JUNE, 1944 BULLETIN P63

W H Ramsey Jr.

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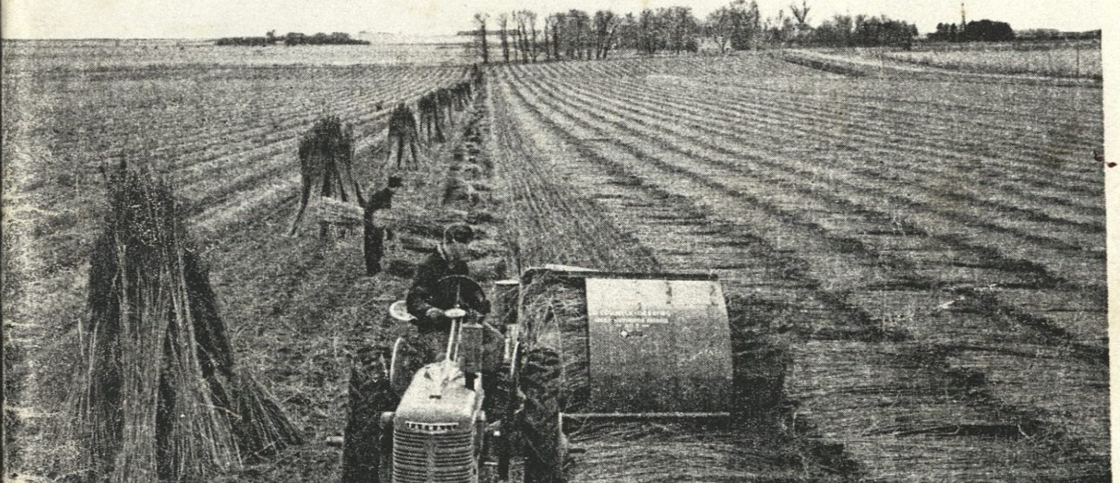
HEMP PRODUCTION Experiments

CULTURAL PRACTICES And SOIL REQUIREMENTS



AGRICULTURAL EXPERIMENT STATION—AGRICULTURAL EXTENSION SERVICE, Cooperating
IOWA STATE COLLEGE AMES, IOWA

THE HEMPSTEAD CO.
2060 PLACENTIA B-2
COSTA MESA, CA 92627

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SUMMARY

Experiments on the rate of seeding hemp in two locations in 1942 indicated that no significant differences in the yield of retted straw were obtained when the seeding rate was varied from 3 to 5 pecks per acre. The percentage of fiber, however, appeared to increase slightly with an increase in the seeding rate, indicating that a higher total yield of fiber might be expected when the higher seeding rates were used.

In 1943, studies on stand in four locations showed that the total stand of plants and the stand of small and dead plants increased rapidly with an increase in rate of seeding, while the stand of desirable plants (4 feet or more in height) increased at a much slower rate. Where there was an excess of nitrogen and the hemp grew extremely tall and rank, much self-thinning occurred, resulting in a relatively thin stand of coarse stalks, a condition not desirable for the production of high quality fiber.

In general, in 1943 as in 1942, there were no significant differences in the yield of retted straw when the seeding rate was varied within rather wide limits. At Kanawha the 5-peck rate outyielded other seeding rates, but there was no definite trend in yield as affected by rate of seeding.

The size of stalks that were more than 4 feet in height was not affected materially by changing the seeding rate. Average stalk size, however, decreased with an increase in seeding rate, due to the higher percentage of small stalks present. The planting of 5 pecks of seed per acre is recommended in preference to 3 pecks because of the greater likelihood that stalks more nearly ideal size, yielding a higher percentage of fiber and a greater total yield of fiber, will be produced.

Drilling of seed was found to be preferable to broadcasting, by producing better stands and higher yields.

A date-of-seeding experiment at Ames indicated that hemp planted May 5 produced higher yields than when planted April 20, and that both of these dates were preferable to May 20 or June 10 in 1943.

Treatment of seed with New Improved Ceresan for the control of seedling diseases was not effective in changing either stand or yield in two field experiments in 1943, but data were not obtained over a sufficiently wide range of soil and weather conditions to justify general recommendations.

Eight replicated fertilizer trials were conducted on six soil types in the hemp-growing area. In experiments employing nitrogen (25 pounds per acre), phosphorus (50 pounds P_2O_5 per acre), and potassium (25 pounds K_2O per acre) singly and in all combinations for hemp, nitrogen gave the most benefit, followed in order by phosphorus and potassium. Average increases in acre yield of dry, retted straw from fertilization ranged as follows: nitrogen, from 0.37 to 0.90 tons; phosphorus, from 0.12 to 0.80 tons; and potassium, from —0.32 to +0.25 tons.

In most instances, the 25-pound application of nitrogen was insufficient to give maximum yields. Nitrogen added at the rate of 100 pounds per acre produced substantial yield increases over those obtained with the 25-pound rate.

The response to phosphorus was limited by the deficiency of nitrogen in a number of cases. Yield increases from phosphorus fertilization generally were larger where nitrogen also was applied than they were where phosphorus was used alone or with potassium. Combinations of nitrogen and phosphorus produced higher yields than did either nitrogen or phosphorus applied singly.

Potassium in general did not increase the yield of hemp, excepting in the highest yielding fields where it appeared to be of some value in combination with nitrogen and phosphorus.

The crops grown prior to the hemp had a marked influence on yield, the highest yield of hemp following crops that left the most available nitrogen in the soil. Considering the yield of hemp following alfalfa and clover as 100 percent, the relative yields of hemp were 75 percent following soybeans, 57 percent following corn and oats and 35 percent following sorghum.

Hemp grown the second year after alfalfa yielded practically as well as it did when grown the first year following that crop. Hemp grown the first year following clover yielded as well as it did following alfalfa; hemp grown the second year following clover yielded considerably less than the first year after clover and about the same as it did the first year after soybeans; and hemp grown 3 to 5 years after clover was not significantly better than that where no legumes had been grown during the 5-year period preceding hemp. The beneficial effect of soybeans disappeared almost entirely in the first year.

Hemp yields were, in general, highest on the soil types which contained the highest quantities of nitrogen and organic matter, provided the drainage was adequate.

Hemp Production Experiments

Cultural Practices and Soil Requirements[1]

By C. P. Wilsie, C. A. Black and A. R. Aandahl[2]

Imports of Manila and sisal fibers from the Philippines and Netherlands Indies were cut off shortly after Dec. 7, 1941. Stock piles of these fibers were inadequate for the rapidly increasing needs of the navy, the army and essential industries. Fiber suitable for the manufacture of rope and other strong cordage suddenly became a strategic war material. American grown hemp *(Cannabis sativa)* appeared to offer the best possibility of meeting the needs of this emergency.

Hemp has been grown in the United States since early colonial days and for many years was used extensively for the manufacture of marine cordage, twines and textile fabrics. During the past century, however, the use of hemp has declined steadily, due primarily to the competition of Manila and sisal fibers in the heavy cordage field, and to the greatly increased use of jute and cotton for common twines and textile purposes.

During World War I the acreage of hemp, grown mainly in Wisconsin and Kentucky, ranged from 10,000 to 15,000 acres but dwindled in postwar years until only about 1,200 acres were grown annually from 1929 to 1933. With the outbreak of the present war in 1939, an increased demand and higher price stimulated production. The acreage in the United States rose to about 7,000 in 1941, 13,500 in 1942 and 176,000 in 1943.

Iowa farmers were asked, early in 1943, to grow 45,000 acres of hemp as their part in the war fiber program. This acreage was distributed in 11 selected areas in north central Iowa, where it was believed that climatic and soil conditions gave the greatest assur-

[1]Project 825 of the Iowa Agricultural Experiment Station, with the cooperation of the Bureau of Plant Industry, Soils and Agricultural Engineering, United States Department of Agriculture.

[2]Research Associate Professor of Farm Crops, Research Associate in Soils, Iowa Agricultural Experiment Station, and Assistant Soil Scientist, Division of Soil Survey, Bureau of Plant Industry, Soils and Agricultural Engineering, United States Department of Agriculture, respectively.

The authors are indebted to the hemp mill managers, county extension directors and farmers whose cooperation made the studies reported in this bulletin possible.

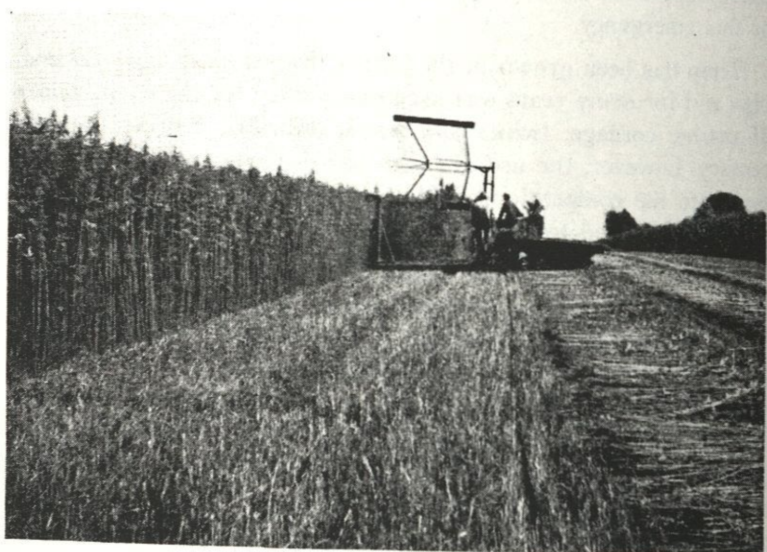

Fig. 1. Harvesting hemp in Tama County, Iowa.

ance of the successful production of a large quantity of good-quality fiber, and where the type of farming and labor conditions suggested the least disturbance of the overall food production program. Hemp had not been grown in Iowa as a farm crop, however, and there was no background of local experience to supply the information necessary for its most effective production. It is true that hemp had been grown in Wisconsin for many years, and full advantage was taken of such information as was available from this area regarding the growing and handling of the crop.

From the standpoint of Iowa conditions, however, such information left much to be desired. Therefore the Iowa Agricultural Experiment Station undertook investigations of some of the agronomic problems of paramount importance to both the grower and the hemp mill manager. The results obtained from these studies in 1943 are presented in this bulletin and include two phases of the general problem: (1) Seeding and other cultural practices as affecting the stand, yield and quality of the hemp; and (2) soil requirements and the effect of fertilizers and of previous crops on the yield of hemp. It is recognized that most of the data given are for 1 year only, but because of their timeliness they are now

being made available. Moreover the reference to soil types and management practices makes it possible, through the use of the soil survey, to extend these results to individual fields.

RATE OF SEEDING

The normal rate of seeding hemp has been about 3 pecks (33 pounds) per acre in Kentucky where the fiber has, until recently, been removed from the straw by hand-breaking.[3] In Wisconsin, where machine-breaking has been used, finer stalks are desired, and the use of five pecks (55 pounds) per acre has been the accepted practice.

