FIELD PLOT TECHNIQUE AND PLANT CHARACTERISTIC STUDIES WITH VARIETIES OF CASTOR PLANTS,

Ricinus communis Linn.

FIELD PLOT TECHNIQUE AND PLANT CHARACTERISTIC STUDIES OF CASTOR PLANTS, *Ricinus communis* Linn.

By

JAMES H. GARDENHIRE

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Chairman, Thesis Committee

Member of the Thesis Committee

Head of the Department

Dean of the Graduate School

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INTRODUCTION

The size of plot needed for securing accurate data with experimental work on the relative yield of castor plants is essential in the breeding and development of the crop. Castor plant breeding and testing have been undertaken in Oklahoma, therefore, it has become necessary to obtain these data. It would also be helpful in a breeding program to obtain data on the characteristics and growth behavior of varieties of the plant when grown under Oklahoma conditions.

The castor plant, Ricinus communis Linn., seed from which castor oil is extracted, is a non-leguminous perennial and is a native of Africa or India. In its native habitat it attains considerable size, as much as 30 or 40 feet in height. In Oklahoma, as in other parts of the United States subject to freezing, the plant behaves as an annual. In southern parts of California, Texas, and Florida where temperatures remain above freezing, the plants survive the mild winters and grow for many years.

The plant has often been called a "bean", but it does not have the ability, in association with any bacteria, to change atmospheric nitrogen into a form usable by plants, as is the case with true bean plants and other legumes. For this reason, the castor plant should not be considered as a soil-building plant.

During the last half of the 19th century, castor seed were grown commercially in parts of Illinois, Oklahoma, Missouri, and Kansas. The growing of these seed was the chief money crop in parts of those states.

Shortly after 1900, crude oil production and the importation of castor seed from Brazil and India practically eliminated this crop from American Agriculture.

During World War I, castor plants were grown, because of an increased demand for a more suitable oil for air craft engines. Several thousand tons of castor seed were produced in the southern states during 1918-19.

Following the outbreak of World War II, castor oil was again in demand for the manufacture of water proof paints, and as oil for recoil mechanisms of naval guns, investigations were therefore begun of the possibility of producing castor seed in the United States.

Castor oil is also used in the manufacture of oil cloth, linoleum, artificial leather, hydraulic fluids, plastics, and hydrated oils for paints and varnishes.

The present varieties of castor plants require at least a 160 day frost-free growing season and at least 15 inches of rainfall from April to September for best growth and production. Castor seed can be grown safely in a rainfall belt where the average is 15 to 37 inches annually. In areas of higher rain fall the plants are attacked by the Gray Mold, Sclerotina ricini Godfrey. This mold by destroying the inflorescence greatly reduces the yield. In other humid areas of the United States, the plants are attacked by a disease known only by its generic name Alternaria. Alternaria ricini (Yoshii) Hansford, attacks seedlings, inflorescences and seed capsules, reducing both yield and quality of seed. Alternaria has been found at the Oklahoma Agricultural Experiment Station but little or no loss has been reported.

Light textured, well drained soils are the most desirable for castor seed growing. The light textured soils warm up quickly in the spring and permit good root spread and aeration. The soil should possess a moderate well-balanced fertility. Soil with high nitrogen content gives rank vegetation growth with no important increase in seed yield.

The region found most suited to castor seed growing includes Kansas, Missouri, Arkansas, Oklahoma, Northern Texas, and Mississippi, Northeastern New Mexico, Southeastern Nebraska, and Southern Illinois.

The possibility of growing castor seed in those areas are chiefly limited by the lack of machines for harvesting. At present the larger part of the crop must be harvested by hand. Mechanical harvesters are now being manufactured on a limited scale. A significant advancement in the castor seed industry.

The purpose of this investigation is to determine the size of plot for experimental use, and to obtain data on date and rate of blooming, height of plant at maturity and number of spikes and capsules per plant as an aid in breeding for yield and machine harvesting.

REVIEW OF LITERATURE

Plant Characteristics

From the 1942 Cooperative Regional Test (21)[1] the results from Stillwater, Oklahoma, on height of plant for Conner, Kentucky 38, and Kansas Common were 71, 56, and 56 inches, respectively. The average number of spikes per plant for the 3 varieties were: Conner 2.6; Kentucky 38, 4.4; and Kansas Common 6.2.

