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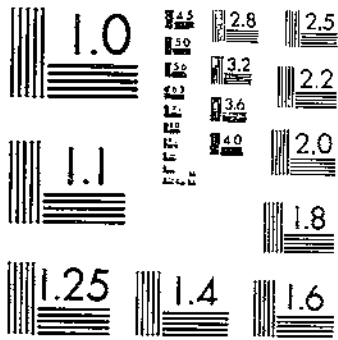
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FLAX-CROPPING IN MIXTURE WITH WHEAT, OATS, AND BARLEY

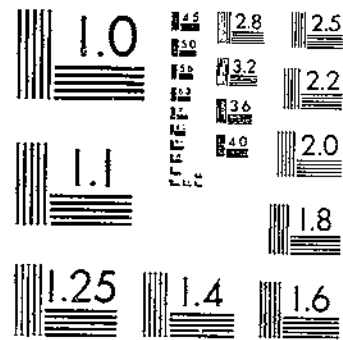
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ARNY, A. C. ET AL

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NATIONAL BUREAU OF STANDARDS-1963-A



UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

FLAX CROPPING IN MIXTURE WITH
WHEAT, OATS, AND BARLEY

By A. C. ARNY, Associate Agronomist, Minnesota Agricultural Experiment Station;
T. E. STOA, Assistant Agronomist, North Dakota Agricultural Experiment
Station; CLYDE MCKEE, Agronomist, Montana Agricultural Experiment Station;
and A. C. DILLMAN, Associate Agronomist, Office of Cereal Crops and Diseases,
Bureau of Plant Industry

IN COOPERATION WITH THE AGRICULTURAL EXPERIMENT STATIONS
OF MINNESOTA, NORTH DAKOTA, MONTANA, SOUTH DAKOTA,
WISCONSIN, AND OHIO

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INTRODUCTION

During the five years from 1923 to 1927, the production of flaxseed in the United States averaged 22,760,000 bushels annually. This relatively large production, however, represents only a little more than half the consumption of flaxseed in the United States, which has amounted to 40,000,000 bushels annually. Where flax cropping in mixture with wheat, oats, or barley is successful, it should enlarge the present area of flax production and help to meet the increasing demand for linseed.

The experiments reported in this bulletin have been conducted over a wide area during a period of four or more years, and it is believed that the results indicate to what extent and in what areas this mixed cropping is likely to be successful. The experiments were planned to answer some of the important problems involved in mixed cropping, namely:

- (1) Does mixed cropping produce an increased yield, either in total grain or in relative yield, as compared with flax and cereals grown in pure stands?
- (2) What effect does the rate of seeding have on the yield, quality, and proportion of each crop in the mixture?

- (3) Does the mixed crop produce a greater acre income than flax or grain grown alone?
- (4) Does the mixed crop check the growth of weeds as compared with their growth in flax grown in pure stands?
- (5) Does the mixed crop help control plant diseases such as flax wilt and stem rust of wheat?
- (6) What effect does growing the crops in combination have on the ease of handling the crop?

HISTORY OF MIXED CROPPING OF FLAX AND CEREALS

The practice of growing crop plants in mixture is not new. It is especially common with forage and feed crops, such as clover and timothy, corn and soy beans, barley and oats. Mixed crops are grown either for the purpose of obtaining a greater total yield per acre or to obtain a better balance in the feeding value of the crop. Such crops generally are consumed on the farm. Flax, on the other hand, is grown as a cash market crop. It is necessary, therefore, to consider not only the advantages and disadvantages of handling flax in a mixed crop but its economic value as well.

The mixed cropping of flax with spring wheat has been practiced for 40 years or more in some localities in southeastern Minnesota (1)¹. In Goodhue County, Minn., especially, there has been a marked increase in the acreage of the mixed crop in recent years, with a corresponding decrease in the acreage of flax grown alone. The mixed crop also is very common in other counties of southeastern Minnesota, where flax is grown to a large extent.

The North Dakota Agricultural Experiment Station conducted experiments with flax-wheat mixtures at Fargo as early as 1898, but the results were not promising (7).

Experiments in seeding flax in mixture with wheat, oats, and barley were conducted under dry-land conditions at Dickinson and Mandan, N. Dak., in 1917 and 1918 (7). Severe drought and weeds, especially the Russian thistle, reduced the yields at both places. It is now known, also, that the cereals were sown at too heavy a rate in the mixtures; the flax suffered by competition from the companion crop as well as from the weeds, which were unusually bad in those two years.

