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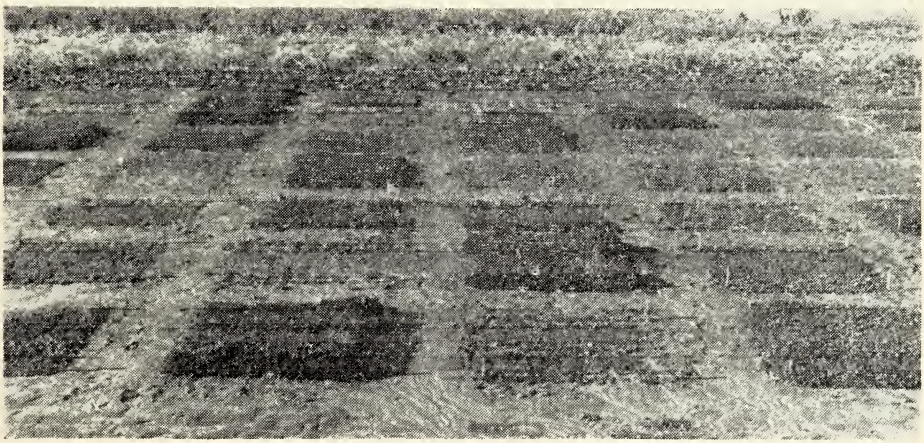

On Distribution of Yield and Seed Production of CRIMSON CLOVER

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The Effect of Thickness of Stand On Distribution of Yield and Seed Production of Crimson Clover

By W. E. KNIGHT[1]

A new concept in forage crop management has been under investigation at the Mississippi Experiment Station for five years. This research, in cooperation with the Crops Research Division, U. S. D.A., showed that dense stands of crimson clover produced earlier fall and winter growth and much greater yields of high quality forage than thin stands.

Crimson clover, **(Trifolium incarnatum L)** is the most versatile and widely adapted winter annual legume crop of the southern region and is extensively used in the coastal section of the western states. It is a soil building crop and does well when grown with annual and perennial grasses and with small grains. For winter and early spring pastures, crimson clover is outstanding in total production of high quality forage. Good yields of seed provide another source of cash farm income.

Few experiments have been reported in which seedling rates of forage crops have been studied in conjunction with factors of the environment. Basic information is needed on management of crimson clover so as to obtain adequate stands and subsequent high yields of forage and seed, and to delineate physiological and ecological interactions essential to its improvement.

It was the purpose of this investigation to study the effects of stand density of crimson clover on physiological and morphological characteristics of the crop, on forage and seed production, and on the incidence of disease.

This investigation, begun in the fall of 1953, has been in progress five years. Dixie crimson clover was grown in square yard field plots in a latin square design. Plantings were made to the edges of the plots. Alleys, two feet wide, were left between plots to facilitate taking records. Plots and alleys were kept free of weeds. Entire plots were harvested for yields. Acre yield calculations are based on a square yard area, plus one-half the distance between plants added to each dimension of the plot. Planting was made the third week in September each year on Leeper fine sandy loam. This soil is reddish brown in color, well drained, and considered an excellent soil for crimson clover.

In 1953, six spacings were used as follows: 3/4, 1½, 3, 6, 12, and 18 inches. In 1954, a 9-inch and a 15-inch spacing were included with those above. The planting plan was altered in 1955 based on the results from the first two seasons. Additional spacings of 1, 2 and 4½ inches were used to provide more continuous data on the relationship of stand density to early growth, and the spacings greater than 6-inches were omitted. This provided a range in number of plants per plot from 2401 for the 3/4-inch spacing down to 49 plants per plot for the 6-inch spacing and a range in calculated seeding rate from 79.6 to 1.2 pounds of seed per acre, respectively. Figure 1 shows the plots after establishment and illustrates the experimental layout. (See cover.)