The mean height for each of the 6 varieties for the 48 stations reporting were: Conner and Doughty 11, 76 inches; Kentucky 38 and U. S. 4, 62 inches; and U. S. 7 and Kansas Common 61 inches (21).

In the 1943 test the average plant height of Conner, Doughty 11, and Kentucky 38 were 75, 74, and 60 inches respectively (22).

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[1] Numbers in parenthesis refer to "Literature Cited", p. 22.

Yield Data

In the castor plant variety test in 1941 (20) the variety Conner had the highest yield in 16 of the 63 tests conducted. The Conner stands were generally poor because of low viability of the seed. Kansas Common was grown in only a small number of tests and had the highest yield in 5 of the tests.

The mean yield from all tests was 792 pounds per acre. This yield was from 63 tests conducted in 16 states.

In Arizona where the tests were grown under irrigation Conner produced 1590 pounds and Kentucky 38 produced 1700 pounds per acre.

In 1942 (21) the mean yields for Kansas Common, Kentucky, and Conner was 908, 886, and 941, pounds, respectively. The mean yield per acre for Conner, Kentucky 38, and Kansas Common at Stillwater, Oklahoma in 1942 was 782, 674, and 765 pounds, respectively. The varieties Conner and Kentucky 38 have been very uniform for the past several years.

In 1943 (22) a total of 53 tests were conducted in 15 states. In 48% of the tests in which Conner occurred, it yielded either the highest or within the 5% range of the highest. Kentucky 38 was high in 31% of all tests in which it occurred. The mean yield for Conner at Stillwater, Oklahoma in 1943 was 432 pounds per acre.

Size of Plot

Numerous plot technique studies have been made with various crops and trees, to determine the most efficient size of plot for experimental purposes. No previous work has been done on the optimum size of plot for use in experimental work with castor plants.

At the present time field plots and nursery plots vary from 1/1000 to 1/10 of an acre in size depending on the crop under investigation. Field plots are larger and generally adapted to the use of farm machinery. Field plots usually range from about 1/100 to 1/10 of an acre in size (5).

The object of most field plot experiments is to compare the performance of various crops in such a manner that the results will be applicable to farm practice (7). There are several factors to consider in determining the size of plot for experimental use. Some of these are: kind of crop, number of treatments or varieties, amount of seed and land available, kind of machinery, and amount of funds available for the experiment (9).

Day (3) states that increasing the size of the plot to at least 1/20 of an acre, and probably much beyond, reduces variation. Day (3) also states that the most effective replicated block from the point of view of shape is one that is long and narrow and has its greatest dimension in the direction of greatest soil variation.

Jardine (6) states that size of plot and replication are useful for giving a greater precision in experiments and furnishes a means whereby the experimenter can determine what reliance can be placed upon the data and conclusions of the experiment.

In field tests with cotton Ligon (11) found that the rows need not be larger than 100 feet in length for determining yield. The plots are three rows in which the central row only, is harvested for field data. Rows of greater length resulted in a reduction in error but not in proportion to the amount of land used. The probable error for a single row 100 feet long was 6.05% for 1 replication.

Siao (15) working with cotton in China, states that wide plots are more desirable than long narrow plots. The coefficient of variability decreased from 14.05% to 9.86% when the plot was increased from 1 to 8 rows.

The size of plot for soils and fertilizer tests should be 1/10 to 1/20 of an acre in size and the plots should be long and narrow (14). The long narrow plots are more adapted to farm machinery.

Klages (8) working in Oklahoma, with sorghum found that single row plots replicated frequently enough will give reliable results as will plots with a larger number of rows replicated less frequently. In the utilization of single row plots care must be exercised in the selection of varieties to grow next to each other. Extreme differences in growing habits must be avoided.

Stephens (16) working with sorghum in Texas found that 3 or 4 replications of 1/40 to 1/80 of an acre plots will give results sufficiently reliable for ordinary sorghum tests. The error of a single plot 1/800 of an acre was 10.67% of the mean. As the plot size was increased from 1/800 to 1/20 acre in size the error was reduced from 10.67% to 3.27% of the mean. This was a reduction in error of 60%.