In 1942, with the cooperation of the Bureau of Plant Industry, Soils and Agricultural Engineering, United States Department of Agriculture, variety and rate of seeding experiments were conducted at Ames and at Kanawha, 75 miles north of Ames in the heart of the present hemp area. Two varieties were used: Chilean, which was imported from South America, and Kentucky, the com-

[3]Breaking refers to the process by which the woody portion of the stalk is broken into small pieces called hurds, thus allowing the loosened fiber to be separated from the stalk. This separation is accomplished by various methods of beating and scraping, a process known as scutching.

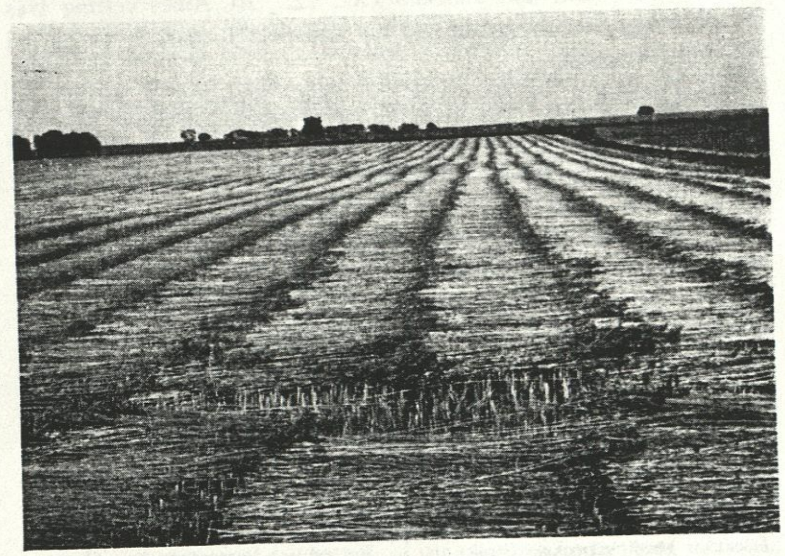

Fig. 2. An excellent hemp crop spread evenly for retting.

mon American variety which traces back to several Chinese varieties introduced many years ago.

The hemp was planted at Ames on May 8 and at Kanawha on May 14. Harvest dates were Sept. 8 at Ames and Sept. 10 at Kanawha, at which time the hemp was cut and spread evenly on the ground for retting. Moisture conditions were favorable at Kanawha and retting proceeded satisfactorily. The hemp was picked up, bound and shocked Oct. 12. At Ames retting was much slower and the hemp was not sufficiently retted to be picked up until Nov. 24.

The Chilean hemp produced only about 40 percent of the yield of the Kentucky variety. It obviously was not well adapted to Iowa conditions, and because of the extremely low yield no data were obtained on fiber from this variety.

Bundle samples of the Kentucky variety were shipped to Madison, Wisconsin, where fiber percentages and fiber yields were determined after milling the hemp with a reciprocating flax brake.[4] A summary of the yield of stalks, retted straw and fiber is given in table 1.

TABLE 1. EFFECT OF RATE OF SEEDING OF HEMP ON YIELD AND PERCENTAGE OF FIBER IN 1942.

Location	Rate of seeding, pecks per acre	Tons per acre, dry wt.		Percentage of fiber	Pounds of fiber per acre
		Stalks at harvest	Retted straw		
Ames	3	4.71	3.60	17.3	1,244
	4	4.50	3.43	17.8	1,225
	5	4.65	3.44	18.3	1,260
Kanawha	3	4.10	3.06	20.1	1,231
	4	4.08	3.05	20.5	1,250
	5	4.33	3.23	22.2	1,436

The data indicate that differences in the yield of retted straw due to changes in seeding rate were not significant. The percentage of fiber, however, appeared to increase slightly with increases in seeding rate, indicating, in the Kanawha experiment, that the total yield

[4]Fiber determinations were made through the cooperation of Mr. H. V. Jordan and Dr. B. B. Robinson of the Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, United States Department of Agriculture.

of fiber per acre was somewhat greater from the 5-peck rate than from the 3-peck rate. In the Ames experiment, however, there was only a slight difference in total fiber yields due to the rate of seeding.

In 1943, the effect of seeding rate on stand of hemp was studied at four locations, Ames, Kanawha, Crystal Lake and Clarinda.[5] At Ames and Kanawha seeding rates were varied from 3 to 6 pecks, at Clarinda (in southwestern Iowa) from 5 to 8 pecks, and at Crystal Lake (on peat soil) from 5 to 11 pecks per acre. Exceptionally high seeding rates were used at Crystal Lake in an attempt to control the size of the stalks, which are likely to be extremely coarse with considerable branching when grown on peat soils.

EFFECT ON STAND

Stand counts were made at harvest time counting the total number of plants per square foot as well as the number of small and dead plants. Plants less than 4 feet in height were considered "small plants," for it was assumed that they would not contribute to the production of line (long) fiber. A summary of stand data from this study is given in table 2 and the results from the Crystal Lake, Kanawha, and Ames experiments are shown graphically in figs. 3, 4 and 5.

It is apparent that the total number of plants per square foot increased steadily with an increase in seeding rate. The number of small and dead plants also increased markedly with the higher rates of seeding, especially at Kanawha and Crystal Lake where growth was rapid, and tall, heavy-yielding hemp was produced. At Ames, where the hemp was considerably smaller, this tendency was much less pronounced. There were very few dead plants in the plots at Ames, while there was an accumulation of considerable dead material at Crystal Lake. Observations throughout the summer indicated that the hemp at Ames was deficient in nitrogen during most of the summer season.

The stand of desirable plants (4 feet or more in height) increased at a much slower rate than did the total stand, although in all experiments there was a consistent trend toward thicker stands as the seeding rate was increased. At Kanawha and at Crystal Lake where the level of nitrogen in the soil was very high and the

[5]Data at Clarinda were obtained through the cooperation of Dr. G. M. Browning, Project Supervisor, Soil Conservation Service, United States Department of Agriculture.

TABLE 2. EFFECT OF RATE OF SEEDING ON THE STAND OF HEMP IN 1943.

Location and soil type	Seeding rate in pecks per acre	Number of plants per square foot: Total stand	Small and dead plants*	Desirable plants (4 ft. or more in ht.)
Kanawha (Webster silty clay loam)	3	13.8	3.3	10.4
	4	17.2	6.1	11.1
	5	25.6	12.3	13.3
	6	29.4	15.7	13.6
	Mean	21.5	9.4	12.1
Crystal Lake (Peat)	5	14.5	7.1	7.3
	7	18.0	10.5	7.5
	9	21.1	12.1	9.0
	11	24.6	15.0	9.6
	Mean	19.6	11.2	8.4
Ames (Webster silty clay loam)	3	14.0	3.4	10.6
	4	17.5	5.1	12.4
	5	19.4	5.4	14.0
	6	22.9	6.9	16.0
	Mean	18.4	5.2	13.2
Clarinda (Marshall silt loam)	5	13.4	3.1	10.3
	8	21.4	9.3	12.1
	Mean	17.4	6.2	11.2

*At Ames and Clarinda, small plants only.

hemp grew tall and rank, doubling the seeding rate resulted in an increase in desirable plants of only about three per square foot. Thick stands were not maintained until harvest time, regardless of the rate of seeding used.

There would appear to be little basis, therefore, for the idea that on "rich" soils a heavier than normal seeding rate should be used. Five pecks per acre should produce a stand that usually is greater than can be supported to maturity and yet develop into desirable sized stalks. The principal effect of planting more than that amount of seed would appear to be a considerable increase in the percentage of small and dead plants, crowded out through the rapid growth of a few plants which had gained an initial advantage. Where less favorable conditions exist, either soil or climatic, a thicker stand might be maintained by a heavier rate of seeding,

although the height of plants in general would be much less than where rapid growth is possible.

EFFECT ON YIELD

The yield of hemp was not affected greatly by changes in seeding rate. In table 3 a summary of yields from the four experi-

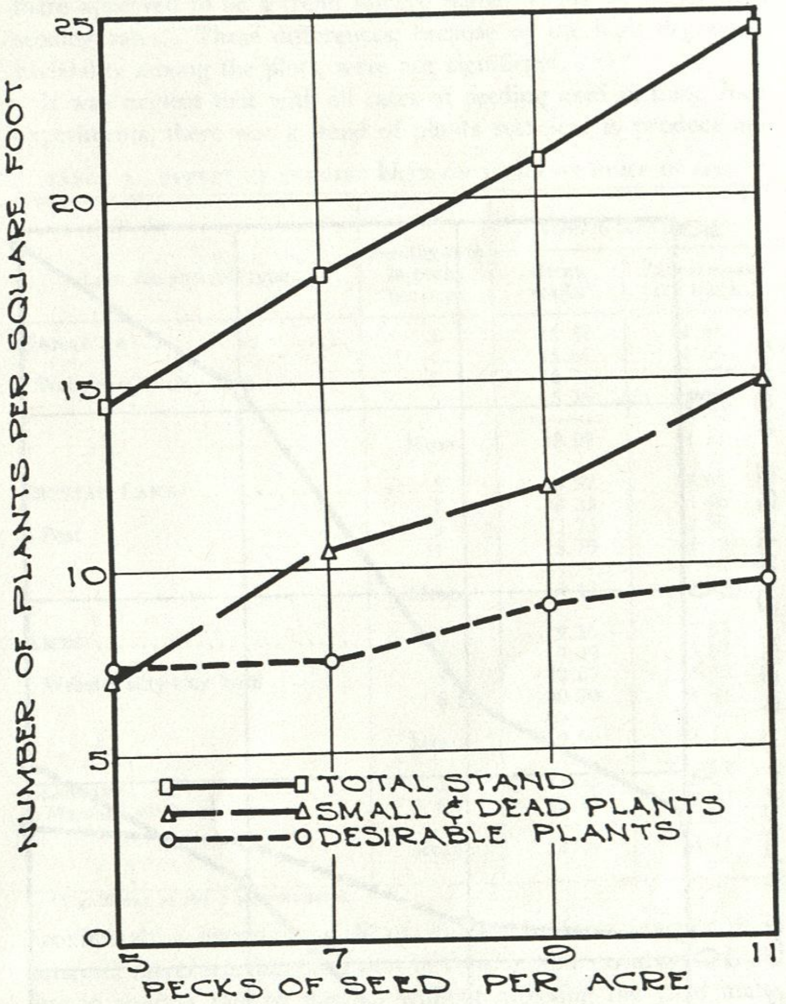

Fig. 3. Effect of seeding rate on stand of hemp on peat at Crystal Lake in 1943.

