.5	1.6	78	114	19.4	22.6	43.3	47.0	16.1	16.6	102.6	111.0	2.4	2.4
4	2.8	2.7	1.8	2.1	79	112	19.7	23.0	50.0	56.6	19.2	21.8	121.6	138.6	2.4	2.5
L.S.D. 0.05	0.3	NS	0.7	0.4	NS	NS	NS	NS	4.6	6.5	2.4	2.7	14.3	16.9	NS	NS

Table 8. Influence of population density on several characters of plants on beds with four rows in 1974

Population Density	Height to first pod cm		Number of branches per plant		Plant height cm		Number of nodes per plant		Number of pods per plant		Seed yield/plant (gms)		Number of seeds per plant		Seeds per pod	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
450 sq. cm per plant	2.8	2.6	2.2	2.6	77	113	19.6	23.2	54.4	56.7	21.9	20.8	132.0	136.4	2.4	2.4
225 sq. cm per plant	2.8	2.6	1.3	1.1	79	114	19.6	21.9	40.5	43.8	14.4	16.1	98.5	104.7	2.4	2.4
L.S.D. 0.05	NS	NS	0.5	0.3	NS	NS	NS	1.1	3.3	4.6	1.7	1.9	10.1	11.9	NS	NS

plant types for number of nodes per plant (table 7). Clark 63 on the average had 3.2 more nodes than Clark Dt_2 and this difference was significant (table 7, fig 4b). Population density affected the number of nodes of Clark 63 significantly but did not influence Clark Dt_2. Clark 63 produced 1.3 nodes more at the lower density than at the higher density (table 8). The differences between the two plant types were significant at both densities.

Number of pods per plant

The two isolines produced more pods on the two outside rows than on the center rows (table 7, fig 4c). Clark 63 produced 10.2 more pods on the outside rows as compared to the center rows. High plant population resulted in a significant reduction in the number of pods of both isolines confirming the work of Reddy (24) and Cooper (6) (table 8). Clark 63 produced 12.9 pods more at the lower density and Clark Dt_2 produced 13.9 pods more at the lower density than at the higher density.

Seed yield per plant

The seed yield of both plant types was significantly higher on the outside rows as compared to the center rows (table 7, fig 4d). Clark 63 produced 4.3 gms more and Clark Dt_2 produced 3.1 gms more on the outside rows as compared to the center rows. The difference between Clark 63 and Clark Dt_2 in seed yield was small (0.3 gms) with Clark 63 giving the higher yield. Yields of the two isolines were higher at the lower density and the differences were significant (table 8). Clark Dt_2 produced 7.5 gms more and Clark 63 4.6 gms more at the lower density than at the higher density.

Number of seeds per plant

Both plant types produced significantly more seeds on the outside rows than on the center rows (table 7, fig 4e). Population density influenced this yield component significantly (table 8). Both isolines produced more seeds at the lower density. These results agree with the findings of Cooper (6) and Reddy (24).

Seeds per pod

There was little variation in number of seeds per pod between plants on the four rows for Clark 63 and Clark Dt_2. The difference between the isolines was small supporting Reddy's (21) conclusion. Population density had little or no influence on the number of seeds per pod for both plant types.

Plants on the two center rows branched less, produced less pods, gave lower seed yields, and less seeds than plants on the two outside rows. These differences might be due to the fact that on the two center rows plants were farther away from the irrigation furrows than plants on the outside rows; hence there were moisture differences. High plant population resulted in fewer branches, taller plants, plants with few nodes, fewer pods and smaller seed yields than the low plant population. However it had no significant effect on height to first pod and seeds per pod.

FIVE ROWS PER BED

Height to first pod

There were no significant differences between plant types in the five rows in height to first pod (table 9). Population density had no influence on this agronomic character as shown on table 10. At both densities Clark Dt_2 produced its first pods higher than Clark 63.

Number of branches per plant

Branching decreased from the outside rows to center rows for both plant types (table 9, fig 4a). The differences between the two outside rows and the center row were significant for both isolines. The two plant types responded differently to population density (table 10, fig 4f). Clark Dt_2 branched 2 times as much at the lower density as it did at the higher density while Clark 63 produced 1.2 more branches at the higher density than at the lower density. At the lower density, Clark Dt_2 produced 0.8 more branches than Clark 63 and at the higher density Clark 63 produced 1.5 more branches than Clark Dt_2. These differences were highly significant.

Plant height

Plants of Clark 63 decreased in height from the outside rows to the center row but Clark Dt_2 increased in height from the outside rows to the center row (table 9). Clark 63 was significantly taller than Clark Dt_2 by 24.2 cm. Population density did not influence the height of the two isolines.

Number of nodes per plant

Clark 63 had 2.2 more nodes in the outside rows than in the

Table 9. Evaluation of several plant characters on beds with five rows in 1974

Row Number	Height to first pod cm		Number of branches per plant		Plant height cm		Number of nodes per plant		Number of pods per plant		Seed yield/plant (gms)		Number of seeds per plant		Seeds per pod	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
1	2.7	2.4	2.0	2.5	76	104	19.5	22.5	50.7	51.9	21.4	20.8	132.8	142.9	2.3	2.2
2	2.7	2.6	1.4	1.8	78	101	19.2	21.4	50.3	45.6	18.3	15.8	111.6	108.2	2.3	2.4
3	2.7	2.3	1.4	1.3	77	97	19.4	20.5	42.9	36.2	16.8	13.1	107.0	83.5	2.5	2.3
4	2.7	2.5	1.5	1.6	76	101	19.7	21.6	48.3	51.0	18.9	17.6	117.1	121.1	2.4	2.4
5	2.7	2.5	1.8	2.7	77	103	19.7	22.9	59.3	56.0	23.8	22.5	147.8	150.7	2.5	2.4
L.S.D. 0.05	NS	NS	0.5	0.6	NS	NS	NS	1.6	12.7	12.9	3.6	3.7	18.9	23.8	0.2	NS

Table 10. Influence of plant population on several plant characteristics in 1974 from plants in five rows per bed

Population Density	Height to first pod cm		Number of branches per plant		Plant height cm		Number of nodes per plant		Number of pods per plant		Seed yield/plant (gms)		Number of seeds per plant		Seeds per pod	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
450 sq. cm per plant	2.7	2.4	2.1	1.4	75	102	19.8	21.1	55.8	39.2	22.8	15.0	141.7	98.4	2.4	2.3
225 sq. cm per plant	2.7	2.5	1.1	2.6	79	101	19.8	22.4	44.8	57.0	16.9	20.9	104.7	144.1	2.4	2.3
L.S.D. 0.05	NS	NS	0.3	0.4	NS	NS	NS	1.0	8.0	8.2	2.2	2.3	12.0	15.1	NS	NS

Fig 4g. Influence of population density on number of pods and seeds per plant in beds with 5 rows.

Fig 4f. Influence of population density on number of branches per plant in beds with 5 rows.

Fig 4h. Influence of population density on seed yield per plant in beds with five rows.

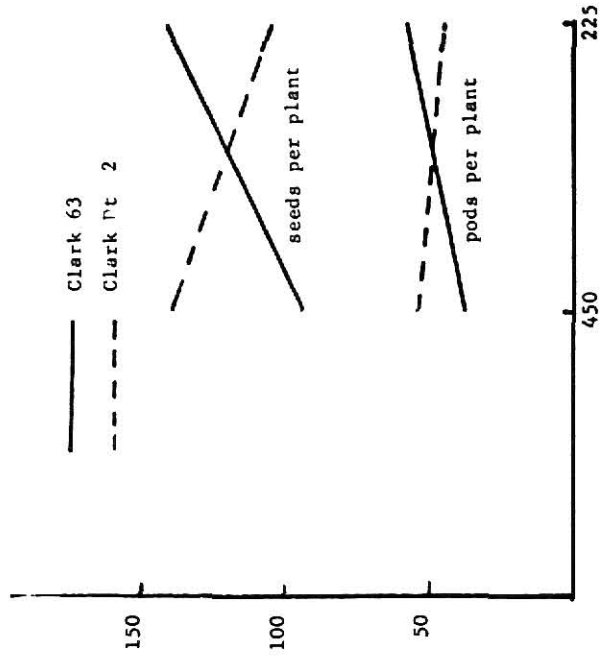


Fig. 4g

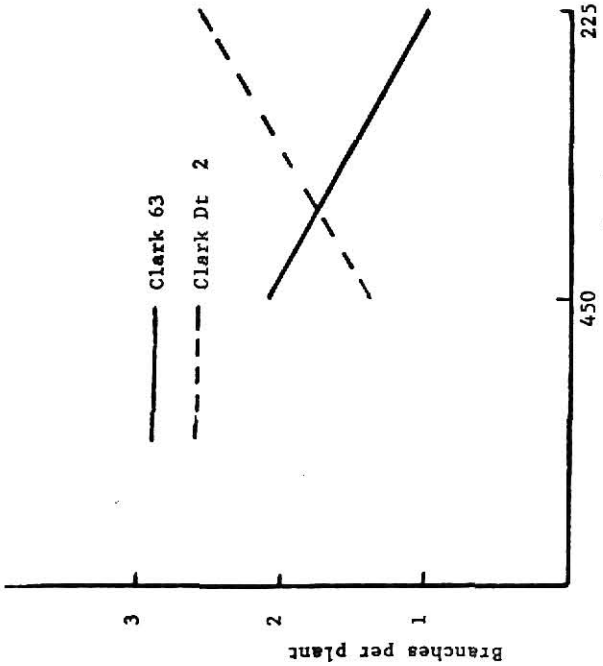


Fig. 4f

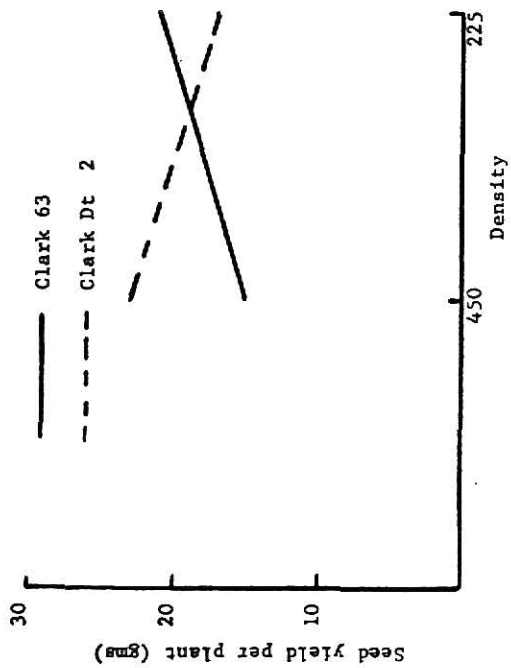


Fig. 4h

center row and 1 node more in the next inner rows as compared to the center row (table 9, fig 4b). The difference between the two outside rows and the center row was significant. On the average Clark 63 produced 2.3 more nodes than Clark Dt_2 and this difference was significant. Population density did not influence the number of nodes for Clark Dt_2. But Clark 63 had 1.3 more nodes at the higher density than at the lower density and this difference was significant (table 10).