The plots were prepared, seeded, and watered by hand to promote establishment and maintenance of stands. The stands were thinned while the seedlings were in the unifoliate stage of growth. All blank spaces were reseeded and additional water was applied until the stands were fully established. Watering was continued for approximately 2 to 3 weeks

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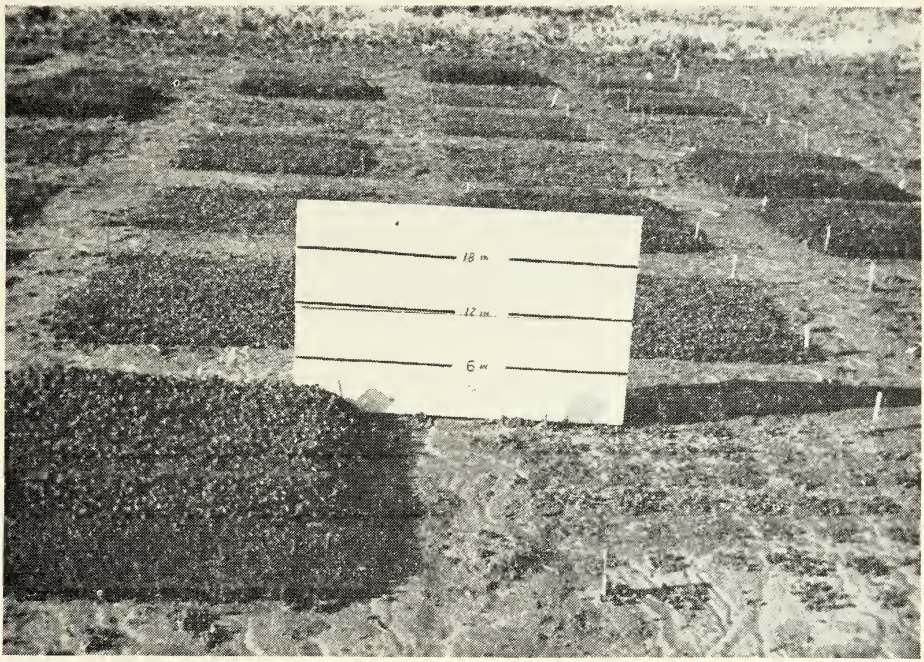

Figure 2. Comparative growth of crimson clover on November 27, 1956 in spacings of 3/4 inch left, and 6 inches right.

after the first seeding. An excess of inoculum was applied with the water after the stands were established to insure thorough and uniform inoculation.

Height, number of vegetative stems, number of seed heads per plant, number of florets per head, and forage yield were measured at full bloom. In addition to these measurements, periodic soil temperature readings were taken in the upper one-half inch of soil beginning with the 1954-55 growing season on selected critical dates, when the minimum air temperatures were low and high. Height measurements were also taken periodically during the growing seasons of 1955-56, 1956-57; and 1957-58. After December 26, 1955, soil temperature, in the upper one-half inch of soil, was recorded by soil thermographs placed in a 3/4-, 2-, and 6-inch spacing. Seed yields were taken in 1956, 1957, and 1958.

Clipping treatments were used during the 1956-57 seasons to determine the effect of forage removal upon the disease caused by **Sclerotinia trifoliorum** Ericks, and to provide a quantitative measure of yield distribution. The plots were clipped when the clover reached a height of 6 inches, leaving a 3-inch stubble.

Results and Discussion

Every year there was a close relationship between stand density and the rate of growth. On November 29, 1955, the clover grown at the 3/4-inch spacing averaged more than 7 times the height of that at the 6-inch spacing on the same date. Typical differences in fall growth of crimson clover grown in various spacings are shown in Figure 2. The plants spaced 3/4 inch had made 6 inches of growth and were ready for clipping on November 5, 1956, whereas, the plants at the 6-inch spacing did not reach 6 inches until February.

Forage yields taken in the full bloom stage did not provide an adequate indication of the differences in early growth and yield distribution. The distribution of forage production measured by clip-

ping treatments initiated in the fall of 1956 is shown in Table 1. Dense stands of crimson clover produced high quality forage in the fall when green forage is usually in short supply. For example, the clover at the 3/4-inch spacing produced an average of 10,634 pounds of green forage per acre on December 5, 1956, with a dry matter content of 18.3%, while a somewhat similar yield for 6-inch spacing did not occur until March 1.