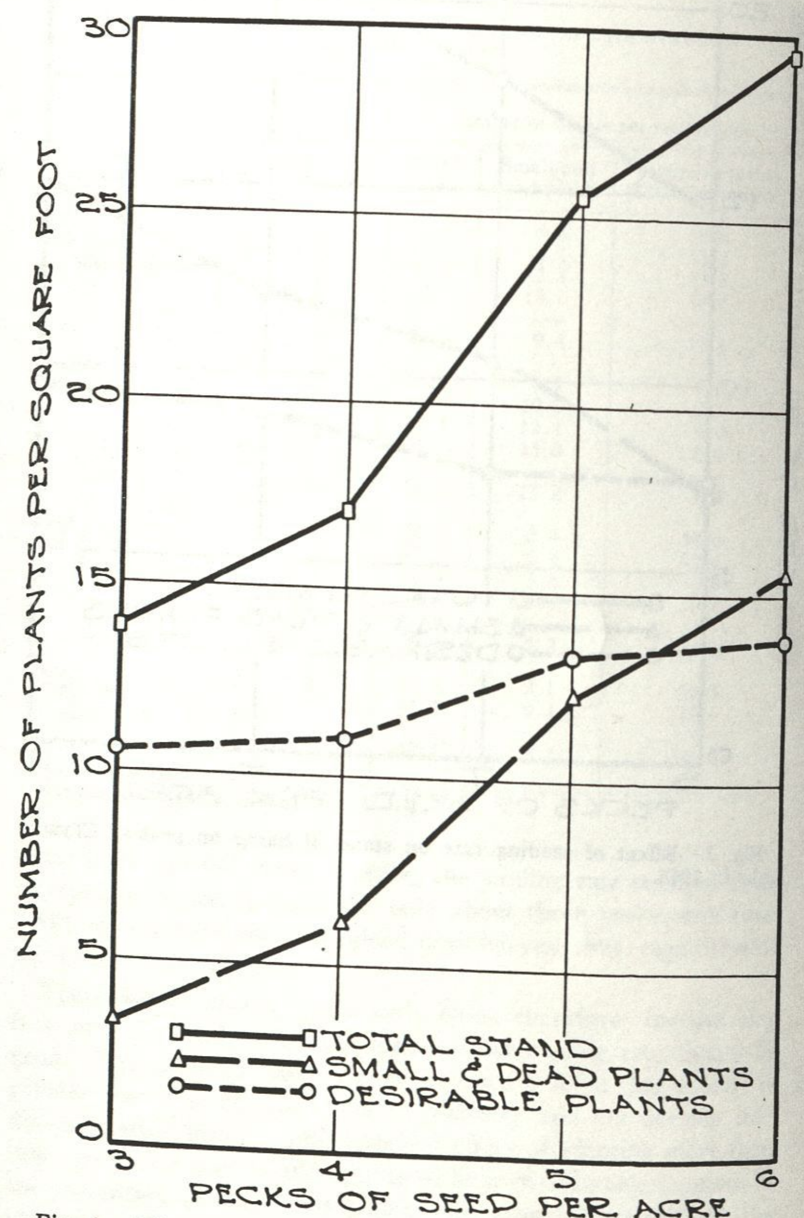

Fig. 4. Effect of seeding rate on stand of hemp on Webster silty clay loam at Kanawha in 1943.

ments previously discussed is given. In only one instance, the 5-peck rate at Kanawha, was there a significant increase in yield due to rate of seeding. In this experiment, however, there appeared to be no definite trend toward increased yields with the higher rates of seeding, and it seems unlikely that the 5-peck rate would actually produce a yield significantly higher than the 6-peck rate. In the Ames experiment, where the hemp was smaller and yields lower, there appeared to be a trend toward higher yields with increased seeding rates. These differences, because of the high degree of variability among the plots, were not significant.

It was evident that with all rates of seeding used in these four experiments, there was a stand of plants sufficient to produce ap-

TABLE 3. EFFECT OF SEEDING RATE ON YIELD OF HEMP IN 1943.

Location and soil type	Seeding rate in pecks per acre	Yield in tons per acre: Green stalks	Yield in tons per acre: Retted straw (dry weight)
KANAWHA	3	15.57	4.61
Webster silty clay loam	4	15.81	4.68
	5	16.76	4.97*
	6	15.75	4.67
	Mean	15.97	4.73
CRYSTAL LAKE	5	14.92	3.61
Peat	7	14.32	3.46
	9	15.73	3.80
	11	15.70	3.79
	Mean	15.17	3.66
AMES	3	9.26	2.96
Webster silty clay loam	4	9.59	3.07
	5	10.07	3.10
	6	10.70	3.38
	Mean	9.90	3.13
CLARINDA	5	12.36	3.77
Marshall silt loam	8	12.13	3.70
	Mean	12.24	3.74

*Significant at the 5 percent level.

proximately a maximum yield of stalks. In farm practice, it is believed, therefore, that there may be considerable variation in stand due to seeding rate or method without affecting the yield materially. With a definite indication of a slightly thicker stand and a higher percentage of fiber from the heavier rates of seeding, 5 pecks per acre would appear to be preferable to 3 pecks. There is no evidence to indicate that it would be worth while to plant much more than 5 pecks of good seed per acre.

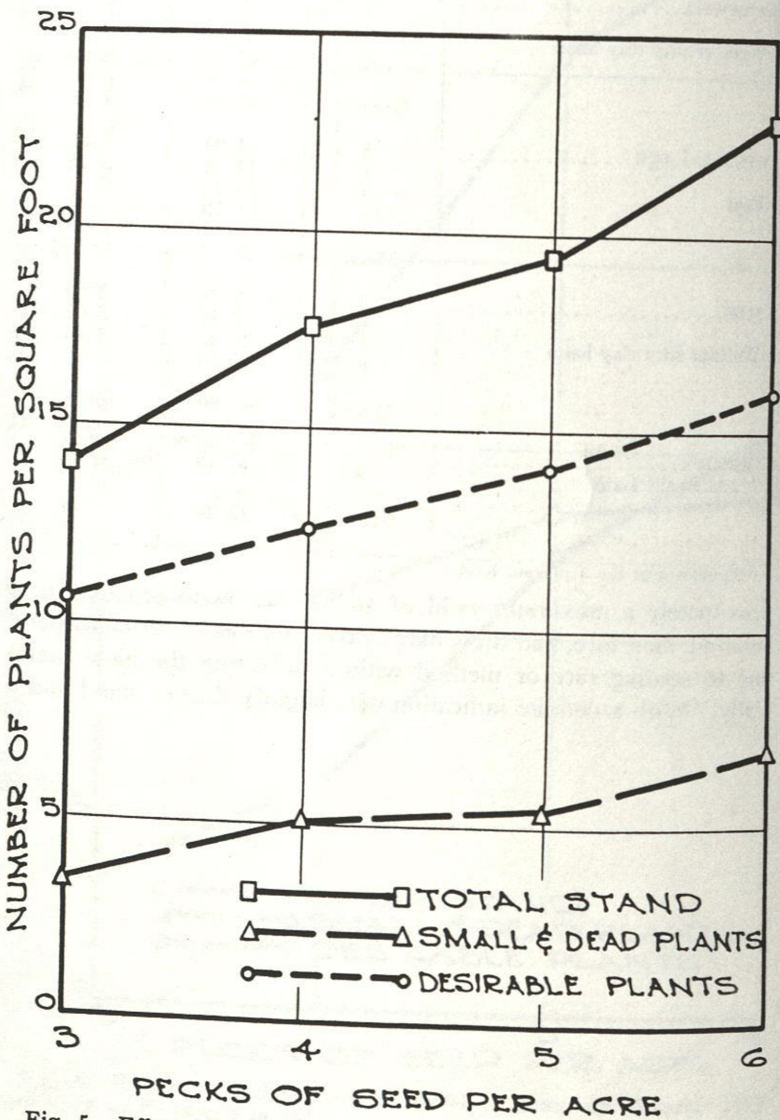

Fig. 5. Effect of seeding rate on stand of hemp on Webster silty clay loam at Ames in 1943.

EFFECT ON STALK SIZE

Tall, slender stalks 6 to 8 feet in height, with a diameter about the size of a lead pencil, are considered best for the production of high-quality fiber. Some studies were made during the 1943 season on stalk size as affected by seeding rate and fertilizer treatment. In general, where plenty of nitrogen was available in the soil the stalks were taller and coarser than where nitrogen was deficient.

It was assumed that small plants, less than 4 feet in height, probably would not make line fiber, and only the larger plants were included. Measurements, in inches, of stalk length and diameter 18 inches from the base, obtained from the different rates of seeding at three locations, are given in table 4.

TABLE 4. EFFECT OF RATE OF SEEDING ON SIZE OF STALKS DESIRABLE FOR LINE FIBER PRODUCTION IN 1943.

Seeding rate pecks per acre	Kanawha		Ames		Cyrstal Lake	
	Stalk length in inches	Stalk diameter in inches	Stalk length in inches	Stalk diameter in inches	Stalk length in inches	Stalk diameter in inches
3	76.4	0.22	62.0	0.18		
4	79.2	0.25	61.5	0.19		
5	77.6	0.22	59.3	0.17	80.1	0.35
6	78.2	0.22	61.3	0.17		
7					82.0	0.34
9					82.1	0.34
11					80.6	0.35

The data indicate that in these experiments there was no appreciable effect due to seeding rate, on either length or diameter of the stalks that were 4 feet or more in height, although the data from the Ames plots indicated a slight trend toward a decrease in stalk size with an increase in seeding rate. It should be remembered that these data are for the desirable plants only and do not represent measurements of the average of all plants including the small ones, which may increase rapidly with an increase in seeding rate.

The effect of phosphate and potash fertilizer treatments on stalk size was determined at Crystal Lake on peat soil. As indicated in table 5 there was no difference in stalk height or diameter of plants from the fertilized and non-fertilized plots.

Fig. 6. A thick stand of tall, slender stalks is desired for high yields of good quality fiber.

TABLE 5. EFFECT OF FERTILIZER TREATMENT ON SIZE OF HEMP STALKS GROWN ON PEAT SOIL AT CRYSTAL LAKE IN 1943. (STALKS 4 FEET OR MORE IN HEIGHT ONLY)

Fertilizer treatment*	Stalk height in inches	Stalk diameter in inches
3P 3K	82.9	0.32
3P	85.2	0.33
3K	80.4	0.32
None	84.9	0.32

*3P = 150 pounds P_2O_5 per acre.
3K = 75 pounds K_2O per acre.

METHOD OF SEEDING

While it is customary to drill hemp seed in Wisconsin and Kentucky, much of the crop in Iowa in 1943 was sown with various kinds of broadcast seeders, including the endgate seeder used so widely for oats in this region. Where drills were available, they were used extensively, but the number was insufficient to plant a large portion of the crop.

An experiment conducted at Ames compared stands and yields obtained from drilling and broadcasting, using different rates of seeding. Broadcasting was accomplished by removing the drill spouts and arranging a board under the feed openings in such a manner that the seed was scattered uniformly on top of the soil just ahead of the drill disks. Stand and yield data are given in table 6 and show that drilling was preferable to broadcasting at all rates of seeding used.