Number of pods per plant

Clark 63 produced 17.8 more pods on the two outside rows than on the center row and this difference was significant. The difference between the next inner rows and the center row was not significant (table 9, fig 4c). On the average, the difference between Clark 63 and Clark Dt_2 was not significant. The two plant types responded to population density differently (table 10, fig 4g). Clark 63 produced 17.8 more pods at the higher density than at the lower density and Clark Dt_2 produced 11 more pods at lower density than at the higher density and these differences were significant. Clark Dt_2 produced 16.6 more pods than Clark 63 at the lower density and Clark 63 produced 12.3 more pods than Clark Dt_2 at the higher density and these differences were significant.

Seed yield per plant

Seed yields of the two isolines on the two outside rows were significantly higher than their yields on the center row (table 9, fig 4d). Yields on the next two inside rows were higher than on the center row but these differences were not significant. On the average Clark Dt_2 produced a higher yield (1.8 gms) than Clark 63. The yield responses of the two isolines to population density were different (table 10, fig 4h).

Clark 63 yield was significantly higher (by 6 gms) at the higher density while the yield of Clark Dt_2 was 5.9 gms higher at the lower density. At the higher density Clark 63 produced 4 gms more of seeds than Clark Dt_2 while at the lower density Clark Dt_2 produced 7.8 gms more than Clark 63. The yield differences were significant.

Number of seeds per plant

The indeterminate type produced 63 seeds more on the outside rows and 31.2 seeds more on the next two inside rows than on the center row. These differences were significant (table 9, fig 4e). Clark Dt_2 produced 33.3 more seeds on the two outside rows than on the center row and this is highly significant. The difference between the next two inside rows and the center row was not significant. On the average Clark Dt_2 produced 2 seeds more than Clark 63. Population density influenced this yield component significantly (table 10, fig 4g). The semi-determinate type produced 35 seeds more at the lower density than at the higher density whereas Clark 63 produced 53.7 seeds more at the higher density than at the lower density. Clark 63 produced 39.3 seeds more than Clark Dt_2 at the higher density and Clark Dt_2 produced 43.3 more seeds than Clark 63 at the lower density. These differences were highly significant.

Seeds per pod

Differences in seeds per pod between the two outside rows, the next two inside rows and the center row were not significant for Clark 63 (table 9). On the other hand Clark Dt_2 produced a higher number of seeds per pod on the center row than on the remaining four rows although the differences were not significant. Population density did not influence

this yield component for either plant type. The two isolines did not differ in the number of seeds per pod.

SIX ROWS PER BED

Height to first pod

For both plant types, there were no significant differences between the outer rows and the center rows in height to first pod (table 11). Also the difference between Clark 63 and Clark Dt_2 was only 0.06 cm with Clark 63 having its first pods higher than Clark Dt_2. Population density did not influence the height at which Clark Dt_2 produced its first pods (table 12) but Clark 63 produced its first pods significantly higher above ground at the higher density.

Number of branches per plant

Branching of the plants was significantly affected by row number. Both isolines produced more branches in the two outside rows than in the center rows. Clark 63 branched 82 percent more and Clark Dt_2 branched 51 percent more in the two outside rows than in the center two rows (table 11, fig 5a). On the average Clark Dt_2 produced 12.3 percent branches more than Clark 63 but this difference was not significant. Population density affected branching significantly but the responses of the two plant types were quite opposite of each other. Clark 63 branched three times as much at the lower density as at the higher density but Clark Dt_2 branched 1.3 times as much at the higher density as at the lower density (table 12, fig 5b). At the higher density Clark Dt_2 produced 1.3 more branches than Clark 63 whereas at the lower density Clark 63 produced 0.9 branches more than Clark Dt_2.

Plant height

Clark 63 was significantly taller than Clark Dt_2. Differences in height of both plant types on the six rows were not significant (table

Table 11. Evaluation of several plant characters on beds with six rows in 1974

Row Number	Height to first pod cm		Number of branches per plant		Plant height cm		Number of nodes per plant		Number of pods per plant		Seed yield/plant (gms)		Number of seeds per plant		Seeds per pod	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
1	2.8	3.0	2.7	2.2	72	114	20.1	22.8	64.9	50.6	22.7	18.2	152.6	117.6	2.3	2.3
2	2.9	2.9	2.0	1.7	77	116	19.4	22.4	50.6	50.6	18.8	17.7	118.3	114.9	2.4	2.3
3	2.9	3.0	1.7	1.2	76	117	19.1	21.7	43.3	39.3	15.8	14.4	102.0	93.5	2.4	2.4
4	2.7	2.8	1.7	1.2	79	116	19.3	21.9	44.0	37.0	15.8	13.2	105.0	86.0	2.4	2.3
5	3.0	2.9	1.0	1.5	79	118	19.0	22.5	40.5	47.0	15.9	18.3	97.3	113.3	2.4	2.4
6	2.8	2.8	2.4	2.3	73	117	19.2	22.8	63.2	58.7	22.7	22.0	128.1	142.5	2.4	2.4
L.S.D. 0.05	NS	NS	0.5	0.4	NS	NS	NS	0.9	8.8	3.7	3.7	3.3	21.4	17.0	NS	NS

Table 12. Influence of population density on several characters of plants on beds with six rows in 1974

Population Density	Height to first pod cm		Number of branches per plant		Plant height cm		Number of nodes per plant		Number of pods per plant		Seed yield/plant (gms)		Number of seeds per plant		Seeds per pod	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
450 sq. cm per plant	2.8	2.8	1.7	2.6	77	109	19.3	22.8	50.9	56.5	18.4	19.7	117.6	130.4	2.3	2.3
225 sq. cm per plant	2.9	3.0	2.1	0.8	75	123	19.4	21.9	51.2	37.9	18.8	15.0	123.5	92.1	2.4	2.4
L.S.D. 0.05	NS	0.2	0.3	0.2	NS	6.0	NS	0.5	NS	3.7	NS	1.9	NS	9.8	0.1	0.1

Fig 5a. Influence of row number per bed on number of branches per plant in beds with 6 rows.

Fig 5b. Influence of population density on number of branches per plant in beds with 6 rows.

Fig 5c. Influence of row number per bed on number of nodes and pods per plant in beds with 6 rows.