The most satisfactory length of plot for sorghum testing appears to be about 8 rods long (18). Moreover, long narrow plots are more convenient to harvest. Increasing the plot from 1/400 to 1/25 of an acre reduced the probable error 54.8%. Below 1/25 of an acre the probable error dropped very slowly. Plots 8 rods long and 4 rods wide reduced error to 4.07 bushels per acre.

Li and others (10) state that plots 2 rows wide and 15 feet in length proved most efficient in millet. Maintaining the same width plot but increasing the length to 30 feet where area is not a limiting factor seems to be very satisfactory. Increasing the width of plots from 2 to 5 rows results in some reduction in standard error and a further increase to 10 rows also results in a reduced standard error but not in proportion to the area of the land used.

Bryan (2) compared open pollinated varieties with inbred lines. The open pollinated varieties required twice as much land as did the inbreds for the same degree of precision. He concluded that 16 hill plots approached the smallest practical size. The Nebraska Station, according to Leonard and Clark (9) used 4 row plots, 12 hills long with the 2 center rows being harvested for yield. At the Oklahoma Agricultural Experiment Station (1) single rows 20 hills long are being used. The minimum standards recommended by Piper and Stevenson (13) for corn was 5 rows each of 25 hills or 5 rods long.

Odland and Garber (13) found that 16 feet plots in single rows replicated 3 times were most satisfactory for soybeans when rows were spaced 30 to 32 inches apart. Both accuracy and land economy were considered. The greatest amount of reduction resulted when the length of row was increased from 8 to 16 feet in length.

When the yield from a small number of plants is used as a measure of differences in plots there may be an error caused by a greater or lesser growth in certain plants not due to the treatment, but to the inherent property of certain individuals (12).

In 1942 (21) the size of plots used for castor plants in Cooperative Regional castor seed tests were 4 rows by 20 hills with 4 replications. The center rows were harvested for yield data.

Domingo and Crooks (4) used 4 rows by 20 hills with 4 replications in rate and date of planting tests. The 2 center rows were used for field data.

Taylor (19) states the size of plots should vary inversely with degree of uniformity of the soil. The less general uniformity of the soil the larger the plots should be and greater the uniformity the smaller they may be.

According to Leonard and Clark (9) Smith compared the coefficients of variability of different crops for a standard 1/40 acre plot. The crops fell approximately into 3 groups: (1) wheat, sugar beets, soybeans, and forage sorghum were less variable; (2) corn, potatoes, and cotton were in intermediate; and (3) fruit trees were the most variable.

It should be kept in mind that plot size varies with the crop, there being no one size for all crops on all soils.

MATERIAL AND METHODS

The experiment was conducted in 1948 on a kirkland silt loam soil on the Oklahoma Experiment Station at Stillwater, Oklahoma. No fertilizer had been applied to the plot previous to the experiment. The seed were obtained from Beltsville, Maryland, for the Regional castor plant variety test.

The 9 varieties used in the experiment were:

No. 71	N51-1-1	Kansas Common
No. 72	N108-3	Conner
No. 93	N201-2	Kentucky 38

The rows extending from northwest to southeast were planted April 5, 1948, and emerged April 12, 1948. The 9 varieties were planted in a randomized block design with 4 replications. The rows were spaced 42 inches apart and there were 12 hills spaced 24 inches apart in each row. There were no alleys between replications and varieties. Border rows of Conner were planted along each side of the replications. The seed were planted at the rate of 3 seed per hill and were thinned to 1 plant per hill when they attained a height of approximately 10 inches.

The first bloom appeared on the variety, Kansas Common on May 28, 1948. Each succeeding day during the pollination season the plants of each variety were checked for blooms until all plants in the experiment had bloomed.

Near harvest time the height of each plant was recorded. This measurement was made from the base to the highest point of the plant.

The first harvest was begun on August 23, 1948, and was finished September 1, 1948. In harvesting, the end plant from each row was discarded to eliminate border effect. Each row was individually harvested and the seed placed in separate sacks. These sacks were placed in a shelter and allowed to air dry for several days.