Mixtures of flax with wheat were grown under irrigation at Newell, S. Dak., in 1917 and 1918 (6). Two mixtures were grown: (1) Flax at 15 pounds with wheat at 37 pounds per acre, and (2) flax at 15 pounds with wheat at 75 pounds per acre. As an average for the two years the following acre yields were obtained:

Flax seeded alone at 15 pounds yielded 904 pounds.
 Wheat seeded alone at 37 pounds yielded 1,204 pounds.
 Wheat seeded alone at 75 pounds yielded 1,371 pounds.
 Mixture 1, flax at 15 plus wheat at 37 pounds, yielded 1,279 pounds.
 Mixture 2, flax at 15 plus wheat at 75 pounds, yielded 1,446 pounds.

Unfortunately the proportion of flax and wheat in the mixed grain was not determined.

The practice of sowing flax in winter-wheat fields where the stands had been thinned by winterkilling was followed for many years by farmers in the vicinity of New London, Ohio (8). The flax was sown early in the spring and matured at the same time as the wheat. This practice has been followed also by Thomas D. Campbell in his exten-

¹ Italic numbers in parentheses refer to Literature cited, p. 47.

sive farming operations near Hardin, Mont. Mr. Campbell raised some 6,000 acres of the mixed crop in 1924.

In India the mixed cropping of flax with wheat, mustard, rape, and chick-peas has been practiced for a very long time. A letter from Dr. A. Howard, economic botanist for India, under date of April 26, 1923, gives a brief description of the method of growing flax for seed (linseed) in India. The following excerpt is from Doctor Howard's letter.

Wheat and linseed are grown together in India, often with rape and mustard also, chiefly on the damp soils of the eastern portion of the wheat areas of the Gangetic alluvium in northern Bihar and to a less extent in Oudh. The linseed-wheat combination is rare in the drier wheat-growing areas of northwestern India. The proportions vary a great deal. On the whole, linseed is the subordinate constituent of the mixture and rarely exceeds 30 per cent. The scientific basis of the combination is probably partly to be found in the assistance given to the wheat by the drying effect on the soil of the linseed plants. The mixed crop is chiefly confined to strong, damp soils, soils which in the ordinary way would be too wet for wheat. If you have such lands in the United States the combination might be effective, especially if the wheat varieties grown have sparse foliage and stand well.

COOPERATION

The investigations reported in this bulletin have been conducted independently by the agricultural experiment stations of Minnesota, North Dakota, Montana, South Dakota, Wisconsin, and Ohio. The Office of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, has conducted experiments independently at the Northern Great Plains Field Station, Mandan, N. Dak., and in cooperation with the North Dakota station at Dickinson, N. Dak., and with the Montana station at Moccasin, Mont. The experiments were outlined independently. However, the utilization to the fullest possible extent of the published data from work of this kind (1, 2), with modification of the rates to suit regional climatic conditions, resulted in a certain degree of uniformity of outline for the different experiments, which makes it possible to compare the results to advantage. This bulletin has been written through the informal cooperation of the authors, each of whom is responsible for the data from his State.

LOCATION OF THE EXPERIMENTS

The principal flax-producing area of the United States includes North Dakota, Minnesota, South Dakota, and eastern Montana. (Fig. 1.) The average annual precipitation in this area ranges from about 32 inches in eastern Minnesota to 15 inches in eastern Montana. The greatest acreage of flax is grown in the eastern counties of the Dakotas and the western counties of Minnesota, where the average annual rainfall ranges from 18 to 25 inches. In all of the flax-producing area the timely distribution of the rainfall is a very important factor in the successful production of the flax crop.

The experiments were conducted in nine localities in Minnesota and at four stations in North Dakota, in addition to 46 field experiments in cooperation with farmers. In Montana the experiments were conducted under irrigation at the State station at Bozeman and under dry-land conditions at Moccasin. In Wisconsin the principal experiments were conducted on the University Farm at Madison, and

field trials were conducted in cooperation with farmers. The experiments reported for South Dakota were conducted at Brookings and those for Ohio at Wooster.