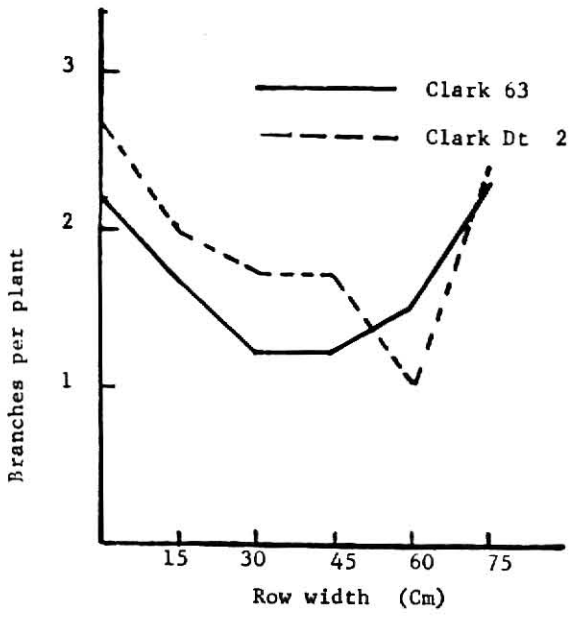


Fig. 5a

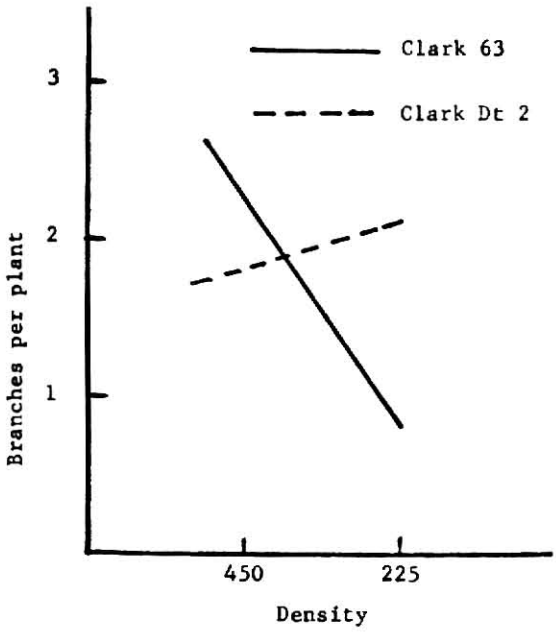


Fig. 5b

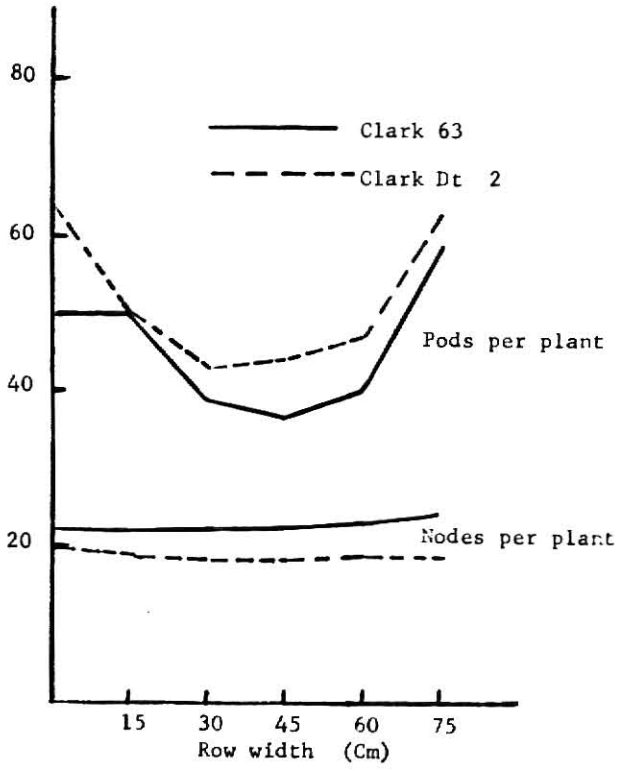


Fig. 5c

Fig 5d. Influence of row number per bed on number of seeds per plant in beds with 6 rows.

Fig 5e. Influence of row number per bed on seed yield per plant in beds with 6 rows.

Fig 5f. Influence of population density on number of pods and seeds per plant in beds with 6 rows.

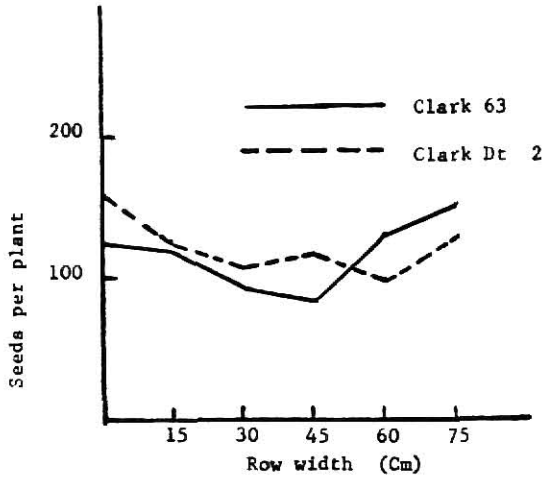


Fig. 5d

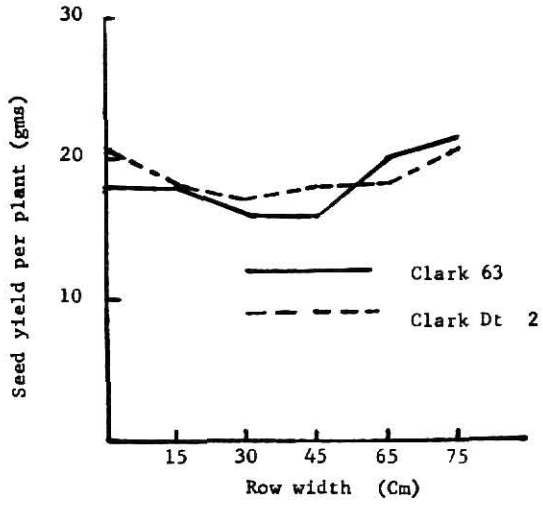


Fig. 5e

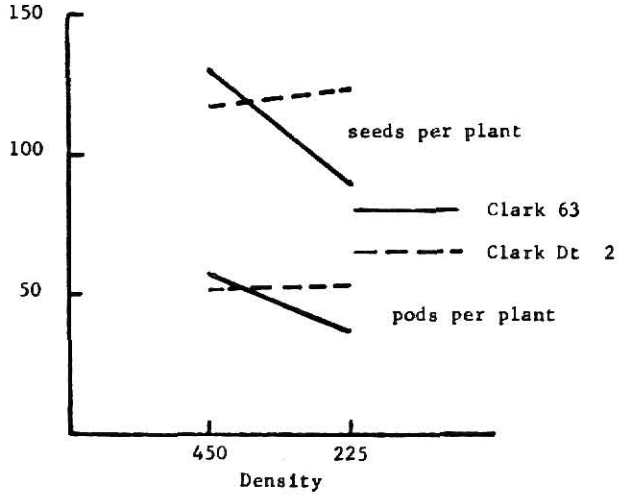


Fig. 5f

11). Clark Dt_2 was shorter (by 3.4 cm) on the two outside rows as compared to the four inner rows. The average height of Clark 63 was also shorter on the two outside rows. While not influencing the height of the determinate type, population density influenced the height of the indeterminate type significantly (table 12). Clark 63 was taller at the higher density.

Number of nodes per plant

Clark 63 had significantly more nodes per plant in the outside rows than in the center rows (table 11, fig 5c). Plants in the outside rows had 1.0 node more than plants in the center rows. Also plants in the next inner two rows had 0.65 nodes more per plant than those in the center rows but this was not significant. There were no significant differences between the plants in the rows of Clark Dt_2. On the average Clark 63 had 3.0 nodes more per plant than Clark Dt_2 (table 11, fig 5c). Population density did not affect Clark Dt_2 but Clark 63 had significantly more (0.9) nodes at the lower density. Also it had 3.5 more nodes at the lower density and 2.5 more nodes at the higher density than Clark Dt_2 and these differences were significant.

Number of pods per plant

There was a gradual decrease in pods per plant from the outside rows to the center rows for both isolines. Clark 63 plants produced 16.5 pods more in the outside rows than in the center rows and Clark Dt_2 plants produced 20.4 pods more in the outside rows than those in the center rows (table 11, fig 5c). Both isolines also produced more pods on the next inner two rows than on the center rows but differences were not significant. Clark Dt_2 produced an average of 3.9 pods more than Clark

63. The effect of population density was different on the two plant types. Clark 63 produced 18.5 pods more at the lower density than at the higher density and this difference was significant. On the other hand, there was little difference between the two densities for Clark Dt_2 (table 12). Clark 63 produced 5.6 pods more than Clark Dt_2 at the lower density and at the higher density Clark 63 produced 13.3 pods more than Clark Dt_2. These differences were significant and highly significant respectively.

Seed yield per plant

Significant differences were found between yields from the outside rows and the center rows for both plant types (table 11, fig 5d). Clark 63 plants produced 6.3 gms more in the outside rows and Clark Dt_2 produced 6.9 gms more in the outside rows than in the center rows. Plant of both isolines also gave higher seed yields in the next inner two rows than on the center rows but the differences were only significant for Clark 63 (4.2 gms). Clark Dt_2 plants produced slightly higher yield than Clark 63. Population density significantly affected Clark 63 yields but had little influence on the yield of Clark Dt_2. Clark 63 produced 4.7 gms more at the lower than at the higher density. Clark Dt_2 produced a higher yield than Clark 63 at the higher density and vice versa but differences were not significant.

Seeds per plant

Seeds per plant decreased gradually from the outside rows to the center rows for both plant types (table 11). Clark Dt_2 plants produced 32.5 more seeds in the outside rows and Clark 63 16 more than in the center rows. The differences however were significant for Clark Dt_2

only. The differences between the other inner rows and the center rows were not significant (table 10, fig 5d).

Clark Dt_2 produced an average of 5.9 more seeds per plant than Clark 63. Population density significantly affected Clark 63 on this yield component but had little influence on Clark Dt_2. Clark 63 produced 38.3 seeds more at the lower plant population than at the higher density and this is significant (table 12, fig 5e). Clark 63 produced 12.9 more seeds at the lower density than Clark Dt_2 but at the higher density Clark Dt_2 produced 31.4 seeds more than Clark 63. These differences were significant.

Seeds per pod

There were no significant differences between the outside rows and the center rows for both plant types on the number of seeds per pod (table 11). There were no differences between the two isolines. Population density affected the two plant types significantly (table 12). Clark Dt_2 produced 5 percent more seeds per pod and Clark 63 produced 5.2 percent more seeds per pod at the higher density than at the lower density.

The influence of row spacing and population density on seed yield per plant, yield components and other agronomic characters of Clark 63 and Clark Dt_2

Height to first pod

Row widths did not influence height to first pod for both isolines (table 13). Population density did not affect height to first pod significantly (table 14). Both plant types produced their first pods higher at the higher population and at both densities Clark Dt_2 first pods were significantly higher than those of Clark 63. Row width x density interaction was not significant.