On September 4, 1948, each sack of seed was weighed on gram scales and the weights recorded.

On October 18, 1948, the plants were killed by the first frost and the second harvest was begun on October 19. The seed were handled in the same manner as for the first harvest.

While harvesting the plants the number of spikes per plant and the number of capsules per spike were recorded for each plant for all rows of each of the 9 varieties.

The hulling percent for each variety was obtained by taking a 500 gram sample, hulling the seed by a hand huller, and determining the hulling percent. This percentage was used in converting the yield of seed per row to pounds per acre of hulled seed.

The yields of each of the 9 varieties of the regional castor plant test was determined by using the yield of the 2 center rows for each variety.

The rows of each variety in each replication, reading from left to right were numbered 1 through 4.

The yield per acre from rows 1 and 4, were made into one unit plot and the yield per acre of rows 2 and 3 were made into one unit plot. These plots were then analyzed by analysis of variance to test for differences between the plots.

Since there was no significant difference between the yields of the 2 middle rows and the 2 outside rows, the yields per acre for 1 row plots, 2 row plots, and 4 row plots were determined. The yield of row number 1 for each variety and in each replication was used in determining the yield for the 1 row plots. For the 2 row plots, rows 2 and 3 and for the 4 row plots all 4 rows were used. These three plot sizes were then analyzed by the analysis of variance to test for significance for the 3 plot sizes.

RESULTS AND DISCUSSION

Yield Test

The growing season at Stillwater, Oklahoma, in 1948, was a favorable season for the production of castor seed. The total number of days in the growing season was 196 days.

The yields were somewhat altered by a hail storm which occurred on August 9, 1948. The damage was estimated for the entire block, which was very uniform throughout the plots. The leaves were more severely damaged than the spikes. On August 12, slight damage was caused by high winds.

The yields per acre and the hulling per cent for the 9 varieties are given in Table 1. The highest yielding variety was N1C8-3, which yielded 1,134.81 pounds per acre, with a hulling percent of 72.8%. The lowest yielding variety was No. 72, which yielded 720.58 pounds per acre with a hulling per cent of 72.6%.

The hulling per cent for each of the 9 varieties were rather uniform.

Table 1.—Average yield of hulled seed per acre and hulling percent for 9 varieties of castor plants at Stillwater, Oklahoma, in 1948.

Variety	Yield lbs/A	Hulling %
No. 71	912.31	74.8
N51-1-1	746.99	68.4
No. 72	720.58	72.6
No. 93	754.65	74.4
Kansas Common	1,016.75	73.6
Conner	924.86	71.8
Kentucky	858.78	73.8
N108-3	1,134.81	72.8
N201-2	999.38	73.0

the highest being No. 71, with 74.8% and the lowest N51-1-1, with 68.4%.

Three of the varieties which were used in the 1947 test were also grown in the 1948 yield test. These varieties were: Conner, No. 71, and No. 93. The yield for Conner, No. 71, and No. 93 in the 1948 yield test were 924.86, 912.31, and 720.58 pounds per acre for the 1947 yield test.

An F value of 3.85 was obtained in variety comparisons and since 2.89 is the value of F at the 1% level, there is a significant difference between the variety yields which is indicated by the varying yields shown in Table 1.

The least significant difference at the 1% level was 322.43 pounds, and the difference between the high and low yielding variety was 414.23 pounds per acre.

Date of Bloom

The average date of bloom for each of the 9 varieties is given in Table 2. The first blooms appeared 53 days after planting on the varieties Kansas Common, No. 93, N108-3, and N201-2. The average date of bloom for Kansas Common was 57.21 ± 2.94 days. The latest variety to bloom was No. 72, which had an average of 72.19 ± 11.90. There were some variable plants in this variety which were very late in blooming causing the large standard deviation. One plant approached the flowerless type plant which bloomed 101 days from planting. The flowerless type plants grow throughout the season and fail to produce any spikes. This may possibly be due to the lack of purity of the seed. Conner being a late variety had an average of 71.51 ± 2.70 days. N51-1-1 had an average of 66.00 ± 9.60 days from date of planting. There were no variable plants in this variety that were late in blooming. The apparent explanation for the large standard deviation for this variety is the large span of blooming for the individual plants.