EXPERIMENTAL METHODS

The results reported here were obtained from plots handled by the usual methods of modern field experimentation. The crop sequence, size of plots, number of replications, and rates and dates of seeding were varied at the different stations and among the different cooperators, as the seasons and conditions required. In most cases the experimental plots were on corn stubble plowed either in the fall or in the spring and were disked and harrowed before the flax was

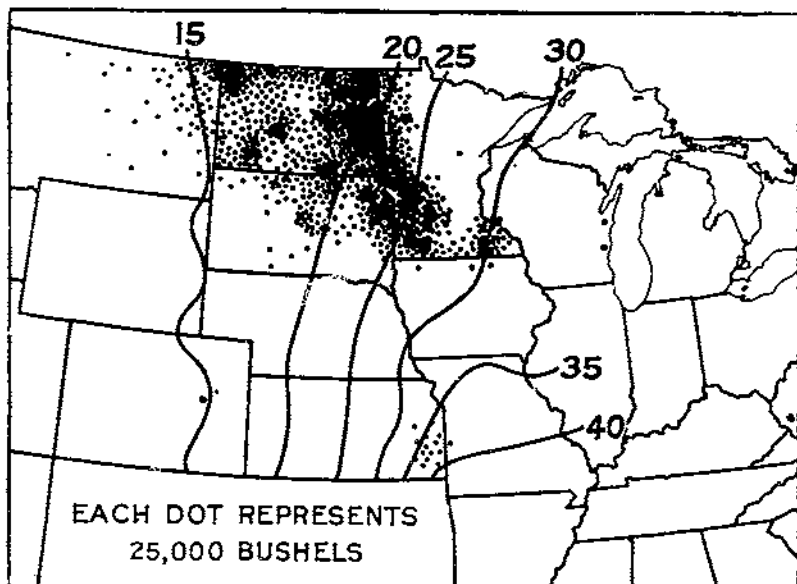


FIGURE 1.—Outline map of the United States, showing flaxseed production in 1924 and lines of average annual precipitation in inches in the flax-producing area

sown. Many of the experiments, especially those in cooperation with farmers in North Dakota, were conducted on fall-plowed wheat stubble. All plots in any one experiment were given uniform treatment. The plots usually were 8 rods long and ranged in area from one-fiftieth to one-tenth of an acre. With a very few exceptions the plots were replicated, so that there were two, three, or more plots of each crop or mixture. Seeds of the two crops were mixed in the desired proportions before seeding, and the mixture was sown in one operation. No appreciable separation of the flax and wheat occurred through the jolting of the drill in seeding. In the flax-oats mixture, however, there was some tendency for the two to separate where only small quantities of seed were placed in the drill box.

The yields per acre were determined by two methods: (1) By harvesting the standing grain from six square-yard areas from each plot. In a very few cases only three to five square-yard areas were harvested. These bundles were placed in cloth bags, dried, threshed,

separated, cleaned, weighed, and the yields of grain and of straw computed. (2) By harvesting the product from the entire plots and computing the acre yields from the yields of the plots. In some cases both methods were employed and the results compared.

COMPUTING THE YIELDS

In each experiment, flax, wheat, and oats were grown alone as well as mixed in different proportions in regularly distributed plots, so that yields would be available with which to compare the results from the mixed crop.

In order to be able to compare the yields obtained from the different crops grown alone with each other and with the results from the mixtures, it was necessary to reduce all yields to a common basis. The first method has been used in the discussion of results of previous work at the Minnesota station (1, 2), and is repeated here for the convenience of the reader. (1) The yield of the flax grown alone was divided by the yield of the wheat grown alone. This gave the yield of the flax as a percentage of the yield of wheat. (2) The yield per acre of wheat grown alone and in each combination crop was then multiplied by this factor, which reduced the wheat yields to a flax basis. (3) The wheat yield in each combination reduced to a flax basis was then added to the flax yields from the same combination. This gave the yields of the wheat alone and the wheat-flax combinations on a flax basis, and hence they are comparable to each other. In order to facilitate comparisons, all yields on the flax basis were then reduced to a percentage of the flax grown alone at the 42-pound seeding rate. This places all yields on a relative basis with flax grown alone as 100. The yields from the oat-flax combinations were reduced to a flax basis in the same manner.

The second and simpler method of converting the yields of the mixed crops to a percentage or relative-yield basis is as follows: (1) Divide the yields of each crop grown in a mixture by the yield of each crop grown alone. These quotients express the percentage yield of each crop in a mixture with the crops grown alone as 100. (2) Add the percentages thus obtained for any mixture, and the sum expresses the percentage or relative yield of the mixture as compared with each crop grown alone. The use of this method serves to reduce the yields directly to the relative basis.