Number of branches per plant

Clark Dt_2 produced 60 percent more branches in the 15 cm row width and 45.4 percent more branches in 25 cm row width than in the 37.5 cm row width and these differences were highly significant (table 13). Clark 63 produced more branches in 18.75 cm rows and fewer branches in 75 cm row width. Thus both isolines branched more in the narrow row widths. This disagrees with Hanway (13), Hinson and Hanson (18), Kilgore (19) and Reddy (24) because the plants were spaced more widely within the narrow rows. Clark 63 produced 58 percent more branches and Clark Dt_2 52 percent more branches (table 14) at the lower density, supporting the findings of

Table 13. Influence of row spacing on several plant characteristics of two soybean isolines in 1974

Row width cm	Height to first pod cm		Number of branches per plant		Plant height cm		Number of nodes per plant		Number of pods per plant		Seed yield/plant (gms)		Number of seeds per plant		Seeds per pod	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
75	3.1	2.6	1.4	1.3	80	113	19.2	22.0	49.3	51.7	19.0	18.4	116.1	120.0	2.3	2.3
37.5	3.0	2.7	1.2	1.5	78	114	19.7	21.9	46.8	47.8	18.9	18.0	114.8	114.5	2.5	2.4
25	2.8	2.6	1.8	1.9	79	113	19.6	22.6	47.2	50.3	18.6	18.9	115.1	120.6	2.4	2.4
18.75	2.7	2.4	1.6	2.0	77	101	19.5	21.7	51.9	52.0	20.6	18.0	123.2	121.2	2.4	2.3
15	2.8	2.9	1.9	1.7	76	116	19.3	22.3	51.0	47.2	18.7	17.6	119.0	111.3	2.4	2.4
Average	2.9	2.6	1.6	1.7	78	112	19.5	22.1	49.3	49.8	19.2	18.2	117.6	117.5	2.4	2.4

L.S.D. 0.05								
Row width	NS	0.2	NS	NS	NS	NS	NS	NS
Plant types	0.1	NS	5.2	0.5	NS	NS	NS	NS
RWX types	NS	0.3	NS	NS	2.7	NS	10.5	NS

Table 14. Influence of plant population on several plant characteristics of two soybean isolines in 1974

Population density	Height to first pod cm		Number of branches per plant		Plant height cm		Number of nodes per plant		Number of pods per plant		Seed yield/plant (gms)		Number of seeds per plant		Seeds per pod	
	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63	Dt_2	Clark 63
450 sq. cm per plant	2.8	2.6	1.8	2.1	77	109	19.7	22.3	52.6	52.6	21.2	18.8	126.0	123.3	2.4	2.4
225 sq. cm per plant	2.9	2.7	1.3	1.3	78	114	19.2	22.0	45.9	47.0	17.2	17.5	109.3	111.8	2.4	2.4
L.S.D. 0.05																
Density	NS		0.2		NS		NS		3.2		1.1		6.9		NS	
Plant type	0.1		NS		5.2		0.5		NS		NS		NS		NS	
Density x type	NS		NS		NS		NS		NS		2.4		NS		NS	

Reddy (24). Row width x density interaction was highly significant for Clark 63 and Clark Dt_2. Clark 63 branched more at the lower density on 75, 37.5, 25 and 15 cm row widths but branched more at the higher density on 18.75 cm row width. Clark Dt_2 branched more heavily at the lower density on all row widths except the 15 cm (Appendix table 26 and 27).

Plant height

Row spacing did not influence the height of the semi-determinate and the indeterminate type (table 13). Clark 63 was significantly taller than Clark Dt_2 on all row widths - the difference being 33.7 cm on the average. Plant population did not influence the height of either plant types significantly (table 14). Both plant types were, however, taller at the higher population density - thus confirming the works of Wiggins (34), Buttery (3), Johnson and Harris (17) and Nelson and Roberts (29). Row width x density interaction was not significant in either case.

Number of nodes per plant

Number of nodes per plant was not significantly affected by row width for both plant types (table 13). However Clark 63 produced a significantly higher number of nodes than Clark Dt_2 on all row widths. On the average Clark 63 had 2.6 nodes more than Clark Dt_2. Plant population did not influence this agronomic character for either plant type (table 14). Both plant types had a slightly higher number of nodes at the lower density. These results disagree with Cooper (6) but were in agreement with Reddy (24). Interaction between row width x density was not significant.

Number of pods per plant

No significant differences were observed between the five row widths (table 13). These results are not in line with the findings of Cooper (6) but agree with those of Reddy (24). High plant population resulted in smaller number of pods for both isolines (table 14). Clark Dt_2 produced more pods and Clark 63 more pods at the lower density and these differences were significant. The difference between the two plant types was small with Clark 63 producing more pods. Interaction between row width and density was significant. Clark Dt_2 produced more pods at the lower density in all row widths except the 15 cm row width. Clark 63 produced more pods at the lower density on all row widths except the 18.75 cm row width (Appendix table 26 and 27).

Seed yield per plant

Differences in seed yield between the five row widths were not significant (table 13). Clark 63 produced smaller seed yields than Clark Dt_2 on all row widths. Clark 63 produced its highest yield from the 25 cm rows and lowest yield from the 15 cm rows. Clark Dt_2 on the other hand produced its highest yield from the 18.75 cm row width and lowest yield from the 25 cm row width. These results agree with Cooper (6) but disagree with Reddy (24). Population density influenced the yield of Clark Dt_2 significantly (table 4). Clark Dt_2 produced more per plant from the lower density than from the higher density. Clark 63 plants produced more from the lower density plots. Row width x density interaction was significant for Clark Dt_2 and highly significant for

Clark 63. Clark Dt_2 produced higher yields from the lower density for all row widths except the 15 cm row width. Clark 63 had higher yields from the lower density on all row widths except the 18.75 cm row width (Appendix table 26 and 27).

Seeds per plant

Statistical analysis of seeds per plant did not show significant differences between the five row widths for both plant types (table 13). On the average the two plant types produced the same number of seeds. These results are not in line with Cooper's (6) findings who reported significant differences between two row widths 50 and 100 cm. Both plant types produced a significantly higher number of seeds from the lower density than at the higher density (table 14). Clark Dt_2 produced more seeds and Clark 63, more seeds at the lower density. At the higher density Clark 63 produced more seeds than Clark Dt_2. Row width x density interaction was highly significant for both isolines. Clark Dt_2 produced more seeds from the lower density for all row widths except the 15 cm row width and Clark 63 seed yields were higher from the lower density for all row widths except the 18.75 cm row width (Appendix 26 and 27).

Seeds per pod

No significant differences were observed between row widths for both plant types in seeds per pod (table 13) or between the two densities (table 14). There was no difference between the two isolines. Row width x density interaction was not significant.

Summary and conclusions

Two Clark soybean isolines were tested under irrigation for two years to evaluate their response to five row widths and two population densities. Row spacing did not influence the height of either plant type both years. Plants were taller in the higher population density. Clark 63, the indeterminate type, was significantly taller than Clark Dt_2, the semi-determinate type, by as much as 39 cm. There was a marked reduction in the height of both isolines in 1974 due to red spider attack and hot and dry weather conditions.

No significant differences in yields of Clark Dt_2 due to row widths were observed in both years. In 1973 Clark Dt_2 produced its highest yield in the widest row spacing (75 cm) but the yield was highest in 18.75 cm rows in 1974. However Clark 63 produced significantly higher yields in 75 and 37.5 cm row widths in 1973 and in the 37.5 cm row width in 1974 than in the narrower rows. Clark Dt_2 produced approximately 10 percent more than Clark 63 in 1973 but yields were approximately the same in 1974. Both isolines had higher seed yields in the outside rows than in the inner rows for the four row widths: 37.5, 25, 18.75 and 15 cm. Average yields of both isolines were lower in 1974. Population density did not influence seed yields, though yields were slightly higher at the higher population density.

Row spacing influenced the quality of Clark 63 seeds both years but influenced Clark Dt_2 only in 1974. Both plant types produced good quality seeds but seeds were better in the wider row widths. Population density did not influence seed quality for either type. In 1973 Clark Dt_2 produced better quality seeds than Clark 63 but in 1974 there were no differences between them.

Row width had no significant effect on seed size of either isoline both years but seeds were larger on narrow row widths. Population density did not influence the size of Clark Dt_2 seeds but Clark 63 produced larger seeds from the lower density in 1973 but in 1974 there were no differences between the two densities. Clark Dt_2 seeds were larger than those of Clark 63 both years and this could have been one of the reasons for the yield differences between the two plant types in 1973.

Row spacing influenced lodging significantly for Clark 63 but not Clark Dt_2. On the average both strains lodged more in the wider rows than in the narrower rows. This is probably due to the closer within row spacing in the wider row widths. Clark 63 lodged more than Clark Dt_2 and there was a greater degree of lodging of both isolines at the higher density.

Height to first pod was not affected by row width for both plant types. Clark Dt_2 produced its first pods highest on plants from the 75 cm row width while the first pods on Clark 63 were highest on plants from 15 cm row width.

Row width did not influence plant height, nodes per plant, seed yield per plant, seeds per plant or seeds per pod.

Plants of both isolines produced the highest number of pods in the 18.75 cm row width.

On the average Clark Dt_2 had its first pods 0.20 cm higher above ground than Clark 63 and also produced 1.0 gm more of seed yield per plant than Clark 63. On the other hand Clark 63 produced 0.13 more branches, had 2.6 more nodes and was 34 cm taller than Clark Dt_2.

For both plant types, high plant population resulted in higher

first pods, less branching, taller plants, fewer nodes per plant, fewer pods per plant but plant population did not influence number of seeds per pod.

On beds with three and five rows, plants in the center row were shorter, produced their first pods nearer the ground, had fewer nodes per plant, branched less, produced fewer pods per plant and gave lower seed yield than plants in the outside rows. These differences may have been partially due to moisture differential between the center row and the outer rows because of the proximity to the irrigation furrows. Higher plant population in beds with three rows resulted in higher first pods for Clark 63 (not for Clark Dt_2), less branching, taller plants, fewer nodes per plant, fewer pods per plant, less seed yield per plant, less number of seeds per plant. On the other hand, in beds with five rows the two plant types responded differently to population density. Clark Dt_2 branched less, was taller, had fewer pods per plant, produced a smaller seed yield per plant and had fewer seeds per plant at the higher density than at the lower density though reverse was true for Clark 63. However, population density had no influence on seeds per pod for either isolines in three or five row plots.