DATE OF SEEDING

Experience of growers in Wisconsin indicated that hemp could be planted successfully from April 15 to June 1, with optimal dates probably from May 1 to 15. A date of seeding experiment was conducted at Ames in 1943, using both Kentucky and Chilean hemp and extending from April 20 to June 10. The same drill, the same rate of seeding, and, as far as was possible, the same kind of seedbed preparation were used. A summary of yield data and plant height is given in table 7.

Planting on May 5 produced the highest yields and tallest plants with both Kentucky and Chilean varieties. April 20 appeared to be

TABLE 6. EFFECT OF METHOD OF SEEDING ON THE STAND AND YIELD OF HEMP ON WEBSTER SILTY CLAY LOAM IN 1943.

Method of seeding	Pecks per acre sown	Plants per square foot	Tons per acre of dry retted straw
Broadcast	3	6.2	2.60
Drilled	3	14.0	2.90
Broadcast	4	8.2	2.91
Drilled	4	17.5	3.01
Broadcast	5	10.4	2.75
Drilled	5	19.4	3.16
Broadcast	6	10.2	3.07
Drilled	6	22.9	3.36
Mean { Broadcast	4.5	8.8	2.83
Mean { Drilled	4.5	18.4	3.10*

Planted April 28
Harvested September 6 and 7
*Mean difference significant at 1 percent level.

TABLE 7. EFFECT OF DATE OF SEEDING HEMP ON YIELD, STAND AND PLANT HEIGHT ON WEBSTER SILTY CLAY LOAM AT AMES IN 1943.

Variety	Date of seeding	Tons per acre dry retted straw	Plants per square foot	Plant height in inches
Kentucky	April 20	3.74	22	68
	May 5	3.88	24	72
	May 20	1.82	14	61
	June 10	0.82	16	38
Chilean	April 20	1.71	9	61
	May 5	1.86	7	67
	May 20	0.31	..	41
	June 30	Failed	..	..

a more favorable time than May 20, while June 10 proved to be entirely too late. While it is recognized that but 1 year's results should not be considered conclusive, these data suggest that planting in late April or in early May, before corn planting, is desirable.

SEED TREATMENT

Greenhouse experiments conducted in the early spring of 1943 indicated a marked increase in seedling stands from seed treatment with New Improved Ceresan, Arasan, Spergon and other seed

disinfectants.[6] On the basis of these and other similar tests conducted in other states, it was decided that the commercial seed should be treated. At the same time it was recognized that few if any field data were available to indicate the benefit that might result from seed treatment.

Field studies during the 1943 season include two seed treatment experiments, one at Ames and one at Kanawha. The hemp seed used was commercial Kentucky-grown seed, testing 95 percent laboratory germination. The treatment was New Improved Ceresan applied at the rate of one-half ounce per bushel. These experiments were combined with the rate of seeding trials in such a way that there were 20 replications of plots planted with treated and non-treated seed in the Ames trial and 16 replications in the Kanawha experiment. The results are given in table 8.

At Ames, counts made on May 26 and again at harvest time on Sept. 6 showed little or no difference due to seed treatment.

TABLE 8. EFFECT OF SEED TREATMENT ON STAND AND YIELD OF HEMP IN 1943.

Location and planting date	Seed treatment	Plants per square foot				Yield of stalks, tons per acre dry weight
		Seedling stage May 26	At harvest Sept. 6-13			
			Total plants	Small & dead	Large plants	
Ames, April 28	New Imp. Ceresan*	23.2	18.5			3.61
	None	22.5	18.4			3.68
Kanawha, May 1	New Imp. Ceresan*		22.2	10.1	12.1	5.12
	None		20.8	8.7	12.1	5.16

*One-half ounce per bushel.

There also was no difference in the yield of stalks. At Kanawha the stand count on Sept. 13, when the crop was harvested, was broken down into two classes, (1) small and dead plants, and (2) large plants 4 feet or more in height. The data show no significant differences either in stand or in yield.

These data are not to be interpreted as indicating that commercial seed treatment for the 1943 crop was unnecessary. They do

6Seed treatment experiments were conducted with the cooperation of Dr. C. S. Reddy of the Botany and Plant Pathology Section and Dr. B. B. Robinson of the U. S. Department of Agriculture.

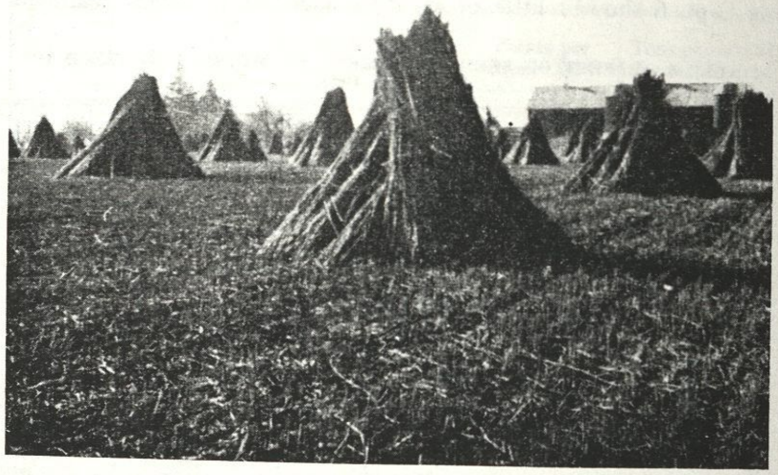

Fig. 7. Retted hemp in the shock is left to dry for a few days before it is stacked.

indicate, however, that under the conditions prevailing in these two experiments, seed treatment was not beneficial. Further experiments, conducted over a wide range of field, seed and seasonal conditions, are needed before reliable recommendations on hemp seed treatment can be made.

EFFECT OF FERTILIZERS ON HEMP

The importance of selecting fertile, well-drained soils for the production of hemp for fiber is generally strongly emphasized. Previous experience in hemp-growing areas has shown that the hemp crop responds greatly to variations in soil fertility and drainage.

In the past, hemp generally has been grown on soils lower in inherent fertility than those selected in Iowa. Other crops grown on the soils selected for hemp in Iowa usually produce high yields and give little response to fertilization. However, no definite information was available as to the response of hemp to fertilizers on these soils.

To determine the value of commercial fertilizers in hemp production, eight replicated experiments were conducted in the hemp-growing area on the more important soil types. Nitrogen, phos-

TABLE 9. LOCATION, SOIL TYPE AND CROPPING HISTORY OF FERTILIZER EXPERIMENTAL FIELDS.

Field No.	Soil type	Name of cooperator and location of field	Past management of field*				
			1938	1939	1940	1941	1942
1	Webster silty clay loam	Northern Iowa Experimental Assoc. Farm, Hancock County	Flax and alfalfa	Alfalfa	Alfalfa	Sugar beets (125 lbs., 0-20-0)	Corn
2	Clarion loam	Iowa State College, Agronomy Farm, Story County	Corn	Wheat	Oats	Oats and clover	Clover**
3	Clarion loam	S. C. Schrage Farm, Wright Co.	....	Oats	Corn	Soybean hay	Corn
4	Clarion loam Webster silt loam	Harold Perkins Farm, Hancock County	Sweet clover	Corn	Oats and sweet clover	Corn	Oats and sweet clover
5	Carrington loam	F. C. Cahalan & Roy Vosbergh Farm, Cerro Gordo County	....	....	Corn	Soybeans (Limed)	Corn
6	Carrington silt loam	Jay Hillman Farm, Floyd County	Corn	Oats and sweet clover	Corn	Oats and sweet clover	Corn
7	Tama silt loam	S. S. Wilson Farm, Tama County	Soybeans	Corn	Soybeans	Corn	Soybeans†
8	Tama silt loam	Jos. B. Kucera Farm, Tama Co.	Corn	Oats	Corn	Soybeans	Soybeans
9	Tama silt loam	Margaret Axon and Dean P. Thomas Farm, Tama County	Oats and clover	Corn	Soybeans	Corn	Soybeans
10	Clarion loam	Iowa State College Alumni Assoc. Farm, Hancock County	....	....	....	....	....
11	Webster silt loam	Mark Miller Farm, Hancock County	....	Corn	Corn	Oats and sweet clover	Sweet clover
12	Carrington loam	Julius Meier Farm, Floyd Co.	Oats and clover	Clover	Corn	Oats and clover	Clover

*Soil treatments are indicated beneath the crop where any were applied. The term "clover" refers to red clover, alsike clover, or to mixtures including these clovers and grasses.
**The area was a feedlot prior to 1910.
†Land first broken about 1923.

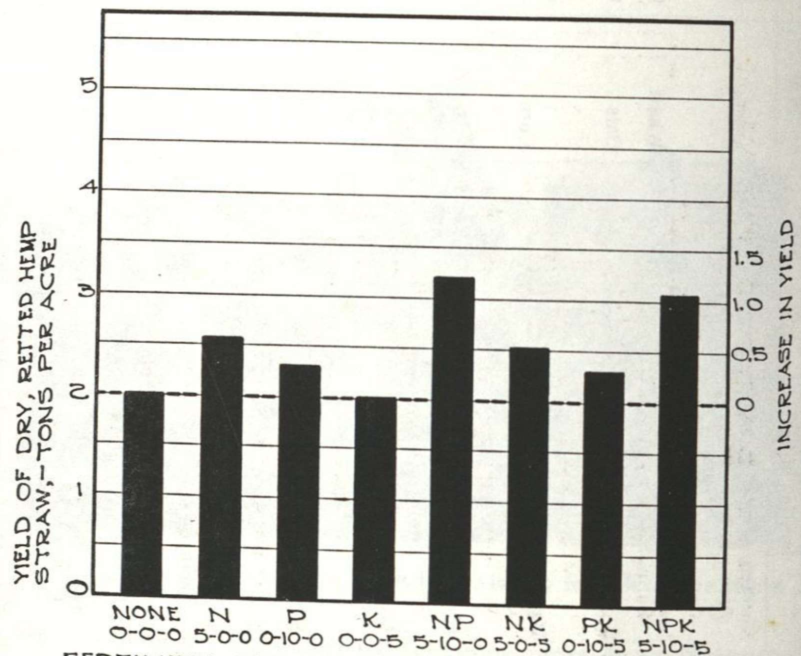

Fig. 8. The effect of fertilizers on the yield of hemp. Average results for low-yielding fields 3, 4, 5, 6 and 8.

phorus and potassium were used singly and in combinations, with the idea of finding which fertilizers or combinations of fertilizers produced the best results. In addition to these replicated experiments, 10 less comprehensive tests were made. Table 9 gives the location, soil type, and cropping history of the fertilizer experimental fields.