Table 2.—Mean number of days from date of planting till date of bloom for 9 varieties of castor plants at Stillwater, Oklahoma, in 1948.

Variety	Number of Days
No. 71	58.68 ± 2.37
N51-1-1	66.00 ± 9.60
No. 72	72.19 ± 11.90
No. 93	58.15 ± 3.78
Kansas Common	57.21 ± 2.94
Conner	71.51 ± 2.70
Kentucky 38	58.48 ± 1.19
N108-3	58.44 ± 2.90
N201-2	57.95 ± 2.93

Spikes and Capsules

The average number of spikes per plant and the average number of capsules per spike are given in Table 3. No. 93 produced the greatest number of spikes per plant with an average of 13.44 spikes with an average of 6.66 capsules per spike. Although No. 93 produced the greatest number of spikes it ranked 8th in total yield per acre. N108-3 produced 13.19 spikes with an average of 10.78 capsules per spike. This compares favorable with the fact that N108-3 was the highest yielding variety. This variety is a bushy type plant that produced many small to medium spikes.

Conner produced the greatest number of capsules per spike with an average of 18.70, but produced only 3.05 spikes per plant. Conner is an erect upright growing plant which produces one main spike and several smaller ones. No. 72, the lowest yielding variety, produced 4.73 spikes per plant and 15.66 capsules per spike. The seed of this variety is somewhat smaller which reduces the total pounds of seed.

Height of Plant

The mean height of plant at maturity for each of the 9 varieties is given in Table 4. Conner being the tallest variety had an average height of 54.46 ± 8.06 inches, as compared to 71 inches for this variety in the 1942, test at Stillwater, Oklahoma. No. 93 and N201-2 were the shortest varieties with an average height of 34.27 ± 3.79 and 34.93 ± 5.89 inches, respectively. These varieties are the dwarf bushy type of plants. Kansas Common and Kentucky 38 had an average height of 40.61 ± 7.42 and 45.89 ± 6.35 inches, respectively, as compared to 56 for each in the 1942 Cooperative Regional Test.

Table 3.—Mean number of spikes per plant and mean number of capsules per spike for 9 varieties of castor plants at Stillwater, Oklahoma, in 1948.

Variety	Spikes per Plant	Capsules per Spike
No. 71	11.66	6.92
N51-1-1	10.89	9.60
No. 72	4.73	15.66
No. 93	13.44	6.66
Kansas Common	8.13	9.01
Kentucky 38	6.30	9.82
N108-3	13.19	10.78
N201-2	9.33	10.42
Conner	3.05	18.70

Table 4.—Mean plant height for each of the 9 varieties of castor plants in the variety test at Stillwater, Oklahoma, in 1948.

Variety	Height of plant at maturity in inches
No. 71	38.21 ± 7.16
N51-1-1	40.65 ± 9.15
No. 72	50.26 ± 9.49
No. 93	34.27 ± 3.79
Kansas Common	40.61 ± 7.42
Conner	54.46 ± 8.06
Kentucky 38	45.89 ± 6.35
N108-3	44.81 ± 7.30
N201-2	34.93 ± 5.89

Border Effect

The analysis of variance for comparing the 2 outside rows against the 2 inside rows is given in Table 5. The total yield from rows 2 and 3 were higher than from rows 1 and 4. This may possibly be due to several plants being destroyed in row 4 of plots 2, 11, 20, and 29, during cultural operations. The plants were later replanted. However, in the analysis of variance for border effect, an F value of 1.31 was obtained and, as 4.03 is the required value of F at the 5% level, there is no significant difference between the yield of the 2 outside rows and the 2 inside rows of the 4 row plot.

An F value of 2.89 was obtained for replications and as 2.79 is the value of the required F at the 5% level, a significant difference between replications is indicated.

There was no significant interaction of varieties x plots; indicating the varieties apparently reacted the same in all four rows.

Size of Plot

The yield per acre for the 1, 2, and 4 row plots are presented in Table 6. The row data for each row are presented in Table 8 (appendix). There is an increase in replication totals which suggests that there is a soil gradient extending from northwest to southeast. If the increase in replication totals is due to the soil gradient, the greatest dimension of the plot was in the direction of the greatest soil variation.