On beds with four rows, plants in the center rows were shorter, had fewer nodes per plant, fewer pods per plant, gave lower seed yield and had fewer seeds per plant than plants on the outside rows. Higher plant population resulted in less branching, taller plants, fewer pods per plant, lower seed yield per plant and fewer seeds per plant for both isolines. Clark 63 had fewer nodes per plant at the higher population density as compared to the lower density.

On beds with six rows, the first pods of Clark Dt_2 were highest

in the next two inner rows but those of Clark 63 were higher in the outside rows than in the center rows. Both isolines branched less, were taller, had fewer nodes, fewer pods per plant, gave lower seed yields per plant and had fewer seeds per plant in the center rows as compared to the four center rows.

High plant population resulted in higher first pods on the stem and more seeds per pod for both plant types. However the two isolines responded differently to population density in seed yield and other agronomic characters. Clark 63 branched less, was taller, had fewer nodes per plant, fewer pods per plant, produced lower seed yield per plant and had fewer seeds per plant at the higher population density as compared to the lower population density. The opposite was true for Clark Dt_2.

Row width x density interactions were significant for both plant types on branches per plant, pods per plant, seed yield per plant and seeds per plant. Also row width x density interactions were significant on seed quality and lodging for Clark 63 and on nodes per plant for Clark Dt_2.

BIBLIOGRAPHY

1. Benerlin, J. E., J. W. Pendleton, M. E. Baner and S. R. Ghovasky. 1971. Effect of branch removal and plant population at equidistant spacings on yield and light use efficiency of soybean canopies. Agron. J. 63:317-319.

2. Buttery, B. R. 1967. Effect of plant population and fertilizer on the growth and yield of soybeans. Can. J. Pl. Sci. 49:659-73.

3. Camper, H. M. and T. J. Smith. The effect of date of planting, rate of planting and width of row on two soybean varieties. Virginia Agr. Expt. Station Res. Rpt. 21.

4. Carter, J. L. and E. E. Hartwig. 1962. The management of soybeans. Adv. Agron. 14:359-412.

5. Cooper, R. L. 1970. Early lodging--a major barrier to higher yields. Soybean Digest 30(3) 12-13.

6. Weber, C. R., R. M. Shibles and D. E. Byth. 1966. Effect of plant population and row spacing on soybean development and production. Agron. J. 58:99-102.

7. Weber, C. R. and W. R. Fehr. 1966. Seed yield losses from lodging and combine harvesting in soybeans. Agron. J. 58:287-289.

8. Gopani, D. D. and M. M. Kabaria. 1970. Correlation of yield with agronomic characters and their heritability in soybean (Glycine max (L) Merr). Indian Journal of Agric. Sci. 40(10) 849-853.

9. Hartwig, Edgar E. and Calton J. Edwards, Jr. 1970. Effects of morphological characteristics upon seed yield in soybeans. Agron. J. 62(1):64-65.

10. Hanway, D. G. 1954. Growing soybeans in Nebraska. Soybean Digest 14(10):19-20.

11. Hicks, D. R., J. W. Pendleton, R. L. Bernard and T. J. Johnson. 1969. Response of soybean plant types to planting patterns. Agron. J. 61:290-293.

12. Holiday, R. 1963. The effect of row width on the yield of cereals. Field Crop Abstr. 16:71-81.

13. Johnson, B. J. and H. B. Harris. 1967. Influence of plant population on yield and other characteristics of soybean. Agron. J. 59: 447-449.

14. Hinson, Knel and W. D. Hanson. 1962. Competition studies in soybeans. Crop Sci. 2:117-123.

15. Kilgore, G. L. 1968. The effect of planting date and row width on three soybean varieties. Masters' Thesis, K.S.U. 1968.

16. Lehman, W. F. and Lambert, J. W. 1960. Effects of spacing soybean plants between and within rows on yield and its components. Agron. J. 52:84-86.

17. Luellen, W. R. 1970. Lodging barrier to higher soybean yields. Crops and Soils 22(7):8-9.

18. Mader, E. L. 1968. Soybean date of planting and row width studies. Kansas Agricultural Expt. Station, Manhattan, Kansas, 1-2, April.

19. Matson, A. L. 1964. Some factors affecting the yield response of soybeans to irrigation. Agron. J. 56:552-555.

20. Saxena, M. C. and R. K. Pandey. 1971. Characteristics and performance of some promising soybeans at Pantnagar. Indian Journal of Agric. Sciences 41(4):355-360.

21. Reddy, M. 1973. Effect of spacing on two soybean plant types. Masters' Thesis, K.S.U.

22. Nelson, C. E. and S. Roberts. 1962. Effects of plant spacing and planting date on six varieties of soybeans. Washington Agr. Expt. Sta. Bull. 639.

23. Probst, A. H. 1945. Influence of spacing on yield and other characteristics in soybeans. J. Am. Soc. Agron. 37:549-554.

24. Reiss, W. E. and L. V. Sherwood. 1965. Effect of row spacing, seeding rate and potassium and calcium hydroxide additions on soybean yields on soils of Southern Illinois. Agron. J. 56:431-433.

25. Cooper, Richard L. 1971. Influence of early lodging on yield of soybeans. Agron. J. 63:449-450.

26. Oswalt, Roy M., James D. Arnold and Ralph S. Matlock. 1969. Soybean row spacing. Oklahoma Agric. Expt. Sta. Prog. Report No. 606-630.

27. Smith, R. L. 1968. Effect of date of planting and row width on yield of soybeans. Crop Sci. Soc. Florida Proc. 28:130-133.

28. Wiggans, R. G. 1939. The influence of space and arrangement on the production of soybean plants. J. Am. Soc. Agron. 31:314-321.

29. Zahnley, J. N. 1942. Soybean production in Kansas. Kansas Agricultural Expt. Station Bulletin 306.

30. _____. 1957. Row width and rate of planting in southern states. Soybean Digest 17:13-15.

APPENDIX

Table 15. Analysis of variance table for plant height, seed quality, seed size and seed yield of Clark 63 and Clark Dt_2 soybeans in 1973

Source of variation	D.F.	Mean squares for Plant height	Seed quality	Seed size	Yield
Replications	3	54.16	0.31	1.68	61.54
Row width (A)	4	8.25	0.03	0.16	90.52*
Density (B)	1	216.22*	0.07	0.48	12.36
Plant type (C)	1	30250.20**	0.74**	3.53**	747.86**
A x B	4	9.01	0.01	0.23	59.77
A x C	4	8.13	0.02	0.30	110.61*
B x C	1	140.77	0.001	0.58	18.51
A x B x C	4	14.52	0.01	0.13	61.76
Error	57	25.43	0.02	0.20	23.24

*Significant at 0.05 percent level

**Highly significant at 0.05 percent level

Table 16. Analysis of variance table for plant height, seed quality, seed size, lodging and yield of Clark 63 and Clark Dt_2 soybeans in 1974

Source of variation	D.F.	Mean squares for Plant height	Seed quality	Seed size	Lodging	Yield
Replications	3	62.62	0.09	0.45	0.59	12.93
Row width (A)	4	152.33*	0.12	0.47	0.17	13.90
Density (B)	1	679.78**	0.01	1.09	0.41*	17.99
Plant type (C)	1	27863.11**	0.002	6.91	1.95**	0.01
A x B	4	59.97	0.05	2.44	0.27	60.05
A x C	4	121.42	0.07	1.19	0.02	25.44
B x C	1	16.20	0.00	0.70	0.35	2.75
A x B x C	4	18.62	0.11	1.29	0.09	14.01
Error	57	154.75	0.04	2.21	0.08	28.62

* Significant at 0.05 percent level

** Highly significant at 0.05 percent level

Table 17. Analysis of variance table for several plant characteristics of Clark 63 on beds with three rows in 1974

Source of variations	D.F.	Mean squares for: Height to first pod	No. of branches	Plant height	No. of nodes	No. of pods	Seed yield	No. of seeds	Seeds/ pod
Replications	3	0.73	0.22	138.30	2.08	147.66	321.04	11889.06	0.03
Row No. (A)	2	0.13	0.46	22.88	0.67	283.73*	857.38*	38918.38*	0.001
Density (B)	1	1.55**	13.50**	906.51**	0.11	433.50**	532.04*	44720.67*	0.02
A x B	2	0.34*	0.32	0.99	0.11	3.19	6.79	485.54	0.01
Error	15	0.06	0.19	95.17	0.95	29.51	179.28	6336.46	0.02

*Significant at 0.05 percent level

**Highly significant at 0.05 percent level

Table 18. Analysis of variance table for several plant characteristics of Clark Dt_2 on beds with three rows in 1974

Source of variation	D.F.	Mean squares for: Height to first pod	No. of branches	Plant height	No. of nodes	No. of pods	Seed yield	No. of seeds	Seeds/ pod
Replications	3	0.26	0.31	230.91	10.48	97.22	398.15	10785.82	0.03
Row No. (A)	2	0.04	0.03	55.52	0.81	128.25*	415.04*	14963.04*	0.007
Density (B)	1	0.03	7.71**	24.81	1.60	580.17**	2752.04**	88938.38**	0.004
A x B	2	0.006	0.27	27.52	0.007	42.07	147.54	9857.63	0.01
Error	15	0.11	0.15	45.17	0.89	25.05	152.87	4296.79	0.02

*Significant at 0.05 percent level

**Highly significant at 0.05 percent level

Table 19. Analysis of variance table for several plant characteristics of Clark 63 in beds with four rows in 1974

Source of variation	D.F.	Mean squares for: Height to first pod	No. of branches	Plant height	No. of nodes	No. of pods	Seed yield	No. of seeds	Seeds/ pod
Replications	3	0.91	0.80	667.07	4.03	52.10	274.13	4782.45	0.05
Row No. (A)	3	0.18	0.87*	10.25	0.58	307.21*	1432.54*	48005.36*	0.02
Density (B)	1	0.06	17.70**	6.85	13.78*	1341.36**	4278.13**	200186.28**	0.003
A x B	3	0.16	0.13	8.40	0.44	10.33	51.88	640.11	0.009
Error	21	0.18	0.17	216.13	2.17	38.71	173.01	6570.33	0.01

