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# Cultural Studies With SPINACH

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# Cultural Studies With Spinach

S. C. Wiggins, C. E. Marshall, and G. V. Odell<sup>1</sup>

Spinach is one of the most important vegetable crops grown in Oklahoma, with an annual average value of over \$700,000 from 1951 to 1960. Most of the commercial acreage is produced in the Arkansas river valley. Until the development of effective mechanical harvesting equipment all spinach was harvested by hand. Even with mechanical harvesters, Oklahoma growers have difficulty competing effectively with some other sections due to relatively lower yields. Thus, it is imperative that Oklahoma growers use a combination of cultural practices to produce optimum yields of a high quality product.

This bulletin reports results of a series of factorial experiments at the Vegetable Research Station, Bixby, Oklahoma, from 1958 through 1961<sup>2</sup>. The experiments were made to determine nitrogen fertilizer and plant spacing practices which would produce maximum yields of high quality marketable spinach adapted to the Arkansas river valley.

## Procedures

The experiments were carried out on well prepared seed beds of Reinach silt loam soil. Representative soil samples, taken prior to planting, showed that the area averaged approximately 10 ppm available nitrogen, 2 ppm available phosphorus, and 5 ppm available potassium. The soil had a pH of 6.1.

Uniform applications of 0-16-8 or 0-20-10 were broadcast and disked into the soil prior to planting to raise the available phosphorus and potassium to non-limiting levels. Differential amounts of nitrogen, as 33-0-0, were applied at weekly intervals beginning two weeks after

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<sup>2</sup> Appreciation is extended to Jack Marshall, Supt. of the Vegetable Research Station, for his assistance in these studies.

planting. At each application, 100 pounds of actual nitrogen per acre were applied until the desired level was reached.

Experimental areas were sprinkler irrigated with two inches of water about one week prior to planting if needed. Thereafter, a two-inch irrigation was applied as needed during the growing season. No irrigation was applied during December and January.

All seed was treated with Arasan. Three gallons of Aldrin per acre was applied to the soil to control seed corn maggot. Malathion was applied when necessary to control aphids and grasshoppers.

A six-row planter was used to drill seed, both in 6-inch and 12-inch rows. A Brillion seeder also was used to broadcast seed in certain trials. Plants in row seedings were thinned by hand at about the two-leaf stage. Vegadex (CEDC) was applied, pre-emergence, in tests to determine effects of weeds on plant growth. Generally, weeds were removed by hand in order to reduce possible variations in yield caused by weed competition.

Plots were 3 by 14 feet with four or six replications per treatment. Ten square feet of each plot (e.g., center ten feet of the middle row or rows, or an area 1 by 10 feet in the center of the broadcast plots) were harvested by hand. Only yields of U. S. No. 1 spinach were recorded.

## 1958 Experiment

### Fall Culture Study

A study was made in the fall of 1958 of the interrelationships between seeding rate and nitrogen fertilization on the yield of two varieties of spinach. Spinach was thinned to 1, 2, 4, or 8 plants per linear foot of row in rows 12 inches wide, providing calculated seeding rates of approximately 1.25, 2.5, 5.0, and 10.0 pounds per acre, respectively.

Average yields of the two spinach varieties, Hybrid No. 7 and Old Dominion, from each of the plant spacing and nitrogen fertilizer rate combinations are shown in Table 1. There were highly significant increases in yield of both varieties as the number of plants per foot of row increased. Yields of Hybrid No. 7 were increased significantly when 300 pounds per acre of nitrogen were applied. Average yields of Hybrid No. 7 spinach were approximately one ton per acre greater than those of Old Dominion at each plant spacing and nitrogen fertilizer rate combination.

Table 2 shows percent nitrogen in the leaves, on a dry weight basis, at various plant spacings and nitrogen fertilizer rate combinations. In general, percent nitrogen in the leaves appeared to increase as the nitrogen fertilizer rate increased. Plant spacing, however, had no apparent effect on percent nitrogen. There was little difference in the percent nitrogen in Hybrid No. 7 and Old Dominion spinach at similar plant spacings and nitrogen fertilizer rates although Old Dominion tended to be slightly higher than Hybrid No. 7.

Although percent nitrogen appeared to increase in the leaves with increased nitrogen fertilizer application to the soil (Table 2), there was no appreciable change in leaf color with either variety. Also, plant spacing apparently had little effect on leaf color either.

The available nitrogen (N), phosphorus ( $P_2O_5$ ), and potassium ( $K_2O$ ) in the soil, as determined by the Spurway soil test, and the average pH of the soil at harvest are shown in Table 3. Plant spacing had little effect on the amount of N or pH of the soil. However, closely spaced plants caused a reduction in the available  $P_2O_5$  and  $K_2O$  remaining in the soil. Increasing the nitrogen fertilization rate increased the amount of available N and  $K_2O$  remaining in the soil, however, it had little effect on the amount of  $P_2O_5$ . High rates of nitrogen fertilization caused a more acid soil pH.

The experiment was accidentally destroyed in February 1959 so that no spring harvest could be made.

## 1959 Experiment

### Spring Culture Study

A study was made in the spring of 1959 of the interrelationships between seeding rate and nitrogen fertilization on the yield of three varieties of spinach. Spinach was thinned to 2, 4, 8, or 16 plants per linear foot in rows 12 inches apart, providing calculated seeding rates of 2.5, 5.0, 10.0, and 20.0 pounds per acre, respectively.

Average yields of the three spinach varieties, Hybrid No. 7, Old Dominion, and Bloomsdale Long Standing, at each of the treatment combinations are shown in Table 4. Highly significant increases in yield were noted as plant spacings were decreased with each spinach variety. However, increasing levels of nitrogen fertilization had little effect on spinach yield. In fact, increasing the nitrogen fertilization rate appeared to cause a corresponding decrease in yield of Hybrid No. 7 spinach planted in March. Hybrid No. 7 spinach planted in

February yielded approximately four tons per acre more than Old Dominion or Bloomsdale Long Standing spinach planted in February and Hybrid No. 7 spinach planted in March.

Table 5 shows the percent nitrogen, phosphorus, and potassium, on a dry weight basis, in the leaves of spinach. In general, there was little change in the percent nitrogen, phosphorus, and potassium in the leaves of any variety as the nitrogen fertilizer rate was increased. Plant spacing also had no apparent effect on the percent nitrogen or phosphorus in the leaves. However, the percent potassium was markedly reduced as the number of plants per square foot was increased. There was a difference between varieties in percent potassium in the leaves, but little difference in percent nitrogen or percent phosphorus.