Clipping during the growing season reduced total forage production by an average of 609 pounds of dry matter per acre. However, the forage from the clipped plots was of high quality, being composed largely of leaves and fine stems. Forage from the plots which were not clipped during the growing season was of poor quality containing a large number of coarse stems.

Yields of dry forage varied widely with seasonal differences (Table 2). In 1953-54 forage yield increased as stand density increased, however differences between the 3/4-, 1 1/2- and 3-inch spacings were not significant. The damage from the March 25, 1955, freeze prevented a similar comparison for 1954-55. The yield data for 1955-56 indicates an increase in yield with stand density through the 2-inch spacing but shows a breakdown of the trend for the 3/4-, 1- and 1 1/2-inch spacings. Mules grazed these treatments on January 1, 1956. The widely spaced plants had insufficient growth for grazing at this time and the total yields for the closely spaced plants were biased downward.

Seed yields are presented in Tables 1 and 2. In 1956-57 and in 1957-58 severe lodging occurred before the plants were in full bloom and this condition apparently caused poor pollination and lower seed yields than in 1955-56. The 1955-56 crop lodged also, but lodging occurred

Table 1. Average yields of forage and seed from crimson clover at various spacings. Forage clipped at 3 inches when 6 inches high.

1956 - 57

Spacing	Dates of clipping and dry forage per acre							
	Dec. 5 1956	Dec. 17 1956	Feb. 4 1957	Feb. 12 1957	Feb. 21 1957	Apr. 26 1957	Season Total	Seed
in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
3/4	1904			2601		8173	12,678	360
1	2062			3345		6873	12,280	504
1 1/2		1918			1784	9859	13,561	491
2			3432			9237	12,669	457
3				2969		6598	9,567	227
4 1/2					1377	6883	8,260	294
6					1280	5867	7,147	267
L.S.D. 5%							2,710	
C. V.							8.9%	

1957 - 58

	Dates of clipping and dry forage per acre						
	March 10 1958	March 20 1958	March 27 1958	April 3 1958	April 24 1958	Season Total	Seed
in.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
3/4	2717				7895	10,612	656
1	2830				8996	11,776	489
1 1/2	2554				7807	10,361	825
2		2717			7129	9,841	593
3			1523		7722	9,245	813
4 1/2			803		6067	6,870	796
6				1049	4279	5,228	732
L.S.D. 5%						1,385	
C. V.						10.2%	

after the bloom stage of growth and seed yields were not affected. Clipping the forage during the growing season, in 1956-57, reduced seed yields by an

Table 2. Plant characteristics of crimson clover grown at various spacings for 4 years.