The analysis of variance for test of significance for plot size is presented in Table 7. An F value of 2.31 was obtained in plot size comparisons and as 3.11 is the required F value at the 5% level, there is no significant

Table 5.—Analysis of variance comparing the 2 outside rows against the 2 inside rows of a 4 row plot of castor plants in the variety test at Stillwater, Oklahoma, in 1948.

Source of variations	Degrees freedom	Sum of squares	Mean square	F
Total	71	2,790,897.76		
Replications	3	251,417.85	83,805.95	2.89*
Varieties	8	892,452.60	111,556.57	3.85**
Plots	1	38,222.41	38,222.41	1.31
Var. x Plots	8	130,019.99	16,252.49	0.560
Error	51	1,478,785.10	28,995.79	

* Significant at the 5% level.

** Significant at the 1% level.

Table 6.—Yields per acre of hulled seed from 1, 2, and 4 row plots for each of the 9 castor varieties grown at Stillwater, Oklahoma, in 194[illegible].

Size of Plot	Variety	Replication I	II	III	IV	Variety Total
1-row	No. 71	8[illegible].18	1,186.9[illegible]	707.50	805.25	3,532.86
	N51-1-1	5[illegible]7.38	919.38	1,2[illegible]7.12	910.51	3,664.39
	N201-2	8[illegible]1.[illegible]7	885.81	1,117.40	1,072.06	3,956.62
	No. 93	[illegible]01.49	66[illegible].05	890.17	898.17	2,939.88
	No. 72	87[illegible]	1,0[illegible]9.60	939.69	908.07	3,726.17
	Kansas Common	8[illegible]5.51	1,057.97	1,007.59	879.35	3,830.42
	Conner	9[illegible]1.09	1,09[illegible].12	6[illegible].60	1,161.67	3,936.28
	Kentucky 38	8[illegible]0.26	[illegible]45.01	1,166.48	927.67	3,747.42
	N108-3	761.07	1,146.15	1,114.42	1,449.66	4,471.30
	Total	7,074.86	8,846.02	8,882.05	9,012.41	33,815.34
2-row	No. 71	612.08	821.16	1,061.26	1,156.68	3,651.18
	N51-1-1	461.82	699.69	938.53	891.03	2,991.07
	N201-2	940.32	999.47	1,028.90	1,026.63	3,995.32
	No. 93	638.90	613.49	888.91	884.28	3,025.58
	No. 72	731.87	758.98	634.74	756.72	2,882.31
	Kansas Common	1,012.17	1,122.09	1,140.42	792.38	4,067.06
	Conner	969.55	777.47	902.53	1,042.74	3,692.29
	Kentucky 38	867.96	900.11	693.45	978.19	3,439.71
	N108-3	1,214.12	1,075.72	1,041.99	1,205.03	4,536.86
	Total	7,448.79	7,768.18	8,330.73	8,733.68	32,281.38
4-row	No. 71	664.45	916.77	784.31	1,020.53	3,386.06
	N51-1-1	479.24	748.88	1,018.34	774.48	3,020.94
	N201-2	934.64	950.59	1,025.50	823.35	3,734.08
	No. 93	530.10	604.18	842.61	872.21	2,849.10
	No. 72	740.91	899.03	725.10	772.53	3,137.57
	Kansas Common	896.98	1,149.57	966.36	769.43	3,782.28
	Conner	947.21	777.43	843.33	1,083.48	3,651.45
	Kentucky 38	843.85	789.82	859.93	991.96	3,485.56
	N108-3	975.13	993.24	1,172.18	1,269.59	4,410.14
	Total	7,012.45	7,829.51	8,237.66	8,377.56	31,457.18

Table 7.—Analysis of variance of 3 sizes of plots used in a variety test of 9 varieties of castor plants at Stillwater, Oklahoma, in 1948.