Fertilizer application had little or no effect on type of plant growth, however a decreased plant spacing (increased plant stand) resulted in plants with an erect type of growth. Bloomsdale Long Standing appeared to be more prostrate than either Hybrid No. 7 or Old Dominion.

Nitrogen fertilizer had no effect on the date of maturity. However, increasing the number of plants from 2 to 16 plants per foot of row resulted in approximately four days earlier maturing for each variety. Hybrid No. 7 matured approximately six to ten days earlier than Old Dominion and Bloomsdale Long Standing, respectively. Delay in planting Hybrid No. 7 by three weeks delayed maturity approximately eight to ten days.

### **Nitrogen Source Study**

Another study was made in the fall of 1959 of the interrelationships between nitrogen source, rate of nitrogen fertilization and seeding rate on the yield of two varieties of spinach. Spinach was thinned to 4 and 8 plants per linear foot of row in rows 12 inches wide, providing calculated seeding rates of approximately 5.0 and 10.0 pounds per acre, respectively.

Average yields of Hybrid No. 7 and Bloomsdale Long Standing spinach at the different treatment combinations are shown in Table 6. There were highly significant differences in Hybrid No. 7 yields from different sources and plant spacings. There were significant differences in Bloomsdale Long Standing yields from different nitrogen sources and plant spacings. However, there was no apparent difference in yield between the two levels of nitrogen with either variety of spinach.

The percent nitrogen, phosphorus, and potassium, on a dry weight

basis, in the leaves of the two spinach varieties at each plant spacing, nitrogen fertilizer rate, and source of nitrogen combination are shown in Table 7. Neither plant spacing nor nitrogen fertilizer rate had any particular effect on the nitrogen, phosphorus, or potassium content of the leaves of either variety. Potassium percentage was lowest when sodium nitrate (16-0-0) was used to supply nitrogen. In general, the percent potassium appeared to be higher in Bloomsdale Long Standing than in Hybrid No. 7 spinach.

Rate of fertilizer application had little effect on the type of growth of Hybrid No. 7 and Bloomsdale Long Standing. However, the plants seeded at a heavier rate (8 plants per foot of row) were more upright due to competition for light. There was little difference between nitrogen fertilizer sources, although Uramite, Nitroform, and Borden "38" caused a more upright type of growth than other sources. In general, Hybrid No. 7 was more upright than Bloomsdale Long Standing at all plant spacings and fertilizer rates.

The level or source of nitrogen fertilizer had little effect on date of maturity with either Hybrid No. 7 or Bloomsdale Long Standing. Hybrid No. 7, however, matured approximately two weeks earlier than Bloomsdale Long Standing.

## 1960 Experiments

### Fall Culture Study

A study was made in the fall of 1960 of the interrelationships between seeding rate, nitrogen fertilizer rate, and date of planting on yields of four spinach varieties. Spinach was thinned to 4, 8, or 16 plants per linear foot of row in rows six inches wide, providing calculated seeding rates of approximately 10.0, 20.0, or 40.0 pounds per acre, respectively.

Yields for each variety and treatment combination are shown in Tables 8, 9, and 10. At all planting and harvest dates, there were highly significant differences in yield due to nitrogen fertilizer levels. Increased nitrogen amounts of up to 100 pounds per acre, increased average yields, particularly in the two spring harvested treatments (Tables 9 and 10). There also were significant differences in yield due to plant spacings and varieties (Tables 8 and 10). Hybrid Basra and Hybrid Salma produced the highest yields, particularly the fall crop. Dixie Market appeared to use more nitrogen since the check plots showed definite deficiency symptoms at harvest.

## 1961 Experiments

### Spring Culture Study

A study was made in the spring of 1961 of the interrelationships between seeding rate, seeding method, method of weed control, and nitrogen fertilization on the yield of two varieties of spinach. The spinach was drilled in six-inch rows and thinned to 4 and 16 plants per foot of row, providing calculated seeding rates of approximately 10.0 and 40.0 pounds per acre, respectively.

Average yields of Hybrid No. 7 and Hybrid Aden spinach, in an incomplete factorial experiment, from various treatment combinations are shown in Table 11. There were marked increases in yield when the rate of nitrogen application was increased from 0 to 100 pounds per acre. Yield also was increased when seeding rate was increased from 10 to 40 pounds per acre. The drilled plots produced the highest yields. However, there was little difference in yield with the different methods of weed control. Hybrid No. 7, in general, produced the highest yields.

Grass appeared to be better controlled than broadleaved weeds in all treatments. There was excellent control of both grass and broadleaved weeds in the clean cultivated plots, but there was little difference between the weed control achieved in the check plots and the Vegadex treated plots. Neither seeding method, rate of seeding, nor nitrogen fertilizer appeared to have much effect on weed control.

Percent nitrogen, on a dry weight basis, in the leaves of two spinach varieties is shown in Table 12. In general, increasing the nitrogen fertilizer from 0 to 100 pounds per acre appeared to increase the percent nitrogen in the leaves. The various seeding rates, seeding methods, and methods of weed control, however, had little effect on the percent nitrogen in the leaves. Hybrid Aden, in general, contained a higher percent nitrogen in the leaves than Hybrid No. 7 spinach.

### Fall Spinach Study

Five spinach varieties, Hybrid No. 7, Hybrid Aden, Hybrid Basra, Hybrid Salma and Dixie Market, were planted in six-inch rows and later thinned to 4, 8, and 16 plants per linear foot of row. This provided calculated seeding rates of 10.0, 20.0, and 40.0 pounds per acre, respectively. There were three levels of nitrogen, 0, 50, and 100 pounds per acre.



Average yields of the five spinach varieties are shown in Table 13. There were significant differences in yield at the 1 percent level for Hybrid Aden, Hybrid Basra, and Hybrid Salma and at the 5 percent level for Hybrid No. 7 as the nitrogen fertilizer rate varied. Plant spacing, (plants per foot), however, had little effect on the yield of any of the varieties. There were marked differences between varieties, with Hybrid Salma being high and Hybrid Aden low at most of the nitrogen level-spacing combinations.