Spacing	Height at Maturity	Seed heads/ plant	Florets/ head	Vegetative stems/ plant	Dry forage	Seed
in.	in.	no.	no.	no.	lbs./A.	lbs./A.
			1953-54			
3/4	31.4	1.0		1.4	7102	
1 1/2	34.3	1.7		2.2	6119	
3	30.9	5.2		6.3	5473	
6	26.0	8.1		7.0	2831	
12	21.7	8.5		8.2	642	
18	20.7	6.5		5.5	347	
LSD 5%	3.31	4.9		1.4	819	
C. V.	12%	36%		26%	20%	
			1954-55			
3/4*	-----	-----	-----	-----	-----	
1 1/2*	-----	-----	-----	-----	-----	
3*	26.2	10.2	52	10.0	7185	
6	25.1	26.8	81	25.8	6860	
9	26.3	52.3	74	34.4	5506	
12	23.4	52.1	79	25.8	4252	
15	22.3	68.1	83	32.6	2762	
18	21.1	58.9	80	27.3	2515	
LSD 5%	2.61	15.6	18	9.3	1100	
C.V.	12%	18%	25%	19%	18%	
			1955-56			
3/4	27.0	1.0	82	1.6	12,589	1370
1	28.0	1.7	83	2.4	13,437	1352
1 1/2	29.8	2.4	101	2.7	12,454	1731
2	31.2	2.7	100	4.1	13,271	1439
3	32.6	6.9	106	9.9	11,653	1491
4 1/2	31.2	11.5	120	16.5	9,946	1440
6	32.0	13.1	116	16.3	8,576	1528
LSD 5%	2.7	1.7	7	1.6	1,510	NS
C. V.	8%	22%	11%	18%	10%	7%
			1956-57			
3/4	29.8	1.4	94	1.6	14,396	404
1	29.0	2.3	88	2.5	11,956	667
1 1/2	33.8	2.4	90	3.2	12,625	536
2	33.6	3.5	89	4.6	13,643	507
3	30.8	7.6	98	8.9	11,259	258
4 1/2	33.4	11.9	111	16.4	8,260	478
6	33.0	15.0	98	25.8	8,285	287
LSD 5%	NS	1.92	NS	1.63	1,694	
C. V.	10%	25%	13%	14%	11%	
			1957-58			
3/4	27.8	1.0	85	1.5	10,612	656
1	28.5	1.0	112	2.0	11,776	489
1 1/2	26.8	1.5	111	2.8	10,361	825
2	29.0	2.8	118	4.3	9,841	593
3	31.3	5.3	120	8.5	9,245	813
4 1/2	29.0	9.5	120	15.3	6,870	796
6	28.6	17.0	131	20.5	5,228	732
LSD 5%	NS	2.48	23.3	2.55	1,385	
C. V.	10%	23%	13%	18.3%	10.2%	

*Plants spaced 3/4 and 1 1/2 inches were killed and the plants spaced 3 inches were damaged by a freeze on March 25, 1955.

average of 89 pounds per acre.

The marked effect of stand density on the number of vegetative stems and the number of seed heads produced by crimson clover is evident in the summary of measurement of plant characteristics (Table 2). Seed heads per plant averaged 1.1 and 15.7 for the 3/4-and 6-inch spacing treatments, respectively, and stems per plant averaged 1.5 and 18.7 for the same treatments. The ability of crimson clover to compensate for thin stands by branching is clearly shown by the number of vegetative stems per plant. The large number of seed heads produced as a result of branching could be very important in the establishment year of a re-seeding variety. Branching to compensate for thin stands may not be too important from the standpoint of forage production since the growth from thin stands always occurred late in the growing season.

Flower stems were always initiated earlier in the dense stands and resulted in slightly earlier blooming. The plants in the thickly seeded plots shown in Figure 3 were in the late bud stage of maturity in early March 1955, whereas, the plants in the thinly seeded plots were vegetative.

Height at maturity and number of florets per head were less affected by stand density than were the numbers of stems and numbers of seed heads. Seasonal variations apparently affected by these characteristics as much as did stand density.

Height measurements, used as an indication of fall growth of crimson clover grown in various spacings, are summarized in Tables 3 and 4. In some instances, the height of plants was lower than for the preceding date due to freezing of the upper leaves. The tendency of crimson clover plants to grow prostrate until leaves of adjacent plants touch is indicated by these height measurements. Therefore, some of the measured differences in height are a direct result of stand density or plant competition.

Surface soil temperatures under the various spacings was another factor contributing to growth differences of crimson clover. The typical soil temperature readings summarized in Table 3 show that the dense stands had a temperature advantage over widely spaced plants. This difference was sufficient to prevent ice crystals from forming in the surface of the soil under these stands, when the air temperature was below freezing and the ground was frozen under the wide spacings. Average minimum temperature readings presented in Table 4 follow the same trend but the averages do not reveal the differences that existed on critical dates when the air temperature was low. In general, minimum temperature readings were higher and the maximum temperature readings were lower under the dense stands than under the thin stands. The lower maximum temperatures under thick stands undoubtedly conserved moisture, particularly in the fall. Soil temperature differences probably accounted for much of the difference in early growth, however, plant competition has been mentioned as one of the factors controlling early growth.