*Significant at 0.05 percent level

**Highly significant at 0.05 percent level

Table 20. Analysis of variance table for several plant characteristics of Clark Dt_2 on beds with four rows in 1974

Source of variation	D.F.	Mean squares for: Height to first pod	No. of branches	Plant height	No. of nodes	No. of pods	Seed yield	No. of seeds	Seeds/ pod
Replications	3	0.13	0.34	234.04	10.42	46.29	788.20	12570.78	0.02
Row No. (A)	3	0.26	0.68	20.24	0.37	200.14*	697.86*	24679.61*	0.04
Density (B)	1	0.02	6.30*	35.70	0.05	1531.81**	11362.78**	225288.28**	0.00
A x B	3	0.01	0.37	2.20	0.98	38.27	277.28	7548.95	0.02
Error	21	0.09	0.43	23.78	1.03	19.52	128.79	4700.85	0.03

*Significant at 0.05 percent level

**Highly significant at 0.05 percent level

Table 21. Analysis of variance table for several plant characteristics of Clark 63 on beds with five rows in 1974

Source of variation	D.F.	Mean squares for: Height to first pod	No. of branches	Plant height	No. of nodes	No. of pods	Seed yield	No. of seeds	Seeds/ pod
Replications	3	0.86	1.09	281.24	0.99	210.54	1401.29	37401.43	0.03
Row No. (A)	4	0.11	2.65*	52.84	6.97*	467.42*	2818.71*	146784.91*	0.02
Density (B)	1	0.02	14.64**	11.66	15.70*	3177.66**	8850.63**	522808.23**	0.002
A x B	4	0.03	0.57	28.71	2.36	396.76	52.94	1701.91	0.01
Error	27	0.07	0.31	300.21	2.43	157.90	319.03	13472.63	0.02

*Significant at 0.05 percent level

**Highly significant at 0.05 percent level

Table 22. Analysis of variance table for several plant characteristics of Clark Dt_2 on beds with five rows in 1974

Source of variation	D.F.	Mean squares for: Height to first pod	No. of branches	Plant height	No. of nodes	No. of pods	Seed yield	No. of seeds	Seeds/ pod
Replications	3	0.17	0.49	347.84	7.12	303.41	101.16	13837.43	0.08
Row No. (A)	4	0.01	0.55	3.68	0.31	281.75	1525.25*	56580.28*	0.14*
Density (B)	1	0.001	11.45**	177.24*	2.81*	1204.51*	8555.63**	340587.03**	0.01
A x B	4	0.11	0.30	6.85	0.14	145.22	5.50	771.90	0.05
Error	27	0.12	0.21	44.76	0.68	152.12	298.68	8477.37	0.04

*Significant at 0.05 percent level

**Highly significant at 0.05 percent level

Table 23. Analysis of variance table for several plant characteristics of Clark 63 on beds with six rows in 1974

Source of variation	D.F.	Mean squares for: Height to first pod	No. of branches	Plant height	No. of nodes	No. of pods	Seed yield	No. of seeds	Seeds/ pod
Replications	3	0.07	0.35	1485.09	13.02	122.55	1242.25	21426.19	0.05
Row No. (A)	5	0.10	1.74*	15.26	1.80	510.81*	1962.98*	79288.94*	0.04
Density (B)	1	0.63*	37.45**	2336.63*	10.18*	4122.55**	6678.80**	439875.52**	0.17
A x B	5	0.07	0.34	10.59	0.12	65.15	83.14	6400.57	0.02
Error	33	0.13	0.16	99.57	0.71	39.62	255.45	7019.28	0.02

*Significant at 0.05 percent level

**Highly significant at 0.05 percent level

Table 24. Analysis of variance table for several plant characteristics for Clark Dt_2 on beds with six rows in 1974

Source of variation	D.F.	Mean squares for: Height to first pod	No. of branches	Plant height	No. of nodes	No. of pods	Seed yield	No. of seeds	Seeds/ pod
Replications	3	0.49	0.84	238.41	5.28	61.81	835.63	17474.14	0.05
Row No. (A)	5	0.09	0.05*	65.74	1.15	896.59*	2274.07*	116584.28*	0.005
Density (B)	1	0.002	2.08*	66.27	0.03	1.20	35.02	10680.33	0.13*
A x B	5	0.05	1.51*	39.56	1.29	303.14	856.97	41816.53	0.005
Error	33	0.17	0.24	43.68	1.26	74.26	339.57	11161.37	0.02

*Significant at 0.05 percent level

**Highly significant at 0.05 percent level

Table 25. Analysis of variance table for several plant characteristics of Clark 63 and Clark Dt_2 soybeans in 1974

Source of variation	D.F.	Mean squares for: Height to first pod	No. of branches	Plant height	No. of nodes	No. of pods	Seed yield	No. of seeds	Seeds/ pod
Replications	3	0.40	0.09	115.28	1.49	3.21	3.19	86.17	0.03
Row width (A)	4	0.22	0.99*	161.16	0.67	50.20	2.83	144.86	0.02
Density (B)	1	0.18	7.75**	197.51	3.16	750.31**	138.34**	3949.45**	0.01
Plant types (C)	1	1.07**	0.21	22676.74**	139.66**	6.27	20.20	0.17	0.01
A x B	4	0.03	1.51*	37.64	1.64	148.14*	19.52	900.52	0.005
A x C	4	0.19	0.31	146.01	0.54	29.30	4.54	110.11	0.001
B x C	1	0.02	0.35	114.96	0.14	7.20	36.99*	135.46	0.02
A x B x C	4	0.11	3.81**	90.41	2.43	531.46**	54.87		0.05
Error	57	0.07	0.12	136.71	1.39	20.67	5.85		0.01

*Significant at 0.05 percent level

**Highly significant at 0.05 percent level

Table 26. Row width x density interaction on the yield, seed quality, lodging, no. of branches, pods per plant, seed yield per plant, seeds per plant of Clark 63 in 1974

Row width cm	Density in cm^2/plant	Yield Kg/ha	Seed quality	Lodging	No. of branches per plant	Pods/plant	Seed yield/plant (gms)	No. of seeds/plant
75	450	3110	1.7	2.3	1.4	55.2	19.7	127.9
75	225	2894	1.4	2.5	1.2	48.2	17.1	112.1
37.5	450	2731	1.5	1.9	1.3	52.1	19.0	123.2
37.5	225	2884	1.9	2.8	0.8	43.6	17.0	105.9
25	450	2727	1.5	2.3	2.7	56.7	20.7	136.4
25	225	2433	1.5	2.1	1.2	43.8	17.1	104.8
18.75	450	2538	1.7	2.0	1.4	42.4	15.0	98.4
18.75	225	2679	1.6	2.1	2.6	61.7	20.9	144.1
15	450	2174	1.8	2.0	2.6	56.5	19.6	130.4
15	225	2697	1.8	2.4	0.8	38.0	15.6	92.2

Table 27. Row width x density interaction on number of branches, nodes per plant, pods per plant, seed yield per plant and number of seeds per plant of Clark Dt_2 in 1974

Row width cm	Density in cm^2/plant	No. of branches per plant	No. of nodes per plant	Pods/plant	Seed yield/plant (gms)	No. of seeds per plant
75	450	1.7	20.3	53.9	20.4	127.4
75	225	1.2	18.2	44.7	17.7	104.7
37.5	450	1.8	19.9	51.7	21.1	126.9
37.5	225	0.6	19.4	41.9	16.7	102.7
25	450	2.3	19.7	53.8	22.8	131.8
25	225	1.3	19.6	40.6	14.4	98.3
18.75	450	2.1	19.8	59.1	24.3	141.6
18.75	225	1.1	19.3	44.8	16.9	104.8
15	450	1.2	18.9	44.5	17.2	102.0
15	225	2.5	19.8	57.6	20.2	136.0

Fig 1. The influence of row width on seed yield of Clark 63 and Clark Dt_2 in 1973 and 1974.

Fig 2. The influence of row width on the seed quality of Clark 63 and Clark Dt_2 in 1973 and 1974.

Fig 3. The influence of row width on the lodging of Clark 63 and Clark Dt_2 in 1973 and 1974.