Effect of plant spacing and nitrogen fertilizer level on percent nitrogen, on a dry weight basis, in the leaves of each spinach variety is shown in Table 14. Increasing nitrogen fertilizer from 0 to 100 pounds per acre generally increased the percent nitrogen in the leaves. However, there was a decrease in nitrogen as the number of plants per foot of row increased, particularly with Hybrid Basra, Hybrid Salma, and Dixie Market varieties.

Neither nitrogen application rate nor plant spacing had any noticeable effect on leaf color. However, Hybrid Basra and Hybrid Aden varieties appeared to have the darkest green color over all treatments. No spring harvest was made in 1962 due to winter kill.

### **Fall Culture Study**

Hybrid No. 7 was planted in September 1961 to study the interrelationships between seeding rates, seeding methods, and methods of weed control, at three levels of nitrogen, 0, 50, and 100 pounds per acre.

The average yield of spinach from each of the treatment combinations is shown in Table 15. Spinach on plots fertilized with 50 and 100 pounds nitrogen per acre yielded an average of 1.5 tons per acre more than control plots. Type of weed control and seeding rate had little effect on yields. The drilled plots produced higher yields than broadcast plots and appeared to result in more erect type of growth than broadcast seeding.

Neither seeding rate, seeding method, nor nitrogen fertilizer rate appeared to have any effect on weed infestation. All plots had some weeds. There appeared to be fewer weeds in the clean cultivated and the chemical weed control plots than in the check plots.

Effect of the various treatment combinations on percent nitrogen in leaves of Hybrid No. 7 spinach is given in Table 16. There was a general increase in nitrogen content with increasing levels of nitrogen

fertilizer application. However, neither seeding rate, seeding method, nor method of weed control had any apparent effect on the nitrogen content of the leaves.

There were no apparent differences in leaf color with the different nitrogen fertilizer rates, seeding rates, seeding methods or methods of weed control.

No spring harvest was made in 1962 due to winter kill.

## Discussion and Conclusions

### Seeding Rate and Yield

Assuming that moisture, nitrogen, phosphorus, and potassium are not limiting factors, yields generally were higher with drilled plots than with broadcast plots using the same planting rates. This was due probably to the unevenness of stand of the broadcast seedings since both depth of seeding and plant spacing were difficult to control. Maximum yields were obtained in plots drilled in six-inch rows with seeds approximately 1½ inches apart in the row. This rate of seeding corresponded to approximately 18 to 22 pounds of viable seed per acre, depending on seed size. Increasing the seeding rate to more than 20 pounds per acre generally reduced the total yield. High seeding rates in drilled rows usually resulted in more erect plants which were easier to harvest.

### Fertility and Yield

Results with nitrogen were variable in different years of this study. From all experiments, it was found that approximately 50 pounds of actual nitrogen per acre, applied within two weeks after planting, was probably adequate for the optimum growth of spinach in a Reinach silt loam soil. If considerable leaching due to excessive rainfall has occurred, however, or if spinach follows a grain crop with the recent incorporation of large amounts of strawy residues, it may be desirable to add more nitrogen. This can be done with supplementary applications of top dressed nitrogen, up to approximately 100 pounds per acre. Too much nitrogen should not be added at any one time since plant damage may occur. With adequate moisture it may be desirable to add a supplementary nitrogen application to over-wintered spinach in the early spring before growth starts.

In addition to adequate nitrogen in the soil for good growth it is

important that a balance be maintained between the available phosphorus and potassium.

### **Varieties**

Hybrid No. 7 produced higher yields than any other variety in both fall and spring planted trials. This variety does not have a true savoyed leaf, however, and sometimes is discounted by the processor. Hybrid Basra and Dixie Market generally produced high yields of an excellent quality spinach in the fall. Hybrid Basra also is a good carryover spinach for early spring harvests.

Hybrid Aden and Hybrid Salma, although relatively high yielders, are not too desirable because of a lack of a savoyed leaf character.

Old Dominion, long a popular variety with growers and processors alike, gave low yields in these tests, and therefore, is not recommended as a variety to be given serious consideration in the future in eastern Oklahoma.

### **Nitrogen Content of Leaves**

Nitrogen fertilizer application, to some degree, affected the nitrogen content of the leaves. Increasing nitrogen fertilizer in the soil usually resulted in a high quality plant with higher nitrogen content in the leaves. Nitrogen content of the leaves was reduced by increased seeding rates, particularly at low nitrogen fertilizer levels.

**Table 1.—Average yields of two spinach varieties at various plant spacings and fertilizer rates. Planted on September 25, 1958 and harvested December 2, 1958. (Average of six replications.)**

Plants per Foot of row in 12" rows†	Nitrogen (pounds per acre)					Avg.
	0	100	200	300	400	
	(Tons per Acre)					
<b>Hybrid No. 7</b>						
1	3.7	5.1	4.6	5.7	4.5	4.7
2	6.5	6.3	7.3	6.0	6.0	6.4
4	6.5	6.8	7.7	8.5	7.0	7.3
8	6.5	8.6	7.1	9.3	8.4	8.0
Avg.	5.8	6.7	6.7	7.4	6.5	
<b>Old Dominion</b>						
1	2.8	3.9	4.4	4.1	4.0	3.8
2	3.2	6.0	6.3	5.2	5.3	5.6
4	5.7	5.9	6.3	6.7	6.0	6.1
8	6.3	6.6	6.6	7.2	7.2	6.8
Avg.	5.6	5.6	5.9	5.8	5.6	
<b>ANALYSIS OF VARIANCE</b>						
		Hybrid No. 7		Old Dominion		
Source		d. f.	MS	d. f.	MS	
Plants per Foot		3	54.42**	3	47.48**	
Nitrogen		4	7.64*	4	2.89	
PF x N		12	3.15	12	.96	
Error		95	2.80	95	2.00	

† Seeding rates for both varieties were approximately 1.25, 2.5, 5.0, and 10.0 pounds per acre, respectively.

\* Significant at 5 percent level. L.S.D. at 5 percent level for Nitrogen for Hybrid No. 7 = 1.0 T/A.

\*\*Significant at 1 percent level. L.S.D. at 1 percent level for Plants per Foot for Hybrid No. 7 = 1.1 T/A; for Old Dominion = 1.0 T/A.