The basic acre rate of fertilizer application (see table 10) amounted to 125 pounds of ammonium sulfate, 250 pounds of 20 percent superphosphate, and 41.7 pounds of muriate of potash. The complete mixture was equivalent to 500 pounds of 5-10-5 per acre. This rate of application was heavy, particularly with respect to nitrogen, if compared with the general usage on other farm crops. In a few instances the rate of application was increased over the basic amounts for the purpose of studying the value of heavier applications. The fertilizers were applied in the spring to fall-plowed land (except in field 7 which was not plowed but disked for hemp) and were worked in by disking (by harrowing in field 3).

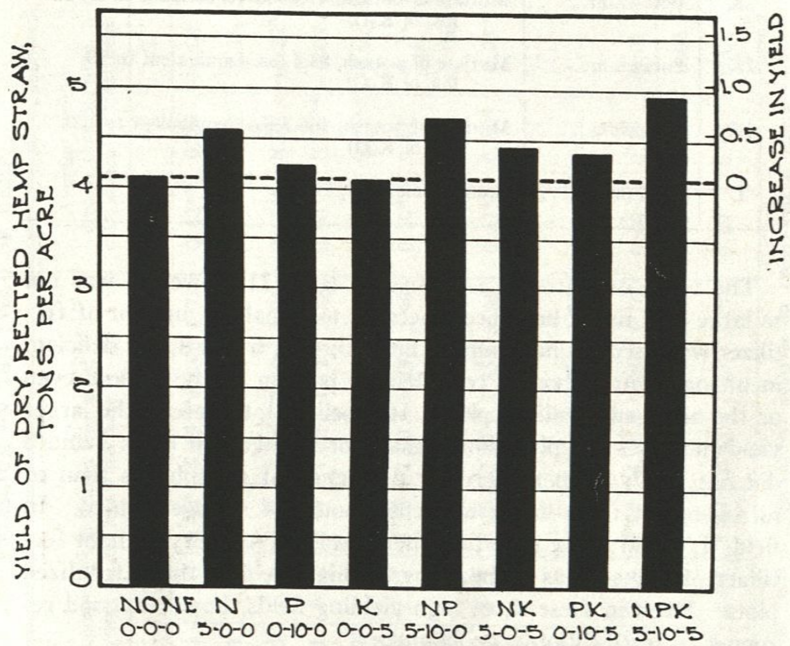

Fig. 9. The effect of fertilizers on the yield of hemp. Average results for high-yielding fields 1, 2 and 7.

The yield data for the eight similar replicated experiments and for two non-replicated tests are given in table 11. The total yields and increases due to fertilization are shown graphically in figs. 8 and 9.

NITROGEN

The most outstanding effect produced by any of the individual fertilizers resulted from the application of nitrogen fertilizer. The effect of nitrogen was significant in all eight fields. The average yield increases[7] for nitrogen (shown on the right hand side of table 11) ranged from 0.37 to 0.90 tons of retted straw per acre. Hemp on the nitrogen-fertilized plots was taller and should produce more long fiber than that on plots which did not receive nitrogen.

[7]The average yield increases take into account all plots receiving nitrogen and all plots which do not receive nitrogen. The average increase for nitrogen is calculated as follows, substituting the yields for the indicated treatments:

$$\frac{(N - None) + (NP - P) + (NK - K) + (NPK - PK)}{4} = \text{Average yield}$$

increase due to nitrogen. The average increases for phosphorus and potassium are calculated in like manner.

TABLE 10. KEY TO SYMBOLS AND RATES OF APPLICATION USED IN FERTILIZER EXPERIMENTS.

Symbol	Fertilizer constituent	Fertilizer applied and acre rate of application
N	Nitrogen.......	Ammonium sulfate, 125 lbs. (equivalent to 25 lbs. of nitrogen)
4N	Nitrogen.......	Ammonium sulfate, 500 lbs. (equivalent to 100 lbs. of nitrogen)
P	Phosphorus.....	Superphosphate, 250 lbs. (equivalent to 50 lbs. of P_2O_5)
4P	Phosphorus.....	Superphosphate, 1000 lbs. (equivalent to 200 lbs. of P_2O_5)
K	Potassium......	Muriate of potash, 41.7 lbs. (equivalent to 25 lbs. of K_2O)
2K	Potassium......	Muriate of potash, 83.4 lbs. (equivalent to 50 lbs. of K_2O)
4K	Potassium......	Muriate of potash, 166.7 lbs. (equivalent to 100 lbs. of K_2O)
L	Calcium........	Ground limestone, 3 tons.

The value of nitrogen as shown in table 11, however, was not so large as it might have been, because too small an amount of fertilizer was used. The hemp on fields 3, 4, 5, 6 and 8 was deficient in nitrogen throughout a considerable portion of the season, even on the nitrogen-fertilized plots. It is believed, therefore, the larger yield increases for phosphorus than for nitrogen on fields 5 and 8 did not result from the greater deficiency of phosphorus than of nitrogen, but from the insufficient amount of nitrogen added. In fields 1, 2 and 7, the growth of hemp was satisfactory without fertilizer of any sort, as is shown by the high yield on the unfertilized plots. Even in these three high-yielding fields, however, good response to fertilization was obtained.

Four tests were made where high rates of application of nitrogen fertilizer (500 pounds of ammonium sulfate per acre) were employed. In each case these heavily fertilized plots were placed alongside experiments where fertilizers were added at the normal rate, thus affording some comparison between the effects of the different rates. The results of the tests are given in table 12.

TABLE 11. EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM ON THE YIELD OF HEMP.

Field No.	Soil type	Yield of hemp with indicated treatment Tons dry, retted straw per acre: None	N	P	K	NP	NK	PK	NPK	Average yield increase, tons per acre, with indicated treatment: N	P	K
1	Webster silty clay loam..........	3.94	4.51	4.51	4.09	4.61	4.46	4.13	4.75	0.42**	0.25	—0.04
2	Clarion loam..........	4.15	4.72	4.11	4.22	4.72	4.46	4.46	5.15	0.53**	0.22	0.15
3	Clarion loam..........	2.43	3.14	2.25	1.99	3.37	2.54	2.39	3.01	0.75**	0.23	—0.32*
4	Clarion loam..........	1.58	1.95	1.51	1.36	2.97	1.95	1.72	2.88	0.90**	0.56**	—0.03
5	Carrington loam..........	1.58	2.27	2.62	1.75	3.24	2.55	2.33	3.15	0.73**	0.80**	0.02
6	Carrington silt loam..........	2.30	3.19	2.48	2.32	3.28	2.80	2.35	2.99	0.70**	0.12	—0.20
7	Tama silt loam..........	4.24	4.59	4.07	3.94	4.67	4.26	4.42	4.80	0.41*	0.23	—0.04
8	Tama silt loam..........	2.14	2.52	2.76	2.59	3.15	2.81	2.85	3.33	0.37**	0.51*	0.25*
9	Tama silt..........	2.67	3.58	3.33	2.58	....	....	....	4.17	....	....	....
10	Clarion loam..........	2.67	....	....	....	....	....	2.75	2.92	....	....	....
Average for fields 1, 2, 3, 4, 5, 6, 7, 8..........		2.79	3.36	3.04	2.78	3.75	3.23	3.08	3.76	0.60	0.37	—0.02
Average for fields 1, 2 and 7..........		4.11	4.61	4.23	4.08	4.67	4.39	4.34	4.90	0.45	0.24	0.02
Average for fields 3, 4, 5, 6 and 8..........		2.01	2.61	2.32	2.00	3.20	2.53	2.33	3.07	0.69	0.44	—0.05

*Significant at the 5 percent level. **Significant at the 1 percent level. (Statistical analyses on green weight basis.)

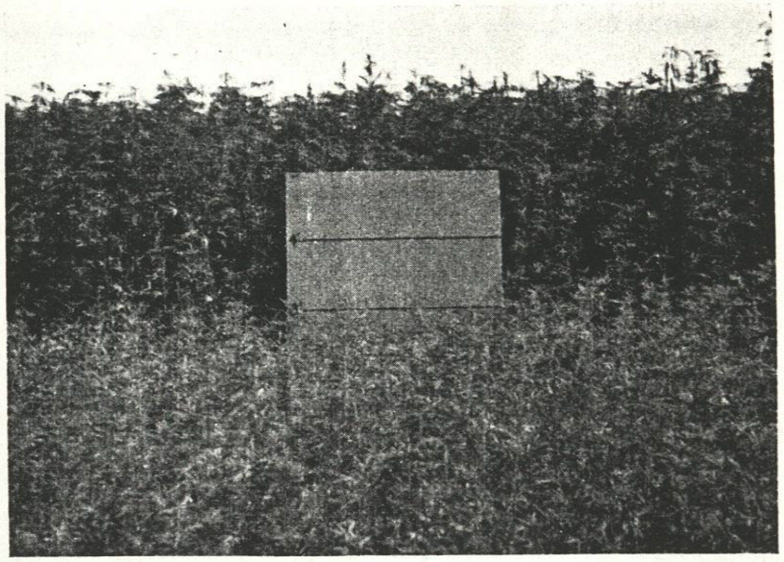

Fig. 10. No fertilizer was used on the plot in the foreground while 500 lbs. of a 20-10-5 fertilizer were applied to the plot in the background.

TABLE 12. EFFECT OF HEAVY FERTILIZATION WITH NITROGEN ON THE YIELD OF HEMP IN NON-REPLICATED TESTS.

Field No.	Soil type	Fertilizer treatment	Yield of dry, retted straw tons per acre**
5	Carrington loam	None	2.24
		NPK	3.15
		4N, PK	3.81
3	Clarion loam	None	1.70
		NPK	3.01
		4N, PK	4.76
		4N, 4P, 4K	4.77
10	Clarion loam	None	2.67
		NPK	2.92
		4N, PK	3.75
7	Tama silt loam*	LPK	4.52
		NLPK	4.80
		4N, LPK	6.04

*Five replications.
**The results for the NPK treatments in fields 5 and 3 and for the NLPK treatment in field 7 were the average yields for these treatments on adjacent experiments.

In all cases the yield and stalk size of the hemp were satisfactory on the heavily fertilized plots, whereas a rather poor crop was produced without fertilization on three of the fields. It is interesting to note that an increase of 1.5 tons was produced even on field 7 where the high yield of 4.5 tons of retted straw was obtained without the use of any nitrogen fertilizer. These few tests emphasize the need for a large supply of available nitrogen in the soil if a high yield is to be produced. It should be pointed out, however, that the highest yield of straw may not result in the highest quality (and perhaps quantity) of fiber. A proper balance of soil nutrients is desired. Excessive nitrogen produces coarse stalks which may be lower in percentage of fiber and possibly lower in fiber strength.

PHOSPHORUS

Average acre yield increases for phosphorus ranged from 0.12 to 0.80 tons of dry, retted straw, as shown in table 11. The increases were significant only on three fields. The value of phosphorus was thus secondary to that of nitrogen.