Crown rot (**Sclerotinia trifoliorum**) caused extensive damage to the dense stands each year, except 1953-54. The greatest damage from rot occurred in February and March of 1955. The thick stands were particularly affected with no apparent damage to the stands in spacings greater than 3 inches. Clipping the forage during the growing season of 1956-57 gave good control of crown rot. The plants in the clipped plots were not killed although the disease was present. Typical areas of dead plants were common in the thick stands which were not clipped.

Wide variations in weather occurred during the 4 years of this experiment with extremely dry fall weather prevailing during the first 2 years. High temperatures and drying winds apparently reduced the efficiency of the water applied since the established plants made very little growth until rain occurred. Fall moisture condi-

tions were good during the fourth and fifth years of this test and excellent fall growth was produced. The plants in spacings greater than 3 inches were severely damaged by heaving during November and December 1953, but no evidence of heaving was observed in the 3/4-inch spacing. The relatively large coefficients of variation for the 1953-54 data are caused by the varying degrees of damage from heaving (Table 2).

An unseasonal freeze on March 25, 1955, killed the plants spaced 3/4 and 1 1/2 inches and severely damaged the plants spaced 3 inches. Cold injury to plants in the remaining treatments was confined to the outer leaves since these plants were vegetative and had not initiated flower stems as had the closely spaced plants (Figure 3). Weather conditions during the late fall and winter of 1955-56 and the fall and winter of 1956-57 were much more favorable for growth of crimson clover than in the two previous growing seasons. Dense stands produced earlier fall growth measured by height and forage yields under both favorable weather conditions.

Results

Results of this research can be applied in the management of volunteer or reseeding stands of crimson clover. Areas of reseeding clover can be fertilized and disked in late August. If necessary and available, supplementary water can be applied to obtain early stands. A good crop of seed from a reseeding variety will assure the presence of adequate seed to provide a dense stand. Early establishment of a dense stand of crimson clover should provide grazing in November with normal rainfall. Protection from grass worms will be necessary, if an infestation occurs to avoid loss of the stand.

Every year, clover in dense stands produced earlier fall and winter growth and greater forage yields than that in thin stands. On November 29, 1955, the clover in the 3/4-inch spacing averaged 5.14 inches in height, whereas, that at the 6-inch spacing averaged 0.7 inch. On December 5, 1956, the clover at a 3/4-inch spacing produced an average of 10,634 pounds of green matter per acre with

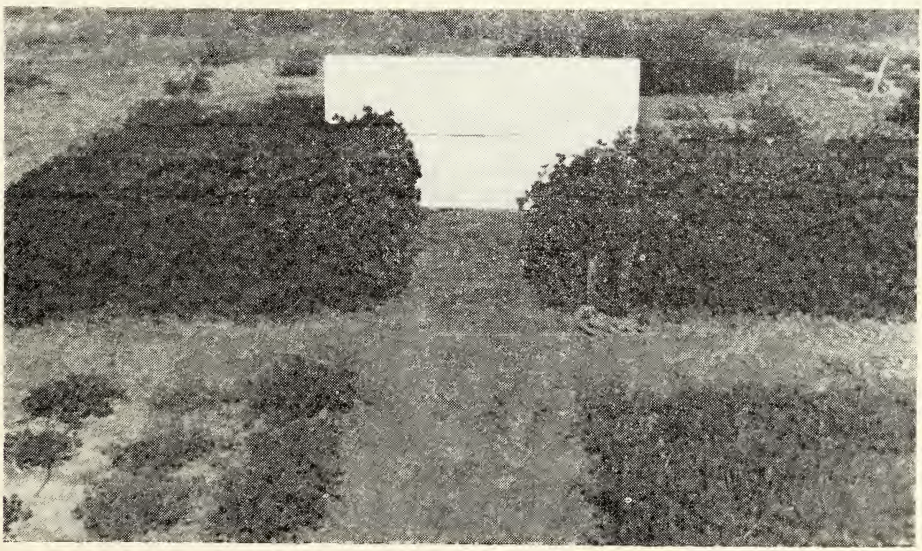

Figure 3. Growth of crimson clover on March 6, 1955, in a 3/4 inch and 1/2 inch spacing from left to right in the background, and a 9-inch and a 6-inch spacing from left to right in the foreground.

a dry matter content of 18.3 percent, while a somewhat similar yield for 6-inch spacing did not occur until March 1.