**Table 2.—Percent nitrogen in leaves of two spinach varieties at various plant spacings and fertilizer rates. Planted September 25, 1958 and harvested December 2, 1958. (Average of 10 leaves from each of two replications, dry weight basis.)**

Plants per foot of row in 12" rows†	Nitrogen (pounds per acre)					Avg.
	0	100	200	300	400	
	(Percent Nitrogen)					
<b>Hybrid No. 7</b>						
1	5.26	5.14	5.43	5.49	6.05	5.47
2	4.95	4.80	5.51	5.07	5.17	5.10
4	5.13	5.67	5.31	4.98	5.17	5.27
8	5.01	5.25	5.44	5.18	5.35	5.25
Avg.	5.01	5.22	5.42	5.18	5.44	
<b>O'd Dominion</b>						
1	5.04	5.62	5.19	5.58	6.15	5.52
2	5.02	5.33	5.80	5.16	5.17	5.30
4	5.29	5.15	5.54	5.93	5.45	5.47
8	5.17	5.25	5.46	5.89	5.45	5.44
Avg.	5.13	5.34	5.50	6.64	5.56	

† Seeding rates for both varieties were approximately 1.25, 2.5, 5.0, and 10.0 pounds per acre, respectively.

**Table 3.—Available nitrogen (N), phosphorus (P<sub>2</sub>O<sub>5</sub>), and potassium (K<sub>2</sub>O) and average pH of the soil after harvest from spinach planted on September 25, 1958 and harvested December 2, 1958. (Average of two replications.)**

Plants per foot of row in 12" rows†	Nitrogen (pounds per acre)					Avg.
	0	100	200	300	400	
<b>Nitrogen (pounds per acre)</b>						
1	0	2	12	12	7	7
2	0	2	7	12	7	6
4	0	0	10	7	10	5
8	0	0	12	14	12	8
Avg.	0	1	10	11	9	
<b>P<sub>2</sub>O<sub>5</sub> (pounds per acre)</b>						
1	98	74	98	98	123	98
2	123	49	49	49	98	74
4	74	98	74	49	98	79
8	98	49	74	49	49	64
Avg.	98	68	74	61	92	
<b>K<sub>2</sub>O (pounds per acre)</b>						
1	51	38	90	231	173	117
2	38	173	129	129	64	107
4	77	64	64	103	103	82
8	129	77	64	64	155	98
Avg.	74	88	87	132	124	
<b>pH</b>						
1	7.1	7.1	6.2	6.0	5.7	6.4
2	7.0	7.1	6.0	6.3	6.6	6.6
4	6.8	6.4	6.6	6.4	6.7	6.6
8	6.8	7.0	6.4	6.2	6.3	6.5
Avg.	6.9	6.9	6.3	6.2	6.3	

† Seeding rates were 1.25, 2.5, 5.0, and 10.0 pounds per acre, respectively.

**Table 4.—Average yields of three spinach varieties in relation to plant spacings and fertilizer rates (average of 4 replications).**

Plants per foot of row in 12" rows†	Nitrogen (pounds per acre)				Avg.
	100	200	300	400	
Variety	(Tons per Acre)				
<b>Hybrid No. 7</b>					
2	6.6	8.7	5.7	5.8	6.7
4	8.8	8.2	8.2	7.6	8.2
8	9.3	9.2	11.4	11.7	10.4
16	13.4	14.1	11.3	10.7	12.4
Avg.	9.5	10.1	9.2	9.0	
<b>Old Dominion</b>					
2	3.7	3.8	2.7	3.3	3.4
4	4.5	5.0	5.0	5.1	4.9
8	3.9	5.6	6.1	7.5	5.8
16	9.8	8.5	6.5	7.4	8.1
Avg.	5.5	5.7	5.1	5.8	
<b>Bloomsdale Long Standing</b>					
2	3.2	3.1	2.7	3.4	3.1
4	4.6	4.7	4.4	5.0	4.7
8	4.1	6.3	6.3	7.3	6.0
16	7.5	8.8	6.3	8.1	7.7
Avg.	4.9	5.7	4.9	6.0	
<b>Hybrid No. 7††</b>					
2	3.9	3.1	3.2	2.1	3.1
4	4.5	4.7	3.7	4.1	4.3
8	6.2	4.3	5.6	5.2	5.3
16	8.9	8.1	6.8	7.0	7.7
Avg.	5.9	5.1	4.8	4.6	

## ANALYSIS OF VARIANCE

Source	Hybrid No. 7		Old Dominion		Bloomsdale L.S.		Hybrid No. 7††	
	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.
Plants per foot	3	99.53**	3	61.11**	3	60.42**	3	61.98**
Nitrogen	3	3.60	3	1.61	3	4.92	3	5.13
PF x N	9	7.65	9	5.36	9	2.52	9	1.40
Error	45	5.25	43	4.46	43	3.75	38	2.11

† Seeding rates for each variety were 2.5, 5.0, 10.0 and 20.0 pounds per acre, respectively.

†† Planted on March 10, 1959. The other varieties were planted on February 17, 1959.

All varieties were harvested on April 28, 1959.

\*\*Significant at 1 percent level. L.S.D. for plant per foot were: Hybrid No. 7—2.2 T/A; Old Dominion—2.1 T/A; Bloomsdale L.S.—1.8 T/A; and Hybrid No. 7††—1.4 T/A.

Table 5.—Percent nitrogen, phosphorus and potassium, on a dry weight basis, in leaves of three spinach varieties.