The reason for the lack of greater response to phosphorus on some of the fields probably was not the lack of enough phosphorus,[8] but the deficiency of nitrogen. Where the growth of hemp was limited by a nitrogen deficiency, heavy phosphate fertilization was of little avail. It is believed, however, that phosphorus is a valuable constituent of a fertilizer for hemp for the following two reasons:

In the first place, early in the season hemp on the various fertilizer plots showed no response to nitrogen or potassium but did show a marked response to phosphorus. At this time there was no deficiency of nitrogen. Later, when nitrogen became a limiting factor, the response to phosphorus began to disappear.

In the second place, hemp on the NP and NPK plots generally outyielded that on any of the others, in spite of the fact that the hemp on the nitrogen fertilized plots in five of the eight replicated experiments was deficient in nitrogen throughout a considerable portion of the season. An inspection of figs. 8 and 9 shows that the yield increases produced by phosphorus were greater where nitrogen was applied than where no nitrogen was used. As an

[8]It is probable that a somewhat smaller amount of phosphorus—perhaps the amount supplied in 150-200 pounds of 20 percent superphosphate—would have been enough to give results nearly as good as those obtained with the 250 pounds of 20 percent superphosphate used in the experiments.

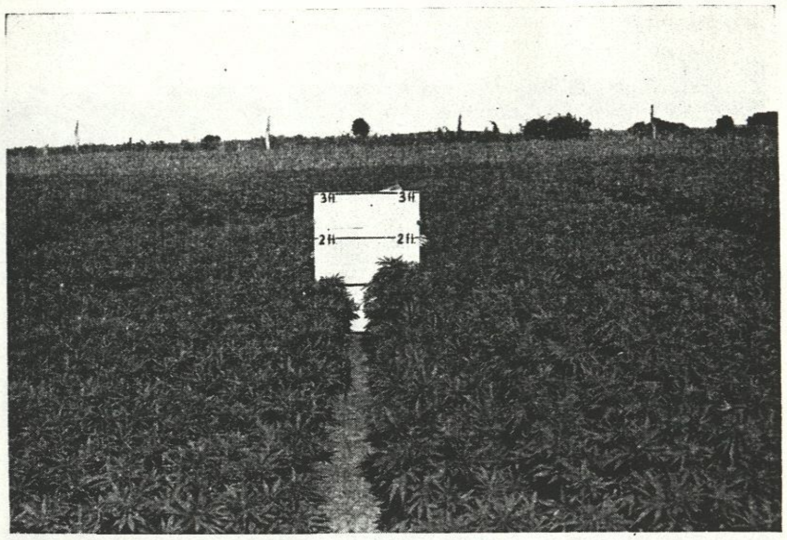

Fig. 11. Hemp plots near Rockford, Iowa, showing response to phosphorus in June 1943. Plot at the left received nitrogen and potassium, while the plot at the right received nitrogen and phosphorus.

average for the eight fields, the yield increase produced by phosphorus without nitrogen was 0.27 tons, while the increase produced by phosphorus in the presence of nitrogen was 0.74 tons—nearly three times as much. Therefore, in all probability, the yield increases for phosphorus would have been greater had the nitrogen application been increased.

POTASSIUM

The average increase in yield of hemp from the addition of potassium in the eight replicated experiments (table 11) ranged from —0.32 to +0.25 tons of dry, retted straw per acre. One experiment showed a significant decrease in yield and one showed a significant increase. As an average of all the experiments, a decreased yield of 0.02 tons of dry, retted straw per acre resulted from the use of potassium. Taking the results as a whole, it is obvious that potassium did not increase the yield. However, it will be noted from fig. 9 that the NPK plots yielded higher than did the NP plots in the three highest yielding fields. Thus, it is possible that a yield increase for potassium might have been obtained in all the fields, had the application of nitrogen been adequate.

Fig. 12. Effect of fertilizers on yield of hemp. Plot at the left received nitrogen and phosphorus, while the plot at the right received potassium only.

One of the problems in corn production in north central Iowa is the marked potassium deficiency encountered on high lime or so-called "alkali" spots in the Webster soils. Except for a greenhouse experiment with hemp which had shown essentially no value for potassium on one of these soils, no information was available to indicate the effect of the high-lime soils on the growth of hemp. Accordingly, three non-replicated tests with muriate of potash were made on high-lime spots in hemp fields.

The results of the three tests indicated little or no benefit from the use of potassium on high-lime soils. No potassium deficiency symptoms were noted on the plants, and chemical tests on the hemp stalks during the growing season indicated "very high" potassium, irrespective of the application of potassium fertilizer.

On the other high-lime spots, no definite stunting of the growth of hemp was observed excepting as it was limited by the lack of available nitrogen. One field was observed where the boundary between hemp and adjacent corn crossed a high-lime spot. At the time the field was visited in July, the corn on the high-lime area was only about 2 feet in height as contrasted to 7 feet on the normal soil nearby. The comparable hemp was about 6½ feet in height on both areas, indicating that the conditions found in high-lime soils did not adversely affect hemp to the extent that they affected corn.

MANURE

Manure applied in sufficient quantity produced a considerable increase in the yield of hemp, as indicated by the results in table 13.

TABLE 13. THE EFFECT OF BARNYARD MANURE ON THE YIELD OF HEMP.

Soil type	Previous crop	Yield of dry, retted straw Tons per acre*	
		Unmanured	Manured
Clyde silt loam	Bluegrass	2.9	4.3
Clarion loam	Rye	1.3	3.2
Webster silty clay loam	Oats	2.4	3.8
Tama silt loam	Soybeans	1.7	2.5

*Calculated (green weight × 0.3)

The yields were determined by sampling commercial hemp fields in which a portion of the field was manured and a portion was left unmanured. The increases reported here are undoubtedly higher than the average results produced since no samples were taken in several fields where the smallness of the increase, the general unevenness of the field, or both, made the exact boundary between the manured and unmanured hemp uncertain.

A number of manured fields were observed in which hemp was nitrogen-deficient and made poor growth. The hemp on several other manured fields was quite uneven in height, evidently because of uneven manuring. The unevenness was especially noticeable in fields which had been pastured the previous year and had not had a legume sod turned under for hemp. As a result of many observations, it seemed evident that if the soil would not produce a fairly good crop of hemp without manuring, the fertilizing value of the ordinary manure application was not sufficient to produce a good crop.[9] It appears, therefore, that if manure is to be used as a fertilizer for hemp on soils not in a high state of fertility, the field should be covered more heavily and more uniformly than is the practice with other crops.

[9]On the other hand, one rich field (used for a feedlot some years previous to the hemp crop) which was very heavily manured for hemp produced a crop which was too rank for best quality.

LIMESTONE

Chemical analyses have shown that the hemp plant contains a large quantity of calcium. Observations on the occurrence of wild hemp in Iowa have shown that it grows most abundantly on soils that are neutral or only slightly acid. In Germany, hemp is said to be favorably influenced by liming the soil. Experience in Wisconsin, however, has shown that hemp can be grown successfully on soils of medium acidity.

The results of two experiments with ground limestone[10] (table 14) show practically no increase in yield from the use of lime. The Tama silt loam was only slightly acid, and a great increase from liming would not be expected from any crop. The Carrington loam was more acid but still gave little if any response. It would appear, therefore, that as far as the hemp crop is concerned, the major benefit to be derived from liming, on medium acid soils, would result largely from the residual effect of the better legume crops grown on limed soils.

TABLE 14. THE EFFECT OF LIMESTONE ON THE YIELD OF HEMP.

Field No.	Soil type	Reaction of unlimed soil, pH	Yield of dry, retted straw Tons per acre	
			Unlimed	Limed
7	Tama silt loam*	5.9	4.26	4.52
12	Carrington loam**	5.5	2.60	2.63

*Five replications
**Four replications
No significant difference in either experiment.

YIELD OF HEMP ON DIFFERENT SOIL TYPES

The yield of hemp varied considerably with the soil type on which it was grown. The data available at present are by no means sufficient to place any definite figure on the average yield for a specific soil type, but will suffice, along with observations, to point out some of the general relationships which were obtained.

It seems clear that there was a general relationship between the nitrogen and organic matter content of the soil and the yield of hemp. Soils well supplied with nitrogen and organic matter gave

[10]The limestone was applied in the spring and disked in during the preparation of the seedbed for hemp.

the highest yield of hemp. The difference in the ability of different soils to supply nitrogen for hemp is well illustrated by fig. 13 which shows the relative growth of hemp and soybeans side by side on four soil types in one field. The general type of topography associated with each soil type is indicated diagrammatically at the top of the figure. The hemp yield dropped off rapidly going from Webster silty clay loam (with a high nitrogen content) up the hill to a knoll of Clarion sandy loam (with a low nitrogen content), whereas the yield of adjacent soybeans, which were not entirely dependent on the soil nitrogen supply, was not greatly affected.

The yield of hemp showed marked differences between soil types on fields which had not had any legumes grown recently. The boundaries between soil types on such fields usually were plainly marked by the differences in the height and color of the hemp. On the other hand, where hemp was preceded by a legume crop and was well supplied with nitrogen, the effect from the inherent differences between soils largely disappeared.

The soils which contain the highest amounts of nitrogen and organic matter occur on nearly flat to depressed topography where

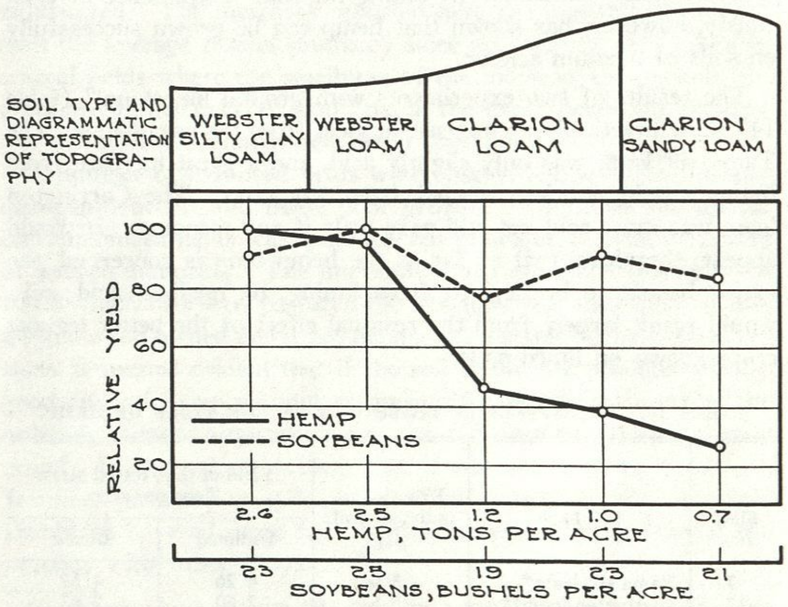

Fig. 13. Relative yields of hemp and soybeans grown side by side on four soil types in the same field.

drainage is a matter of prime importance. The lack of sufficient drainage accounts for the lower nitrate production and poorer yield observed on many of the fields which should be more highly productive under favorable conditions.