Stand density had a marked effect on the number of vegetative stems and the number of seed heads produced by crimson clover. Seed heads per plant average 1.1 and 15.7 for the 3/4 - and 6-inch spacings, respectively, and stems per plant averaged 1.5 and 18.7 for the same treatments. Seasonal variation apparently affected height at maturity and number of florets per head as much as did stand density.

In general, an increase in stand density produced an increase in total forage yield. In 1955-56, the clover at 3/4-inch spacing averaged 4,013 pounds of dry matter per acre more and 158 pounds of seed per acre less than at the 6-inch spacing.

Dense stands of crimson clover were damaged by disease when the forage was not clipped. In 1956-57, clipping the forage controlled the disease during the growing season. Total dry forage yields were reduced an average of 609 pounds per acre by clipping and seed yields were reduced an average of 89 pounds per acre. Forage from the clipped plots was of much higher quality than that from the unclipped plots.

Table 3. Soil temperatures on selected dates and plant height of crimson clover at various spacings, 1955.

	Soil temperature, 8-8:30 a.m. and date of measurement				Soil temperature and height, Nov. 29, 1955		
Spacing	Jan. 26 1955	Jan. 28 1955	Feb. 12 1955	Feb. 26 1955	Spacing	Height	Temperature
in.	°F.	°F.	°F.	°F.	in.	in.	°F.
3/4	34.2	34.4	32.8	46.8	3/4	5.14	36.1
1 1/2	34.8	33.2	32.4	47.2	1	4.86	34.9
3	31.6	30.0	30.0	48.6	1 1/2	3.50	32.3
6	30.2	30.0	29.0	50.2	2	2.18	29.9
9	30.0	29.8	29.0	50.4	3	1.36	28.9
12	30.6	29.8	28.8	49.8	4 1/2	0.79	28.7
15	30.0	29.8	29.0	50.0	6	0.71	28.6
18	30.0	29.8	29.2	50.8	.....	.....	.....
36	30.0	30.0	29.2	50.6	.....	.....	.....
Minimum air temperature	26.0	21.0	21.0	46.0	.....	.....	21.0

Table 4. Minimum and maximum soil temperatures under crimson clover at different spacings and clover height, 1956-57.

	Height of plants and soil temperatures measured in the upper 1/2 inch of soil								
	3/4 inch spacing			2 inch spacing			6 inch spacing		
Dates of observations	Height	Temp.* min.	Temp.* max.	Height	Temp.* min.	Temp.* max.	Height	Temp.* min.	Temp.* max.
	in.	°F.	°F.	in.	°F.	°F.	in.	°F.	°F.
1956-57									
Oct. 25	3.6	61	73	1.6	59	79	1.3	62	84
Nov. 5	6.9	62	71	2.3	57	81	0.9	57	83
Nov. 12	7.4	56	62	2.5	51	62	0.9	50	71
Dec. 5	7.8	45	53	4.1	43	52	1.8	42	63
Dec. 17	8.0	56	61	5.0	53	60	2.0	56	69
Jan. 7	8.2	54	58	6.6	48	53	2.6	50	61
Jan. 29	8.3	54	59	7.0	44	50	2.8	46	55
Feb. 4	8.3	63	66	8.0	52	57	4.1	56	64
Feb. 12	9.8	67	71	10.0	57	61	7.0	61	69
Feb. 21	9.0	55	61	10.5	45	51	6.5	49	57

*Average temperatures recorded with soil thermographs since previous measurements.