Plants per foot of row in 12" rows†	Nitrogen Fertilizer (pounds per acre)											
	100	200	400	Avg.	100	200	400	Avg.	100	200	400	Avg.
	(Percent Nitrogen)				(Percent Phosphorus)				(Percent Potassium)			
<b>Hybrid No. 7</b>												
2	5.67	5.90	5.63	5.75	0.50	0.53	0.56	0.55	8.08	6.96	7.03	7.36
4	5.54	5.68	6.03	5.77	0.61	0.55	0.60	0.59	6.76	9.03	7.78	7.86
8	5.70	5.65	5.78	5.71	0.69	0.51	0.55	0.58	6.63	7.15	7.43	7.07
16	5.78	5.75	5.91	5.81	0.52	0.49	0.58	0.53	5.63	6.90	6.11	6.21
Avg.	5.67	5.75	5.91		0.58	0.53	0.57		6.78	7.51	7.09	
<b>Old Dominion</b>												
2	5.16	5.56	4.99	5.06	0.53	0.53	0.47	0.51	7.43	7.51	8.33	7.76
4	5.85	5.62	5.87	5.78	0.59	0.54	0.56	0.56	7.67	7.50	6.99	7.39
8	5.75	5.65	5.11	5.50	0.61	0.59	0.56	0.59	6.72	5.28	8.80	6.93
16	5.17	5.80	6.09	5.69	0.52	0.49	0.53	0.51	4.17	8.28	4.66	5.70
Avg.	5.60	5.66	5.52		0.56	0.54	0.53		6.50	7.15	7.20	
<b>Bloomsdale Long Standing</b>												
2	5.25	5.60	4.93	5.26	0.51	0.55	0.49	0.52	7.43	7.42	7.26	7.37
4	5.45	5.55	6.10	5.70	0.50	0.43	0.51	0.50	9.00	7.70	8.67	8.46
8	5.75	5.67	5.45	5.62	0.67	0.49	0.47	0.54	7.68	9.64	7.30	8.21
16	5.52	5.04	6.02	5.53	0.60	0.43	0.57	0.55	7.22	6.93	6.34	6.83
Avg.	5.49	5.47	5.63		0.57	0.50	0.51		7.83	7.92	7.39	
<b>Hybrid No. 7††</b>												
2	5.36	4.83	5.43	5.21	0.50	0.42	0.52	0.43	8.81	9.03	10.21	9.35
4	5.13	5.24	5.31	5.43	0.50	0.41	0.46	0.46	8.81	8.74	8.41	8.65
8	5.12	5.60	5.56	5.43	0.41	0.47	0.54	0.47	9.19	8.32	9.00	8.84
16	5.24	5.95	5.38	5.52	0.36	0.59	0.44	0.46	6.88	7.90	7.39	7.39
Avg.	5.21	5.41	5.42		0.44	0.47	0.49		8.42	8.50	8.75	

† Seeding rates for all varieties were 2.5, 5.0, 10.0 and 20.0 pounds per acre, respectively.

†† Planted March 10, 1959. The other varieties were planted February 17, 1959. All varieties were harvested on April 28, 1959.



**Table 6.—Average yield of two spinach varieties in relation to plant spacings and fertilizer rates, using six sources of nitrogen. Planted on February 17, 1959 and harvested April 27, 1959. (Average of six replications.)**

Nitrogen Source	Plants per Foot of Row†				Avg.
	4		8		
	Nitrogen (pounds per acre)				
	200	400	200	400	
(Tons per Acre)					
<b>Hybrid No. 7</b>					
Ammonium nitrate (33-0-0)	7.6	5.8	8.6	7.4	7.4
Ammonium sulfate (21-0-0)	7.4	7.9	7.8	9.2	8.1
Sodium nitrate (16-0-0)	7.9	10.2	9.8	9.8	9.4
Uramite (38-0-0)	8.0	7.9	8.1	10.2	8.6
Nitroform (38-0-0)	8.2	8.2	7.4	8.8	8.2
Borden "38" (38-0-0)	6.3	5.9	8.2	8.3	7.2
Avg.	7.6	7.7	8.3	9.0	
<b>Bloomsdale Long Standing</b>					
Ammonium nitrate (33-0-0)	4.8	4.0	5.4	5.0	4.8
Ammonium sulfate (21-0-0)	5.5	4.1	6.3	5.8	5.4
Sodium nitrate (16-0-0)	4.5	5.6	6.0	6.0	5.5
Uramite (38-0-0)	5.8	5.5	6.1	6.7	6.0
Nitroform (38-0-0)	4.9	5.2	4.9	5.2	5.1
Borden "38" (38-0-0)	4.4	5.8	6.5	6.2	5.7
Avg.	5.0	5.0	5.9	5.8	

## ANALYSIS OF VARIANCE

Source	Hybrid No. 7		Bloomsdale Long Standing	
	d.f.	MS	d.f.	MS
Nit. Source	5	17.90**	5	3.77*
Plants per Foot	1	55.74**	1	3.71*
Nit. Level	1	2.81	1	3.32
NS x PF	5	2.56	5	.76
NS x NL	5	5.17	5	1.70
PF x NL	1	1.62	1	.10
PF x NS x NL	5	3.63	5	1.35
Error	115	3.34	115	1.46

† Seeding rates for both varieties were approximately 5.0 and 10.0 pounds per acre, respectively.

\* Significant at 5 percent level. L.S.D. for Bloomsdale Long Standing for Nitrogen Source = .7 T/A; for Plants per Foot = .7 T/A.

\*\*Significant at the 1 percent level. L.S.D. for Hybrid No. 7 for Nitrogen Source = 1.4 T/A; for Plants per Foot = 1.4 T/A.

**Table 7.—Percent nitrogen, phosphorus and potassium, on a dry weight basis, in leaves of two spinach varieties in relation to plant spacings and fertilizer rates.†**