In the Tama soil area, hemp on well-drained Waukesha, Muscatine, Garwin, and Wabash-Judson soils generally yielded better than did the hemp on the associated Tama silt loam. However, in a number of fields the better hemp was produced on Tama silt loam because of inadequate drainage in the other soils. In the Carrington-Clyde soil area, well-drained Clyde and Floyd soils were superior to the Carrington soils. Here again, however, poor drainage was encountered on a number of Floyd and Clyde fields, and the hemp grew poorer than it did on the associated Carrington soils. Webster soils were superior to Clarion and Dickinson soils in the Clarion-Webster area. The sandy types of Clarion and Dickinson soils were especially poor. The drainage on a number of Webster fields limited the growth of hemp. In a year with less rainfall than the 1943 season, however, the lack of drainage should not have such an important effect.

YIELD OF HEMP FOLLOWING VARIOUS CROPS

EFFECT OF THE CROP IMMEDIATELY PRECEDING HEMP

The relative yield of hemp following different crops was found to be in the same order as the effect of these crops on the supply of available nitrogen in the soil. Alfalfa and clover, which take the most nitrogen from the air and leave large amounts of nitrogen in the crop residue and roots, had the most beneficial effect on the yield of hemp. Sorghum, a crop widely known for its depressing effect on available nitrogen, stood at the bottom of the list. Soybeans, corn and oats were intermediate, with soybeans standing above corn.

In fig. 14, the various crops grown in 1942 have been rated according to their effect on the yield of hemp in 1943. These data are based on yields obtained from 43 fields, each of which had been split between two different crops in 1942. To present the results on a simple, relative basis, the yields are given as a percentage of the yields obtained where alfalfa and clover were the previous crops.

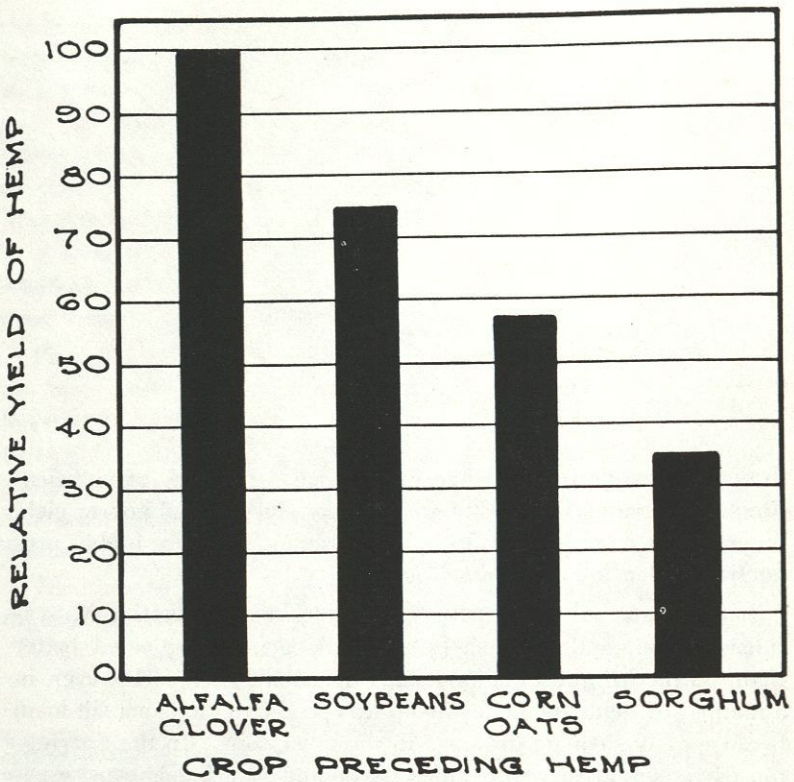

Fig. 14. A rating of various crops grown in 1942 with respect to their effect on the yield of hemp in 1943.

With a value of 100 for alfalfa and clover,[11] the other crops rated as follows: soybeans, 75; corn and oats, 57; and sorghum, 35. Alfalfa and clover were grouped together since there was no significant difference between their effects on hemp. Corn and oats were likewise considered together because the yield of hemp following these two crops was practically the same.

In selecting the alfalfa and clover fields only those fields were included on which the soil had been limed or was not in need of lime. This makes little difference with alfalfa or sweet clover fields because these crops fail on unlimed acid soils and are seldom seeded there. Red clover, however, is frequently grown on soils in need of lime. Hemp following red clover grown under these conditions

[11]The term "clover" is used to include both red clover and sweet clover grown as biennial crops.

was found to be deficient in nitrogen, apparently because of the small amount of nitrogen obtained by the clover from the air.

A further point of importance in connection with the rating of 100 given to alfalfa and clover is the length of time these crops had occupied the land. The alfalfa fields included were those on which 2 or more years of hay had been taken, and the clover fields included were those having only 1 year of hay or pasture following the year of seeding. In the Clarion-Webster soil area, a practice commonly followed is that of seeding sweet clover with oats and plowing under the clover in the fall or in the following spring for corn. Hemp following oats and sweet clover was apparently but little better than hemp following oats in which no sweet clover had been seeded. This apparent lack of benefit from the sweet clover may possibly be explained by the fact that the fall of 1942 was unfavorable for the growth of sweet clover and the fixation of nitrogen. In some cases, the fields were plowed so early in the fall

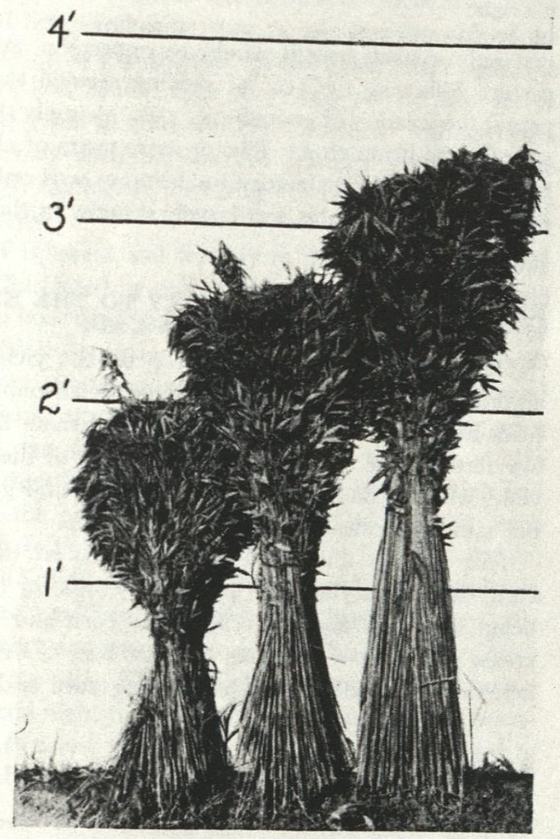

Fig. 15. Bundles from left to right show the comparative growth of hemp following sorghum, corn and soybeans on the same soil type.

Fig. 16. Hemp following soybeans on the left, following corn on the right.

that only a small benefit would be expected. A year of hay or pasture following the year of seeding seemed to be important to permit the fixation of enough nitrogen to supply the amount necessary for the hemp crop. Two or more years of clover hay or pasture were not so satisfactory for hemp as was only 1 year because the stand in these fields was largely timothy in the second and succeeding years of hay.

RELATION OF SOIL FERTILITY TO THE EFFECT OF THE PREVIOUS CROP

The effect of the preceding crop on the yield of hemp varies according to the soil fertility conditions encountered in different fields and even in different places in the same field. On soils of low fertility, the spread between the effect of the different crops is wide, whereas on soils of high fertility, hemp grows more nearly the same regardless of the preceding crop.

This point is illustrated by the results of the comparisons of corn, oats and soybeans as preceding crops for hemp. Where the hemp yield was above average after corn and oats, the yield increase produced by soybeans was 0.50 tons of dry, retted straw per acre, and the yield of hemp following corn and oats averaged 88

percent as great as that following soybeans. On the other hand, an increase of 0.95 tons of dry, retted straw was produced by soybeans where the hemp yield was below average following corn and oats. On these lower-yielding fields, hemp after corn or oats yielded but 67 percent as much as did hemp after soybeans. Thus, using the yield of hemp following corn or oats as a measure of the fertility of the soil, it is evident that on the more fertile soils, the soybeans were of less benefit than they were on the less fertile soils. The rating given to corn and oats compared with soybeans would therefore vary with the state of fertility of the soil—the higher the fertility, the higher the rating for corn and oats relative to that for soybeans.

The relation of inherent soil fertility to the effect of preceding crops is further illustrated by an example taken from a hemp field where an old crop boundary had crossed two soil types—Dickinson sandy loam and Webster loam. The former of these two soils has a relatively low supply of nitrogen and the latter has a good supply. Both sides of the field were planted to corn the year prior to the hemp crop, but for the 3 years preceding the corn, alfalfa hay had been produced on one side and a corn-oats rotation had been followed on the other. The higher yield of hemp on each soil was produced on the area where the alfalfa had been grown. The data in table 15 show first of all the tremendous difference in the ability of the two soils to produce hemp where the hemp crop followed oats and corn and was therefore dependent upon the native nitrogen supply in the soil. The Webster loam with a large supply of nitrogen produced eight times as much hemp as did the Dickinson sandy loam with a low supply. Where nitrogen was added to the Dickinson sandy loam through fixation by alfalfa, the growth

TABLE 15. THE EFFECT OF PREVIOUS CROPS ON THE YIELD OF HEMP GROWN ON DICKINSON SANDY LOAM AND ON WEBSTER LOAM.

Soil type	Relative nitrogen content of soil	Cropping system	Yield of dry, retted straw*	
			Tons per acre	Relative
Dickinson sandy loam	Low	Corn-oats	0.57	14
		Alfalfa	4.17	100
Webster loam	High	Corn-oats	5.01	83
		Alfalfa	6.06	100

*Calculated (green weight x 0.3).

of hemp was greatly increased. However, it was increased only moderately on the Webster loam where the yield was already high. Considering the yield of hemp following the alfalfa as 100 in each case, the relative figures for the yield following the corn-oats rotation are 13 for the Dickinson sandy loam and 83 for the Webster loam.

RESIDUAL EFFECT OF LEGUMINOUS CROPS

The value of leguminous crops as a source of available nitrogen for a subsequent crop of hemp has been emphasized. It is important also to know the length of time the beneficial effect of a leguminous crop will last. To obtain some information on this question, the yields from 75 fields were classified into eight categories according to the kind of leguminous crop and the number of years which had elapsed since the legume had been grown. The results, given in fig. 17, show the increases in yield of dry, retted straw (green weight x 0.3) using as a basis for calculation the average yield of 2.28 tons from fields on which no legume had been grown for 5 years preceding the hemp.