Source of Variation	Degrees Freedom	Sum of Squares	Mean Square	F
Total	107	3,656,801.84		
Plot Sizes	2	80,449.13	40,224.56	2.31
Varieties	8	1,249,529.03	156,191.13	9.00**
Replications	3	454,729.43	151,576.48	8.73**
(Var. x Sizes)	16	149,783.57		
(Reps. x Sizes)	6	71,821.47		
Error	94	1,650,489.21	17,345.48	

** Significant at the 1% level.

difference between the 3 plot sizes used in these comparisons. The results indicate that in castor plant comparisons 1, 2, or 4 row plots 12 hills long may be used with equally reliable results.

An F value of 8.73 was obtained for replications and as 4.20 is the value of F required at the 1% level, a highly significant difference was found between the replications.

An F value of 9.00 was obtained in variety comparisons indicating significance at the 1% level.

SUMMARY AND CONCLUSIONS

Size of plot and plant characteristic studies for castor plants were conducted at the Oklahoma Agricultural Experiment Station in Stillwater, Oklahoma, in 1948, as an aid in breeding for yield and machine harvesting.

The average date of bloom, average number of spikes per plant, average number of capsules per spike and height of plant at maturity were studied.

No significant difference was obtained between the yields of the 2 outside rows and the 2 inside rows of a 4 row plot, indicating no appreciable increase in yield because of row position in the plot.

A significant difference was obtained for replications indicating an increase in yield possibly due to a soil gradient between replications.

A significant difference was obtained for varieties indicating a significant difference in yield for the 9 varieties tested.

No significant difference was obtained between the yields of 1, 2, and 4 row plots 12 hills long. This indicates that 1, 2, or 4 row plots may be used for experimental work with castor plants with comparable results.

LITERATURE CITED

1. Brooks, J. S. and Chessmore, Roy A.
   Performance tests of corn. Oklahoma Agr. Exp. Sta. Bul. B-317. 1947.

2. Bryan, A. A.
   A statistical study of the relation of size and shape of plot and number of replications to precision in yield comparisons with corn. Ia. Agr. Exp. Sta. Rpt. for 1930-31. 1931.

3. Day, J. W.
   The relation of size, shape and number of replications of plots to probable error in field experimentation. Jour. Amer. Soc. Agron., 12:100-106. 1920.

4. Domingo, W. E. and Crooks, D. M.
   Investigations with the castor-bean plant. Rate of planting and date of planting. Jour. Amer. Soc. Agron., 37:812-820. 1945.

5. Hayes, H. K. and Immer, F. R.
   Field plot technique. Methods of plant breeding. First Edition. McGraw-Hill Book Company, Inc. New York and London. 1942.

6. Jardine, W. M.
   Size of plots for field experiments with crops. Bibliog. Amer. Soc. Agron., 9:402-405. 1917.

7. Kiesselbach, T. A.
   The mechanical procedure of field experimentation. Jour. Amer. Soc. Agron., 20:433-442. 1928.

8. Klages, K. H.
   Yield of adjacent rows of sorghums in variety and spacing tests. Jour. Amer. Soc. Agron., 20:582-599. 1928.

9. Leonard, W. H. and Clark, A. G.
   Size, shape and nature of plots. Field plot technique. Burgess Publishing Co. Minneapolis, Minn. pp. 141-153. 1946.

10. Li, H. W., Meng, C. J., and Liu, T. N.
    Field results in a millet breeding experiment. Jour. Amer. Soc. Agron., 28:1-15. 1936.

11. Ligon, L. L.
    Size of plot and number of replications in field experiments with cotton. Jour. Amer. Soc. Agron., 22:689-699. 1930.

12. Lyon, T. L.
    Some experiments to estimate errors in field plot experiments. Proc. Amer. Soc. Agron., 3:89-114. 1911.

13. Odland, T. E. and Garber, R. J.
Size of plot and number of replications in field experiments with soybeans. Jour. Amer. Soc. Agron., 20:93-108. 1930.

14. Piper, C. V. and Stevenson, W. H.
Standardization of field experimental methods in agronomy. Proc. Amer. Soc. Agron., 2:70-76. 1910.

15. Siao, Fu.
Uniformity trials with cotton. Jour. Amer. Soc. Agron., 27:974-979. 1935.

16. Stephens, J. C.
Experimental methods and the probable error in field experiments with sorghum. Jour. Agr. Res., 37:629-646. 1928.