Nitrogen Source	Plants per foot of row†† in 12 inch rows										
	4		8		Nitrogen Fertilizer (pounds per acre)					8	
	200	400	200	400	Average		200	400	200	400	Average
	HYBRID NO. 7					BLOOMSDALE LONG STANDING					
	(percent nitrogen)										
Ammonium nitrate (33-0-0)	5.97	6.17	5.73	5.34	5.80	5.40	5.70	5.57	5.65	5.53	
Ammonium su.fate (21-0-0)	5.21	5.45	6.07	5.72	5.61	4.29	5.26	5.60	5.24	5.10	
Sodium nitrate (16-0-0)	5.27	5.80	5.49	5.01	5.39	5.35	5.19	4.75	4.73	5.01	
Uramite (38-0-0)	5.25	5.37	4.74	4.43	4.95	5.22	5.28	5.37	5.15	5.33	
Nitroform (38-0-0)	5.18	5.44	4.84	5.56	5.26	5.53	5.21	5.04	5.54	5.33	
Borden "33" (33-0-0)	5.54	5.22	5.72	5.54	5.51	5.22	5.25	5.61	5.35	5.36	
Average	5.40	5.58	5.43	5.27		5.17	5.37	5.32	5.28		
	(percent phosphorus)										
Ammonium nitrate (33-0-0)	0.66	0.64	0.54	0.45	0.57	0.58	0.56	0.54	0.46	0.54	
Ammonium sulfate (21-0-0)	0.69	0.62	0.66	0.54	0.63	0.48	0.49	0.56	0.42	0.49	
Sodium nitrate (16-0-0)	0.49	0.59	0.54	0.51	0.53	0.50	0.51	0.51	0.57	0.52	
Uramite (33-0-0)	0.56	0.43	0.62	0.39	0.50	0.53	0.51	0.57	0.50	0.54	
Nitroform (38-0-0)	0.59	0.55	0.43	0.52	0.54	0.51	0.47	0.54	0.62	0.54	
Borden "33" (38-0-0)	0.48	0.61	0.57	0.44	0.53	0.48	0.52	0.50	0.48	0.50	
Average	0.58	0.57	0.57	0.48		0.52	0.51	0.54	0.51		
	(percent potassium)										
Ammonium nitrate (33-0-0)	7.17	6.94	5.98	7.83	6.98	7.88	9.30	7.04	7.86	8.02	
Ammonium sulfate (21-0-0)	6.34	6.78	6.19	6.80	6.53	7.50	8.28	6.96	7.86	7.65	
Sodium nitrate (16-0-0)	5.77	6.42	5.68	5.76	5.91	7.60	7.52	6.71	6.81	7.16	
Uramite (33-0-0)	6.87	7.16	8.04	6.93	7.25	7.12	6.65	7.31	8.15	7.31	
Nitroform (38-0-0)	6.82	7.31	8.69	6.93	7.44	7.17	9.25	8.91	6.64	7.99	
Borden "38" (38-0-0)	6.38	6.67	7.75	7.37	7.04	8.67	7.74	7.50	7.01	7.73	
Average	6.56	6.88	7.06	6.94		7.66	8.12	7.41	7.39		

† Both varieties were planted on February 17, 1959, and harvested on April 27, 1959.

†† Seeding rate for both varieties were approximately 5.0 and 10.0 pounds per acre respectively.

**Table 8.—Average yields of four spinach varieties in relation to plant spacings and fertilizer rates. Planted on September 6, 1960 and harvested October 26, 1960. (Average of four replications.)**

Plants per foot of row in 6" rows†	Nitrogen (pounds per acre)			Avg.
	0	50	100	
<b>Hybrid No. 7</b>	(Tons per Acre)			
4	7.4	6.6	7.4	7.1
8	5.7	7.8	6.4	6.6
16	4.5	6.9	7.2	6.2
Avg.	5.9	7.1	7.0	
<b>Dixie Market</b>				
4	6.5	8.7	11.6	8.9
8	5.8	8.7	7.3	7.3
16	4.4	6.5	3.3	4.7
Avg.	5.1	6.5	6.6	
<b>Hybrid Basra</b>				
4	9.8	12.5	11.4	11.2
8	8.3	10.7	13.1	10.7
16	8.4	10.6	11.8	10.3
Avg.	8.8	11.3	12.1	
<b>Hybrid Salma</b>				
4	9.4	11.2	10.8	10.5
8	9.4	10.6	12.7	10.9
16	7.6	11.7	9.1	9.5
Avg.	8.8	11.2	10.9	
<b>ANALYSIS OF VARIANCE</b>				
Source	d.f.	MS		
Variety	3	121.31**		
Plants per Foot	2	15.52**		
Nitrogen	2	63.20**		
V x PF	6	1.77		
V x N	6	3.23		
PF x N	4	3.28		
V x N x PF	12	4.14		
Error	105	4.44		

† Seeding rates were 10.0, 20.0, and 40.0 pounds per acre, respectively.

\* Significant at 5 percent level. L.S.D. at 5 percent level for Plants per Foot = 1.1 T/A.

\*\*Significant at 1 percent level. L.S.D. at 1 percent level for Varieties = 2.3 T/A; for Nitrogen = 2.3 T/A.

**Table 9.—Average yields of four spinach varieties in relation to plant spacing and fertilizer levels. Planted on September 6, 1960 and harvested April 5, 1961. (Average of four replications.)**

Plants per foot of row in 6" rows†	Nitrogen (pounds per acre)			Avg.
	0	50	100	
<b>Hybrid No. 7</b>	(Tons per Acre)			
4	6.5	8.7	11.6	8.9
8	4.9	7.6	7.7	6.7
16	3.5	7.0	8.4	6.3
Avg.	5.0	7.8	9.2	
<b>Dixie Market</b>				
4	5.1	4.4	9.1	6.2
8	5.8	8.7	7.3	7.3
16	4.4	6.5	3.3	4.7
Avg.	5.1	6.5	6.6	
<b>Hybrid Basra</b>				
4	5.8	5.2	6.4	5.8
8	7.3	7.3	7.8	7.5
16	7.5	7.7	9.4	8.2
Avg.	6.9	6.7	7.9	
<b>Hybrid Salma</b>				
4	10.0	8.4	6.9	8.4
8	5.8	6.1	9.0	
16	6.2	7.2	7.8	7.1
Avg.	7.3	7.2	7.9	
<b>ANALYSIS OF VARIANCE</b>				
Source	d.f.	MS		
Variety	3	14.74		
Plants per Foot	2	12.16		
Nitrogen	2	50.29**		
V x PF	6	16.55		
V x N	6	8.77		
PF x N	4	6.43		
V x PF x N	12	10.34		
Error	105	8.58		

† Seeding rates were 10.0, 20.0, and 40.0 pounds per acre, respectively.

\*\*Significant at 1 percent level. L.S.D. for 1 percent level for Nitrogen = 3.2 T/A.

**Table 10.—Average yields of four spinach varieties in relation to plant spacings and fertilizer rates. Planted on November 22, 1960 and harvested April 5, 1961. (Average of six replications.)**

Plants per foot of row in 6" rows†	Nitrogen (pounds per acre)			Avg.
	0	50	100	
<b>Hybrid No. 7</b>		(Tons per Acre)		
4	5.7	7.4	8.5	7.2
8	5.5	7.4	9.3	7.4
16	5.9	8.9	9.6	8.1
Avg.	5.7	7.9	9.2	
<b>Dixie Market</b>				
4	5.5	7.1	10.0	7.5
8	5.7	7.7	11.5	8.3
16	6.3	7.9	9.7	8.0
Avg.	5.8	7.6	10.4	
<b>Hybrid Basra</b>				
4	6.0	7.9	8.6	7.5
8	7.5	10.9	13.3	10.6
16	8.5	10.4	11.6	10.2
Avg.	7.3	9.7	11.2	
<b>Hybrid Salma</b>				
4	6.0	7.9	8.6	7.5
8	4.4	8.3	10.0	7.6
16	7.5	7.3	8.5	7.8
Avg.	6.0	7.8	9.0	
<b>ANALYSIS OF VARIANCE</b>				
Source	d.f.	MS		
Variety	3	23.40*		
Plants per Foot	2	316.38**		
Nitrogen	2	22.19*		
V x PF	6	12.21		
V x N	6	3.46		
PF x N	4	7.16		
V x PF x N	12	1.23		

† Seeding rates were 10.0, 20.0, and 40.0 pounds per acre, respectively.