It will be seen from fig. 17 that alfalfa had a marked residual

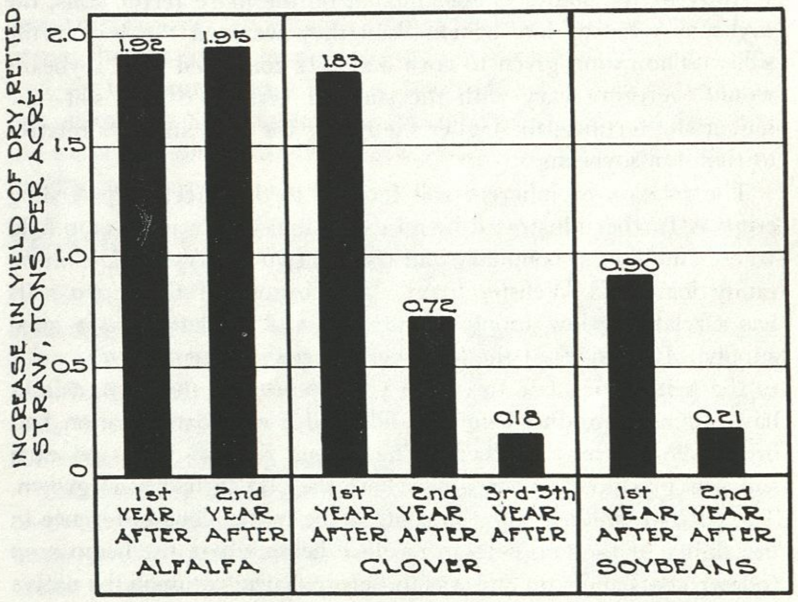

Fig. 17. Increase in yield of hemp after alfalfa, clover and soybeans.

effect. Hemp grown the second year after the alfalfa yielded as high as did hemp grown the first year following this crop. One field was found in which a direct comparison between the first year and the second year could be made. This particular field (Clyde silt loam) had been planted to oats and alfalfa in 1939. One side of the field had been plowed for corn in 1942 and the other side had been allowed to remain in alfalfa in 1942. The 1943 yield of hemp was 3.7 tons per acre where hemp directly followed alfalfa and 3.6 tons where the hemp followed corn (preceded by alfalfa). No definite information is available on the effect of alfalfa when two non-leguminous crops came between the alfalfa and the hemp. A few observations indicated, however, that the beneficial effect of the alfalfa was much less noticeable in the third year than it was in the second.

There was no significant difference between the yield of hemp following alfalfa and that following clover.[12] However, when a crop of corn or oats followed the clover, but preceded the hemp, the yield of hemp was significantly smaller than it was when hemp followed the clover directly. In other words, the residual effect of the clover crop was much less marked than was that of the alfalfa crop, as might be expected from the longer time the alfalfa occupies the land.[13] When clover was grown once in the period of 1938 to 1940 (3 to 5 years before the hemp crop) and corn or oats was grown each year thereafter, the 1943 hemp crop did not yield significantly higher than it did on fields where no legume had been grown in the 5-year period preceding the hemp crop.

The value of the preceding soybean crop for hemp disappeared almost entirely after the first year. Hemp grown the second year after soybeans did not give a yield significantly higher than that obtained on fields which had had no legumes for the 5 years preceding the hemp.

RELATIVE YIELDS OF HEMP AND OTHER CROPS

To determine the relationship between yields of hemp and of corn a number of samples were taken in fields of hemp and corn grown side by side. The areas selected were only those in which

[12]Grown on neutral or limed soils.

[13]Observations indicated that alfalfa was no better than clover if the alfalfa field was plowed up after one year of hay.

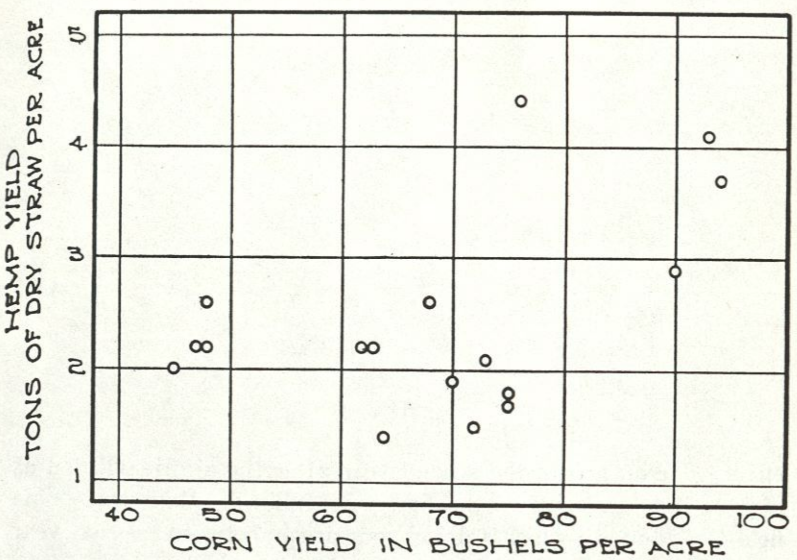

Fig. 18. Relative yields of hemp and corn grown side by side on land previously treated the same.

the soil conditions were apparently uniform and in which the previous treatment both as to crops and to fertilization had been the same. The results in fig. 18 do not show very much relationship between the yield of dry hemp straw and of corn. Of the four fields yielding over 75 bushels of corn to the acre, three yielded approximately 4 tons of dry hemp straw and one yielded about 3 tons. Apparently, fields that produce very high yields of corn also will generally produce high yields of hemp. Fields which produce lower but still good yields of corn, cannot be depended upon to produce good hemp yields.

Seven areas were selected for sampling hemp and soybeans using the same criteria as were used for those areas sampled for hemp and corn. The yields of soybeans on these fields were relatively stable, but the yields of hemp varied greatly. While the more fertile soils probably would produce high yields of both hemp and soybeans, in general there would appear to be little or no correlation between the yields of these two crops on the same soils.

OBSERVATIONS ON CULTURAL PRACTICES

SEEDBED PREPARATION

In advising farmers on growing hemp, thorough preparation of the seedbed was emphasized. It was believed to be especially important in Iowa because much of the seed had to be planted with endgate seeders. In 1943, weather and soil conditions were, in general, favorable for good seedbed preparation both on fall- and spring-plowed land. In the few fields observed, where a portion was fall plowed and a portion spring plowed, no differences were apparent in the growth of the hemp. With less favorable spring conditions, fall plowing might have given the better results and, in general, is still to be recommended.

The hemp field should be left in a relatively level condition, particularly to facilitate harvesting. Because of rough and poorly prepared seedbeds or of unevenness caused by the washing of soil on slopes, the hemp crop, in many fields, had to be cut leaving a high stubble to prevent the harvester from scraping the ground and stalling. The leaving of high stubble was a disadvantage be-

Fig. 19. Tall growth of hemp above a tile line on Webster silt loam soil illustrates the importance of adequate drainage.

cause it meant the loss of considerable fiber at the base of the stalks and also caused the straw to ret more slowly than where it lay close to the ground.

In parts of the hemp area the rainfall during both April and May was below normal. Under these dry conditions poor germination was obtained on many fields where the hemp had been sown broadcast. Farmers who used the spike-tooth harrow only, after planting, often obtained poor stands because the seed was not in contact with soil sufficiently moist to promote good germination. Those who disked lightly after broadcasting, or used a drill for seeding, had more uniform and better stands. In areas where plenty of moisture was present, broadcast seedings were satisfactory even if the seed was not well worked into the soil.

GROWING CONDITIONS

While weather conditions in the commercial hemp area in general were nearly normal in the spring, the summer of 1943 was warmer and considerably wetter than normal.

At Ames, hemp on Webster silty clay loam soil, that was not adequately drained to take care of the excess of 9 inches of rainfall which came during the summer months, grew slowly and appeared yellowish-green in color. This condition was typical of hemp on fields lacking sufficient drainage and deficient in available nitrogen. Growth was much better directly over tile lines in such fields.

Where drainage was adequate, hemp probably benefited by the plentiful supply of moisture. At Kanawha, in Hancock County, hemp on Webster soil produced a considerably higher yield of stalks in 1943 than was produced on similar soil in the 1942 season. It is believed, especially in view of the high yields of all farm crops, that conditions for hemp production in Iowa probably were better than average in the 1943 season.

WEED CONTROL

Experience has shown that hemp is a good crop for controlling weeds, but weed-infested soil must be properly managed in order that the hemp be given good conditions for establishment. Where

seedbeds were properly prepared and the hemp germinated quickly, the rapid growth that usually followed during the early part of the season resulted in effective weed control. Poor seedbed preparation without thoroughly destroying the weed growth was responsible in some instances for such a slow growth of hemp that the weeds practically crowded out the crop. Heavy infestations of Canada thistle and quack grass on soils low in available nitrogen were not controlled by seeding to hemp. Smartweed was troublesome on some poorly drained areas.

Tall, rapidly growing hemp was effective in weed control. Canada thistles, when present, grew spindly and finally the tops died. The ground usually was bare of anything but hemp if hemp was tall. On a peat area near Crystal Lake where weeds were abundant, the hemp crop controlled them effectively.

The fertilizer experiments offered excellent examples of the effect of the height of hemp on weed growth. Plot boundaries were in many instances clearly marked by the abundant grass and weed growth under the short hemp and the complete lack of any such growth under the tall hemp.

DATE OF HARVEST

While a few acres of hemp were cut about Sept. 1, harvesting in most of the Iowa mill areas was started on an extensive scale about Sept. 10. There were some favorable rains during the first part of September, which would have hastened field retting, but most of the hemp was still standing. During the latter part of September and all of October, rainfall was so light that conditions were not favorable for field retting. In 1942 a similar situation existed, particularly at Ames, where field plots were located.

It is believed that if hemp is sufficiently mature to be harvested during the last week in August and the first 10 days in September, field retting can be expected to be more successful than when harvesting is delayed until Sept. 15 or later. A study of weather records has shown that moisture conditions usually are more favorable for retting in September than in October. Chilean hemp at

Ames, cut Aug. 18, was retted by Sept. 9. Kentucky hemp cut Sept. 4 to 7, and turned Oct. 10, was well retted by Nov. 15. Hemp cut in the same plots the last of September was not retted by December 1.

Fig. 20. Turning hemp straw over, when it is partially retted, promotes more uniform retting.

If tank retting instead of dew retting were used commercially, early harvesting might not be desirable. There is some evidence to indicate that stronger fiber is produced from hemp that is more nearly mature than it is when harvested at the full bloom stage or just past full bloom. Under Iowa climatic conditions, however, late-harvested hemp does not ret rapidly in the field and so would not be desired unless a controlled retting process were adopted.

Cooperative Extension Work in Agriculture and Home Economics, Iowa State College of Agriculture and Mechanic Arts and the United States Department of Agriculture cooperating. Extension Service, R. K. Bliss, director, Ames, Iowa. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914.

Agricultural Experiment Station, Iowa State College of Agriculture and Mechanic Arts, R. E. Buchanan, director, Ames, Iowa.