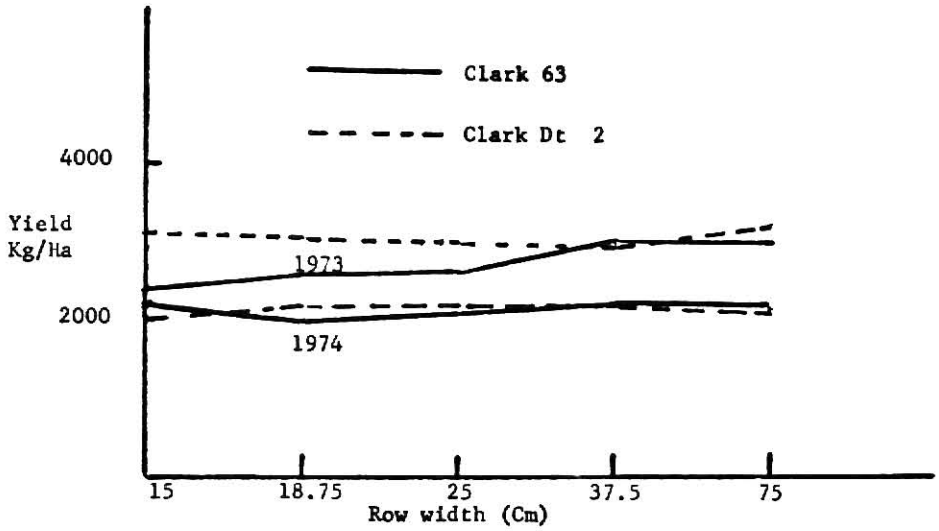


Fig. 1

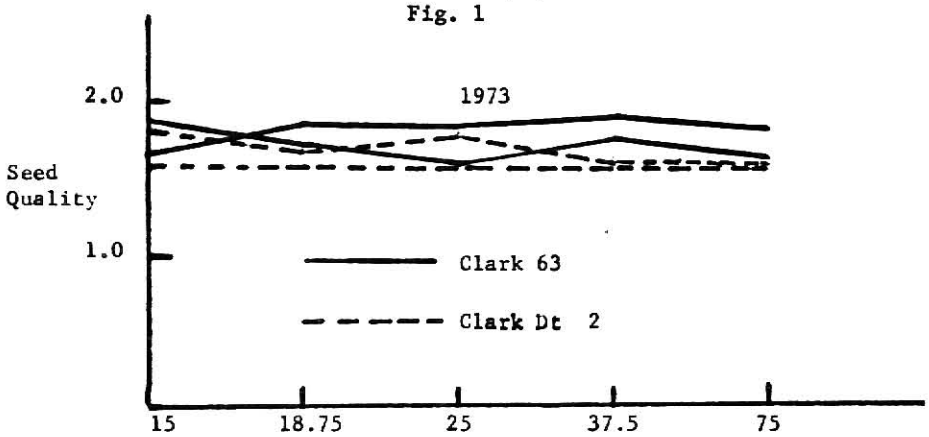


Fig. 2

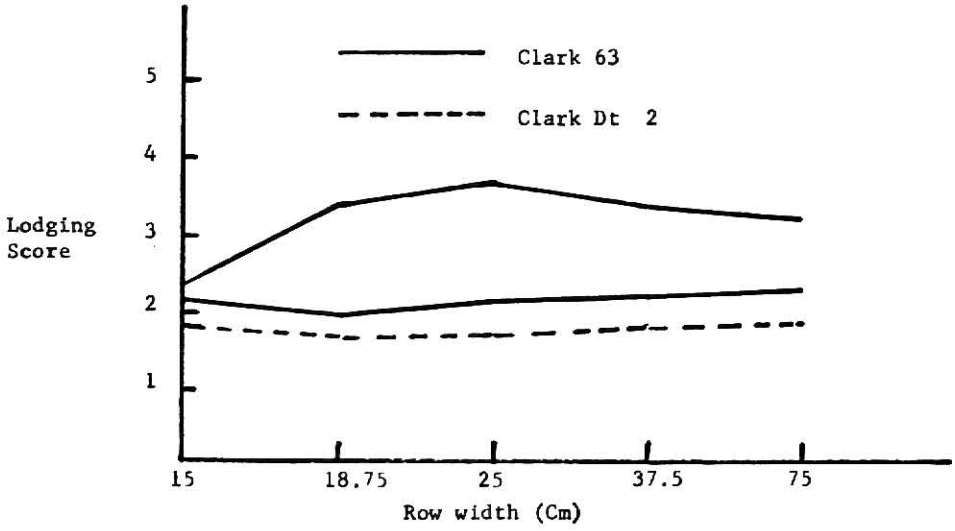


Fig. 3

Fig 4a. Influence of row number per bed on plant branching in beds with four and five rows.

Fig 4b. Influence of row number per bed on number of nodes per plant in beds with four and five rows.

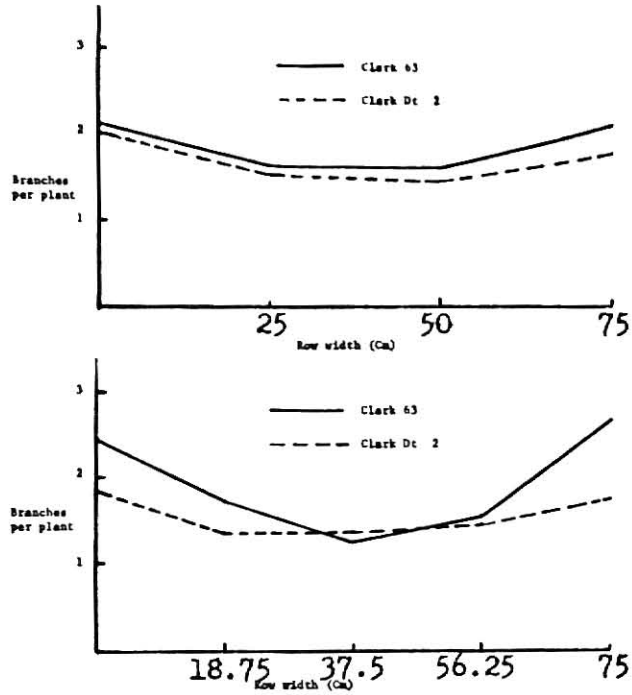

3
2
1
Branches per plant
Clark 63
Clark Dt 2
25
50
75
Row width (Cm)
3
2
1
Branches per plant
Clark 63
Clark Dt 2
18.75
37.5
56.25
75
Row width (Cm)

Fig. 4a

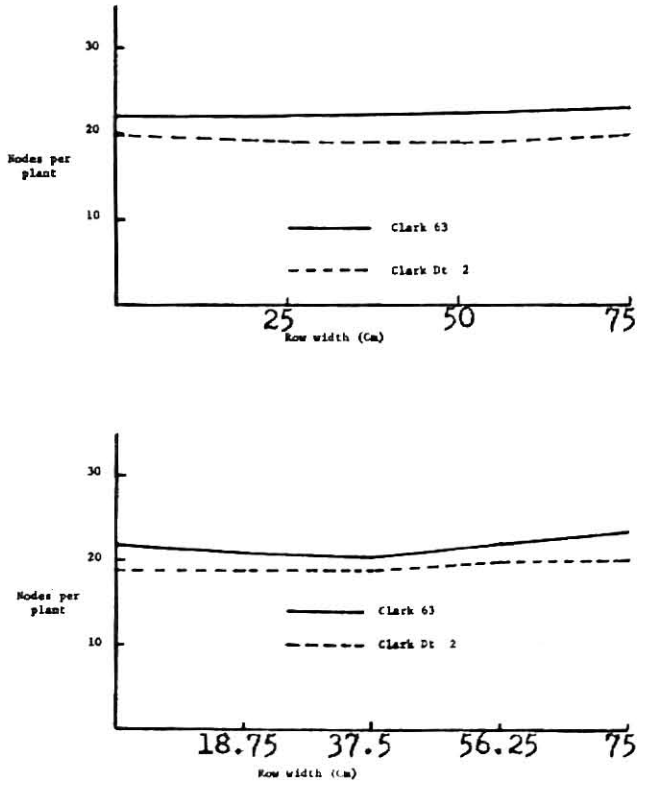
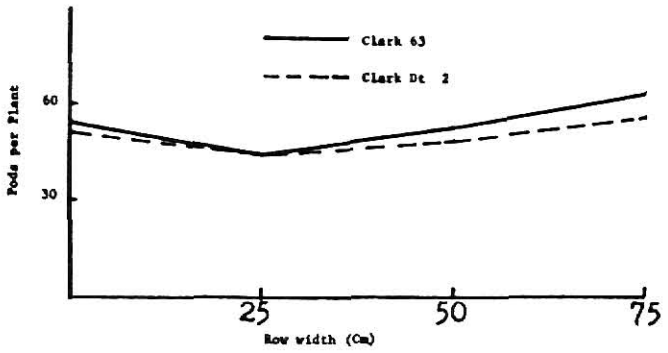

30
20
10
Nodes per plant
Clark 63
Clark Dt 2
25
50
75
Row width (Cm)
30
20
10
Nodes per plant
Clark 63
Clark Dt 2
18.75
37.5
56.25
75
Row width (Cm)

Fig. 4b

Fig 4c. Influence of row number per bed on number of pods per plant in beds with four and five rows.

Fig 4d. Influence of row number per bed on seed yield per plant in beds with four and five rows.


Clark 63
Clark Dt 2
Pods per Plant
60
30
25
50
75
Row width (Cm)

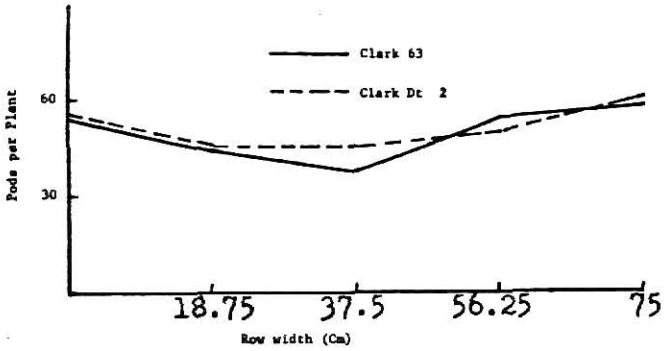
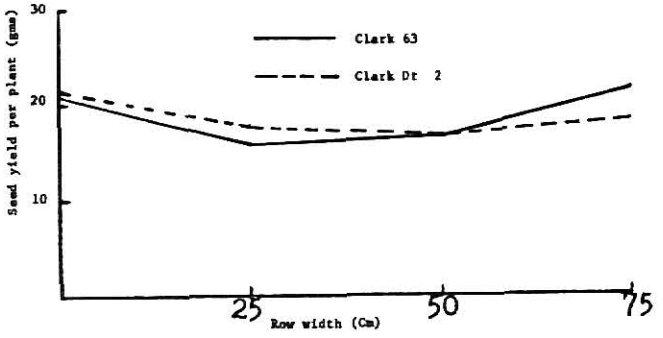

Clark 63
Clark Dt 2
Pods per Plant
60
30
18.75
37.5
56.25
75
Row width (Cm)