\* Significant at the 5 percent level. L.S.D. at 5 percent level for Variety = .6 T/A; for Plants per Foot = .6 T/A.

\*\*Significant at the 1 percent level. L.S.D. at 1 percent level for Nitrogen = .8 T/A.

**Table 11.—Average yields of two spinach varieties in relation to seeding rates, seeding methods, weed controls, and fertilizer levels.† (Average of six replications.)**

Seeding Rate (pounds per acre)	Seeding Method	Weed Control Method	Nitrogen Fertilizer (pounds per acre)		
			0	100	Avg.
(Tons per acre)					
<b>Hybrid No. 7</b>					
10.0	Drilled in 6" rows	None (Ck)	7.7	11.8	9.8
		Clean Cult.	9.4	11.2	10.3
		CEDC (3 lb/A)	6.7	11.5	9.1
	Broadcast	None (Ck)	6.3	7.8	7.1
		CEDC (2 lb/A)	5.4	7.8	6.6
		Avg.			
40.0	Drilled in 6" rows	None (Ck)	9.4	15.6	12.5
		Clean Cult.	8.1	16.9	12.5
		CEDC (3 lb/A)	8.8	11.9	10.4
	Broadcast	None (Ck)	7.6	13.4	10.5
		CEDC (3 lb/A)	8.3	12.0	10.3
		Avg.	7.8	12.0	
<b>Hybrid Aden</b>					
10.0	Drilled in 6" rows	None (Ck)	6.0	12.0	9.0
		Clean Cult.	6.8	11.2	9.0
		CEDC (3 lb/A)	7.3	10.3	8.8
	Broadcast	None (Ck)	7.7	6.9	7.3
		CEDC (3 lb/A)	7.4	7.7	7.6
		Avg.			
40.0	Drilled in 6" rows	None (Ck)	8.2	13.5	10.9
		Clean Cult.	9.3	12.6	11.0
		CEDC (3 lb/A)	9.2	13.0	11.1
	Broadcast	None (Ck)	7.6	9.7	8.7
		CEDC (3 lb/A)	6.9	9.8	8.4
		Avg.	7.6	10.7	

† Planted on February 14, 1961. Hybrid No. 7 was harvested April 25, 1961 and Hybrid Aden on April 28, 1961.

**Table 12.—Percent nitrogen, on a dry weight basis, in leaves of two spinach varieties in relation to planting rates, seeding methods, and nitrogen fertilizer levels.†**

Seeding Rate (pounds per acre)	Seeding Method	Weed Control Method	Nitrogen Fertilizer (pounds per acre)		
			0	100	Avg.
(Percent Nitrogen)					
<b>Hybrid No. 7</b>					
10.0	Drilled in 6" rows	None (Ck)	3.81	4.30	4.06
		Clean Cult.	3.92	3.94	3.93
		CEDC (3 lb/A)	3.85	4.22	4.04
	Broadcast	None (Ck)	4.00	4.27	4.14
		CEDC (3 lb/A)	3.82	4.55	4.19
40.0	Drilled in 6" rows	None (Ck)	3.80	4.19	4.00
		Clean Cult.	3.86	4.07	3.97
		CEDC (3 lb/A)	3.52	4.06	3.79
	Broadcast	None (Ck)	4.16	4.38	4.27
		CEDC (3 lb/A)	3.96	4.09	4.03
Avg.		3.77	4.21		
<b>Hybrid Aden</b>					
10.0	Drilled in 6" rows	None (Ck)	4.38	4.69	4.54
		Clean Cult.	4.54	4.88	4.71
		CEDC (3 lb/A)	4.30	4.64	4.47
	Broadcast	None (Ck)	4.46	5.01	4.74
		CEDC (3 lb/A)	4.35	4.74	4.55
40.0	Drilled in 6" rows	None (Ck)	4.37	4.46	4.42
		Clean Cult.	4.55	4.55	4.55
		CEDC (3 lb/A)	4.53	4.46	4.50
	Broadcast	None (Ck)	3.76	4.14	3.95
		CEDC (3 lb/A)	4.19	4.31	4.25
Avg.		4.34	4.59		

† Planted on February 14, 1961. Hybrid No. 7 was harvested April 25, 1961 and Hybrid Aden on April 28, 1961.

**Table 13.—Average yields of five spinach varieties in relation to plant spacings and nitrogen levels. Planted on September 4, 1961 and harvested October 26, 1961. (Average of six replications.)**

Plants per Foot of Row in 6" Rows†	Nitrogen (pounds per acre)			Avg.
	0	50	100	
<b>Hybrid No. 7</b>				
4	8.5	9.7	9.0	9.1
8	8.1	8.7	10.8	9.2
16	8.2	10.7	10.9	9.9
Avg.	8.3	9.7	10.2	
<b>Hybrid Aden</b>				
4	6.8	7.1	9.3	7.7
8	7.4	8.1	9.7	8.4
16	7.4	8.0	10.0	8.5
Avg.	7.2	7.7	9.7	
<b>Hybrid Basra</b>				
4	7.3	8.9	9.5	8.6
8	7.8	8.9	8.7	8.5
16	7.5	9.4	10.1	9.0
Avg.	7.5	9.1	9.4	
<b>Hybrid Salma</b>				
4	9.4	10.4	10.6	10.1
8	10.1	10.8	12.4	11.1
16	6.2	12.4	12.8	10.5
Avg.	8.6	11.2	11.9	
<b>Dixie Market</b>				
4	8.0	9.7	9.4	9.0
8	9.4	10.2	11.0	11.1
16	8.4	9.7	10.2	9.4
Avg.	8.6	9.9	10.2	

## ANALYSIS OF VARIANCE

Source	d.f.	MS				
		Hy. No. 7	Hy. Aden	Hy. Basra	Hy. Salma	Dixie Mkt.
Plants per Foot	2	3.56	2.97	1.60	4.69	6.18
Nitrogen	2	18.14*	29.64**	18.30**	51.73**	12.82
PF x N	4	4.61	.11	1.16	10.50	.55
Error	40	5.28	2.64	3.37	5.65	5.05

† Seeding rates were 10.0, 20.0, and 40.0 pounds per acre, respectively.