17. Summerby, R.
A study of sizes of plots, number of replications, and the frequency and methods of using check plots in relation to accuracy in field experiments. Jour. Amer. Soc. Agron., 17:140-149. 1925.

18. Swanson, A. F.
Variability of grain sorghum yields as influenced by size, shape, and number of plots. Jour. Amer. Soc. Agron., 22:833-837. 1930.

19. Taylor, J. W.
The size of experiment plots for field crops. Proc. Amer. Soc. Agron., 1:56-58. 1907-09.

20. U. S. Bur. of Plant Industry, Soils, and Agricultural Engineering, Division of Drug and Related Plants. Results of the cooperative regional castor bean tests. Refer to D. R. P. 34. 1941.

21. ________________.
Results of the cooperative regional castor bean tests. Mimeographed. Refer to D. R. P. 35. 1942.

22. ________________.
Results of the cooperative regional castor bean tests. Mimeographed. Refer to D. R. P. 40. 1943.

A P P E N D I X

Table 8.—Yield per acre of hulled seed for individual rows in all replications for each of the 9 varieties in the castor plant variety test at Stillwater, Oklahoma, in 1948.

	ROW			
	1	2	3	4
		No. 71		
Reps. 1.	833.18	516.66	707.51	600.44
2.	1,186.93	706.75	935.58	837.83
3.	707.50	912.31	1,210.21	307.21
4.	805.25	1,117.12	1,196.25	963.51
		N51-1-1		
Reps. 1.	587.38	510.77	412.87	395.84
2.	919.38	820.53	578.86	676.76
3.	1,247.12	898.10	978.97	949.17
4.	910.51	872.55	910.55	404.36
		N201-2		
Reps. 1.	881.27	999.37	881.27	976.67
2.	885.81	1,185.81	813.13	917.61
3.	1,117.48	994.84	1,062.97	926.70
4.	1,072.06	867.64	1,185.63	168.08
		No. 93		
Reps. 1.	481.49	597.24	680.57	361.12
2.	662.05	606.50	620.39	527.79
3.	898.17	861.14	916.68	694.46
4.	898.17	787.06	981.51	824.10
		No. 72		
Reps. 1.	844.81	795.12	668.62	655.08
2.	1,043.60	840.30	677.66	1,034.56
3.	939.69	596.34	673.15	691.22
4.	908.07	668.62	844.82	668.62
		Kansas Common		
Reps. 1.	885.51	961.79	1,062.56	677.83
2.	1,057.97	1,163.31	1,080.87	1,296.13
3.	1,007.59	980.12	1,300.72	577.07
4.	879.35	838.13	746.54	613.72
		Conner		
Reps. 1.	991.89	1,018.70	920.40	857.85
2.	1,099.12	908.70	746.15	455.74
3.	683.60	982.96	822.11	884.65
4.	1,161.67	1,170.61	924.87	1,076.78
		Kentucky 38		
Reps. 1.	808.26	808.26	927.69	831.23
2.	845.01	831.23	969.00	514.05
3.	1,166.48	381.17	1,005.74	886.34
4.	927.67	978.19	978.19	1,083.81
		N108-3		
Reps. 1.	761.07	1,123.54	1,304.70	711.24
2.	1,146.15	983.05	1,168.79	674.99
3.	1,114.42	1,123.48	960.40	1,490.43
4.	1,449.66	1,177.85	1,232.21	1,218.62

Table 9.—Randomized block design for the 9 varieties in the variety test at Stillwater, Oklahoma, in 1948.

Conner

Kans. Comm. 28	No. 72 19	N51-1-1 10	No. 71 1
No. 72 29	Conner 20	No. 93 11	N51-1-1 2
N51-1-1 30	No. 71 21	Conner 12	No. 72 3
N201-2 31	Kans. Com. 22	Ky. 38 13	No. 93 4
No. 93 32	N201-2 23	N108-3 14	Kans. Com. 5
N108-3 33	N51-1-1 24	No. 71 15	Conner 6
Conner 34	No. 93 25	No. 72 16	Ky. 38 7
Ky. 38 35	N108-3 26	Kans. Com. 17	N201-2 8
No. 71 36	Ky. 38 27	N201-2 18	N108-3 9

Conner

Typist: Mary Wallace Spohn