Fig. 4c


Clark 63
Clark Dt 2
Seed yield per plant (gms)
30
20
10
25
50
75
Row width (Cm)

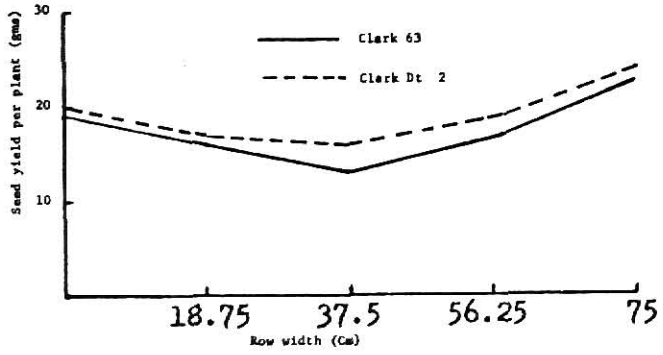
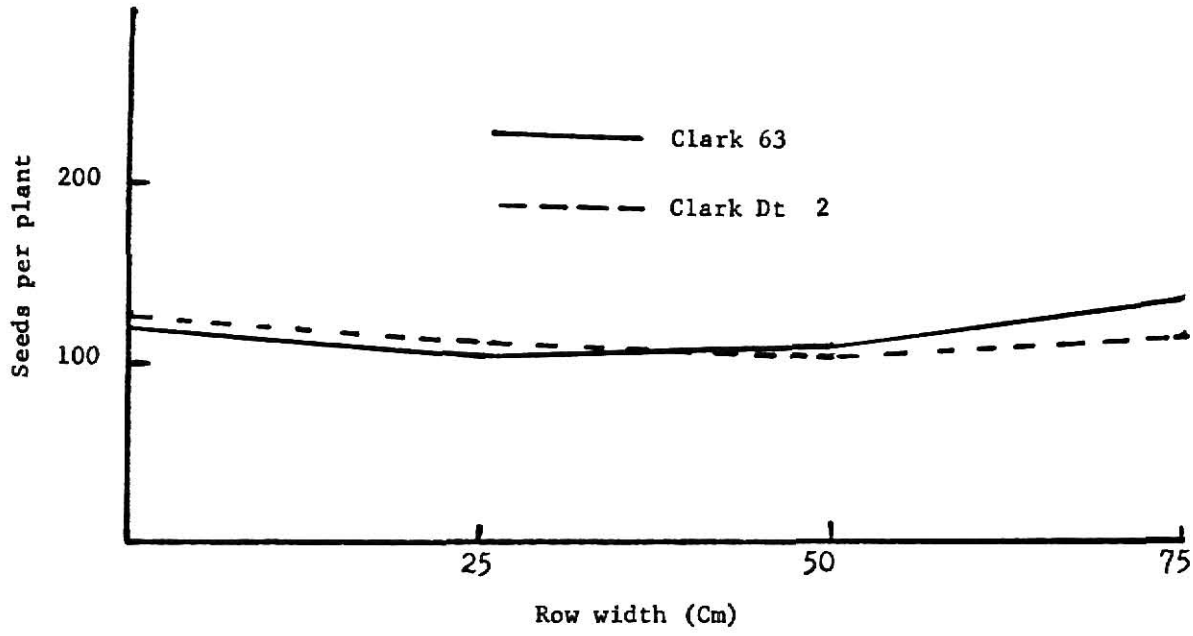

Clark 63
Clark Dt 2
Seed yield per plant (gms)
30
20
10
18.75
37.5
56.25
75
Row width (Cm)

Fig. 4d

Fig 4e. Influence of row number per bed on number of seeds per plant in beds with four and five rows.


Clark 63
Clark Dt 2
Seeds per plant
200
100
25
50
75
Row width (Cm)

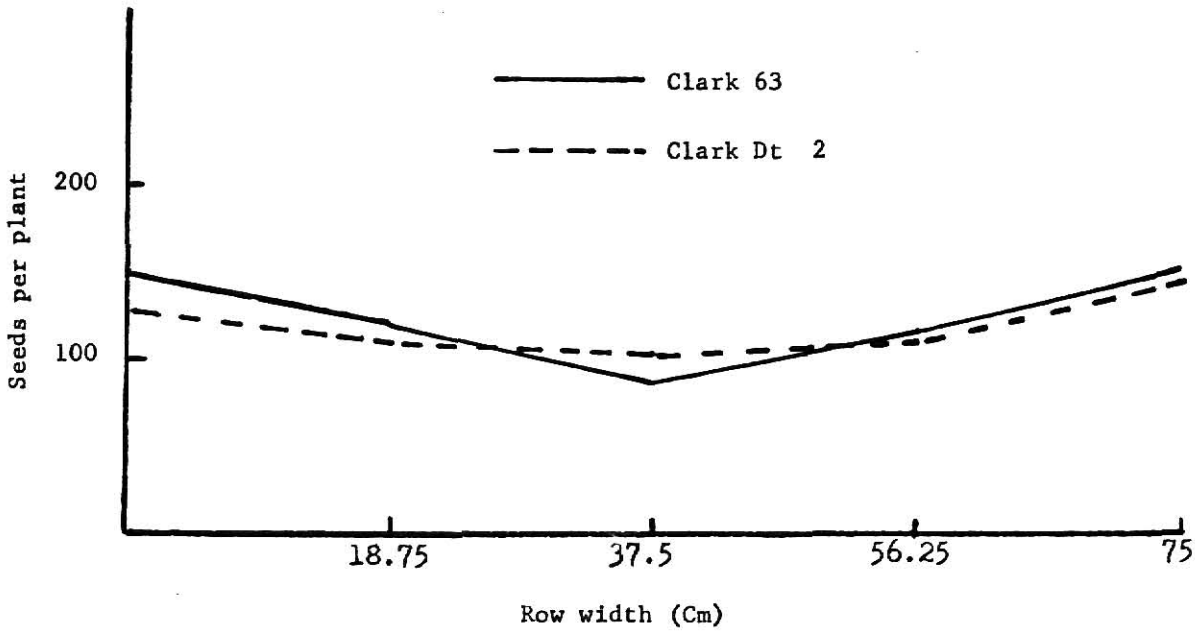

Clark 63
Clark Dt 2
Seeds per plant
200
100
18.75
37.5
56.25
75
Row width (Cm)

Fig. 4e

INFLUENCE OF ROW SPACING AND POPULATION DENSITY ON SEVERAL AGRONOMIC CHARACTERS OF TWO CLARK SOYBEAN ISOLINES

by

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B.Sc. Ahmadu Bello University, Zaria, Nigeria, 1972

AN ABSTRACT OF A MASTER'S THESIS

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Manhattan, Kansas

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Two Clark soybean isolines, Clark 63 an indeterminate type and Clark Dt_2, a semi-determinate type, were tested for two years, 1973 and 1974 under irrigation to evaluate their response to five row widths (75, 37.5, 25, 18.75 and 15 cm) and two population densities (450 and 225 sq. cm per plant).

Characters measured were plant height, seed quality, seed size, seed yield, height to first pod, number of branches, number of nodes, number of pods, seed yield per plant, number of seeds per plant and seeds per pod.

Row width did not influence the height of plant types either year. Clark 63 was significantly taller than Clark Dt_2. There was a marked reduction in the height of both isolines in 1974 due to red spider mite attack and adverse weather conditions.

Row width influenced seed quality of Clark 63 but not Clark Dt_2. However row width did not influence seed size, number of nodes, seed yield, number of seeds per plant and seeds per pod for both isolines.

There were significant differences between row widths for Clark 63 yields in 1973. The yields were highest from the 75 and 37.5 cm row widths. Clark 63 seeds were significantly better in quality from the narrower row widths (25, 18.75 and 15 cm) than from the wider row widths in 1974. Clark 63 lodged significantly more in the wider row widths than in the narrower row widths.

Clark Dt_2 branched more in the 15 cm row width while Clark 63 produced more branches in the 18.75 cm row width. The two isolines produced significantly more pods from the 18.75 cm row than from other row widths.

Plants of Clark 63 produced their first pods highest in 15 cm rows and Clark Dt_2 produced its first pods highest in 75 cm rows.

In comparing the yields of individual rows on a bed, both plant types gave higher yields from the outside than from the center rows. Also on beds with three, four, and five rows, plants in the center row were shorter, produced their first pods nearer to the ground, had fewer nodes, branched less, produced fewer pods per plant and gave lower seed yields per plant than from the outside rows.

On beds with six rows, plants were taller in the inner rows, first pods were higher on the outside rows and plants from the center rows branched less, had fewer nodes per plant, fewer pods per plant, produced lower seed yields and seeds per plant.

High population density resulted in taller plants, a greater degree of lodging, higher first pods, less branching, fewer nodes, fewer pods, smaller seed yield and less seeds per plant for both isolines in 1974.

On beds with five rows, Clark Dt_2 branched more at the lower density whereas Clark 63 branched more at the higher density. The same observations were made with regard to pods, seed yield, and number of seeds per plant.

On beds with six rows, Clark 63 branched more at the lower density, while Clark Dt_2 branched more at the higher density. Clark 63 produced more pods at the lower density than at the higher density, but number of pods per plant of Clark Dt_2 was not influenced by population density. Other yield components of the two isolines were not influenced by plant density.

Plants of Clark 63 were taller, lodged more, produced smaller

seeds in 1973, had more branches, and more nodes than Clark Dt_2. On the other hand Clark Dt_2 produced more seed yield in 1973, bore its first pods higher above ground and produced higher seed yield per plant than Clark 63.

Row width x density interaction was significant for both isolines on number of branches, number of pods, seed yield, and seeds per plant. The interaction between row width and population density was significant for Clark Dt_2 on nodes per plant, seed quality, and lodging. It was also significant for average seed yield for Clark 63.