\* Significant at the 5 percent level. L.S.D. at 5 percent level for Nitrogen for Hybrid No. 7 = 1.6 T/A.

\*\*Significant at the 1 percent level. L.S.D. at 1 percent level for Nitrogen for Hybrid Aden = 1.5 T/A; for Hybrid Basra = 1.6 T/A; and for Hybrid Salma = 2.1 T/A.



**Table 14.—Percent nitrogen, on a dry weight basis, of five spinach varieties in relation to plant spacings and nitrogen levels. Planted on September 4, 1961 and harvested October 26, 1961. (Average of six replications.)**

Plants per Foot of Row in 6" Rows†	Nitrogen (pounds per acre)			Avg.
	0	50	100	
<b>Hybrid No. 7</b>		(Percent Nitrogen)		
4	4.96	4.75	4.97	4.89
8	4.52	4.67	5.08	4.76
16	4.68	4.91	5.33	4.97
Avg.	4.72	4.78	5.13	
<b>Hybrid Aden</b>				
4	4.88	5.37	5.30	5.18
8	4.76	4.94	5.40	5.03
16	4.98	4.85	5.29	5.04
Avg.	4.87	5.05	5.33	
<b>Hybrid Basra</b>				
4	4.63	5.16	5.25	5.01
8	5.18	4.83	5.24	5.08
16	4.20	4.47	5.01	4.56
Avg.	4.67	4.82	5.17	
<b>Hybrid Salma</b>				
4	4.90	5.08	5.21	5.06
8	4.41	4.69	5.07	4.85
16	4.44	4.94	4.88	4.63
Avg.	4.52	4.90	5.05	
<b>Dixie Market</b>				
4	4.72	4.86	5.35	4.98
8	4.41	5.46	5.20	5.02
16	4.44	4.42	4.75	4.54
Avg.	4.52	4.91	5.10	

† Seeding rates were 10.0, 20.0, and 40.0 pounds per acre, respectively.

**Table 15.—Average yield of Hybrid No. 7 spinach in relation to seeding rates, seeding methods, methods of weed control, and nitrogen levels†. (Average of six replications.)**

Seeding Rate (pounds per acre)	Seeding Method	Weed Control Method	Nitrogen Fertilizer (pounds per acre)			Avg.
			0	50	100	
			(Tons per Acre)			
10.0	Drilled in 6" rows	None (Ck)	8.5	10.4	7.7	8.9
		Clean Cult.	9.2	8.8	10.5	9.5
		CEDC (3 lb/A)	8.6	9.6	9.4	9.2
	Broadcast	None (Ck)	6.3	8.7	7.5	7.5
		CEDC (3 lb/A)	6.5	7.2	8.4	7.4
	20.0	Drilled in 6" rows	None (Ck)	7.8	8.9	6.3
Clean Cult.			6.5	9.4	8.9	8.3
CEDC (3 lb/A)			6.0	9.3	8.2	7.8
Broadcast		None (Ck)	5.7	8.1	8.5	7.4
		CEDC (3 lb/A)	7.4	8.0	8.6	8.0
40.0		Drilled in 6" rows	None (Ck)	6.2	7.4	8.2
	Clean Cult.		7.7	8.1	9.7	8.5
	CEDC (3 lb/A)		7.1	9.1	10.1	8.8
	Broadcast	None (Ck)	6.8	8.0	9.0	7.9
		CEDC (3 lb/A)	7.9	9.0	8.7	8.5
	Avg.			7.2	8.7	8.6

† Planted on September 7, 1961 and harvested October 28, 1961.

**Table 16.—Percent nitrogen, on a dry weight basis, in leaves of Hybrid No. 7 spinach in relation to seeding rates, seeding methods, methods of weed control and nitrogen fertilizer levels.† (Average of six replications.)**

Seeding Rate (pounds per acre)	Seeding Method	Weed Control Method	Nitrogen Fertilizer (pounds per acre)			Avg.
			0	50	100	
10.0	Drilled in 6" rows	None (Ck)	4.07	3.70	3.79	3.85
		Clean Cult.	4.20	3.80	4.27	4.09
		CEDC (3 lb/A)	3.61	3.98	3.88	3.82
	Broadcast	None (Ck)	4.47	4.56	5.04	4.69
		CEDC (3 lb/A)	4.42	4.61	4.90	4.65
20.0	Drilled in 6" rows	None (Ck)	3.86	3.86	4.16	3.96
		Clean Cult.	3.77	3.98	4.36	4.04
		CEDC (3 lb/A)	4.00	3.70	4.43	4.04
	Broadcast	None (Ck)	4.00	4.43	4.40	4.28
		CEDC (3 lb/A)	4.13	4.52	4.35	4.33
40.0	Drilled in 6" rows	None (Ck)	4.59	4.20	5.58	4.79
		Clean Cult.	3.86	4.65	4.53	4.35
		CEDC (3 lb/A)	3.92	4.32	4.57	4.27
	Broadcast	None (Ck)	4.49	4.16	4.60	4.42
		CEDC (3 lb/A)	4.26	4.48	4.57	4.44
Avg.		4.11	4.20	4.50		

† Planted on September 7, 1961 and harvested October 28, 1961.

## Oklahoma's Wealth in Agriculture

Agriculture is Oklahoma's number one industry. It has more capital invested and employs more people than any other industry in the state. Farms and ranches alone represent a capital investment of four billion dollars—three billion in land and buildings, one-half billion in machinery and one-half billion in livestock.

Farm income currently amounts to more than \$700,000,000 annually. The value added by manufacture of farm products adds another \$130,000,000 annually.

Some 175,000 Oklahomans manage and operate its nearly 100,000 farms and ranches. Another 14,000 workers are required to keep farmers supplied with production items. Approximately 300,000 full-time employees are engaged by the firms that market and process Oklahoma farm products.