TABLE I.—Estimated annual and average farm prices of flax, wheat, oats, and barley in five States on December 1, 1923-1927

[From Bureau of Agricultural Economics, United States Department of Agriculture]

Crop and State	Farm price per bushel (cents)						Crop and State	Farm price per bushel (cents)					
	1923	1924	1925	1926	1927	Average		1922	1924	1925	1926	1927	Average
Flax:							Oats:						
Montana.....	103	221	220	185	175	190	Montana.....	38	47	53	53	44	47
North Dakota.....	212	227	226	193	184	208	North Dakota.....	28	36	27	33	35	32
South Dakota.....	208	223	225	190	185	208	South Dakota.....	31	40	28	36	36	34
Minnesota.....	213	233	230	197	192	213	Minnesota.....	34	43	31	34	40	38
Wisconsin.....	210	225	226	200	190	210	Wisconsin.....	43	48	38	40	47	43
Wheat:							Barley:						
Montana.....	82	124	140	113	97	111	Montana.....	48	60	72	64	60	63
North Dakota.....	86	126	131	117	104	113	North Dakota.....	38	62	43	46	59	50
South Dakota.....	81	125	128	118	106	112	South Dakota.....	40	64	47	52	58	52
Minnesota.....	95	130	137	123	110	110	Minnesota.....	44	69	52	51	65	58
Wisconsin.....	98	128	136	126	117	121	Wisconsin.....	61	78	66	65	75	69

COMPUTATION OF THE ACRE INCOME

The gross income per acre from the mixed crops and from each crop grown alone is calculated on the basis of the 5-year (1923-1927) average farm price on December 1 of flax, wheat, and oats in each State. These prices (in cents per bushel) are given in Table 1.

EXPERIMENTS IN MINNESOTA

By A. C. ARNY, Associate Agronomist, Minnesota Agricultural Experiment Station

OUTLINE OF THE EXPERIMENTS

The history of growing flax and wheat in mixtures in Minnesota has been given in Bulletins 204 (1) and 206 (2) of the Minnesota Agricultural Experiment Station. The former bulletin reports results of experiments with flax grown in mixture with wheat, oats, and barley at University Farm previous to 1923, and Bulletin 206 includes summaries presented in Bulletin 204, together with the results obtained from tests conducted in 1923. The present bulletin reports the results obtained in eight counties for the three years 1924 to 1926, inclusive, together with some data obtained in 1923.²

In all of the cooperative tests with farmers the operations of seeding, harvesting, and handling the grain samples were conducted by one man, experienced in this sort of work, who was sent out from University Farm.

In 1923, N. D. R. No. 114 flax was used in the tests, but thereafter Winona, a new wilt-resistant variety developed at the Minnesota station, was used. Marquis wheat and Victory oats were the varieties of cereals used in all the tests. The several mixtures of seed were prepared at University Farm and the proper quantity of each mixture sent to each cooperator for seeding.

The mixtures were grown in 1/40-acre plots in triplicate. The plots without exception were 8 rods long by 8¼ feet wide, separated by 18-inch alleys. The seedings were made each spring as early as the land was in fit condition to work.

In the cooperative trials with farmers, six regularly distributed square-yard areas of the standing grain were removed from each plot when the crop was ripe. Practically no loss from shattering occurred, even when the square-yard samples were removed several days after the crops were ripe. The samples of grain from each plot were bagged separately and shipped to University Farm, where they were threshed, the seed separated and weighed, and the yields computed. At University Farm, Morris, and Crookston the product of the entire plots was cut with the binder after two drill rows of grain had been removed from each side of each plot to obviate border effect.

PROBABLE ERROR OF THE EXPERIMENTS

After the yields were converted to the flax basis the probable error of each trial was computed by the pairing method. The average probable error in percentage was derived by the use of the formula

$$1/N\sqrt{a^2 + b^2 - N^2}$$

² The experiments at the Northwest Experiment Station, Crookston (Polk County), were under the direction of R. S. Durham, agronomist; those at the West Central Experiment Station, Morris (Stevens County), were conducted by R. O. Bridgford, agronomist. Other cooperators and county agricultural agents assisting in the tests were as follows: Goodhue County—Cooperators, Henry Schwarfau (1923), B. O. Featherstone (1924-1926), and Henry Heinrichs, agents, V. H. Kingsbury and Preston Halo. Faribault County—Cooperator, Tobias Peterson, agent, F. E. Krause. Rowville County—Cooperators, A. R. Wolfe and John Melhouse (1925-26); agents, F. C. Hathaway and E. N. Johnson. Wilkin County—Cooperator, F. M. Nash; agent, L. S. Stallings. Clay County—Cooperator, C. E. Bennington.

The probable errors in percentage for the period of the test at each location and for all locations are given in Table 5.

RELATION OF RAINFALL AND SOIL PRODUCTIVITY TO YIELDS

The yields of the crops varied considerably each year in the different locations where the tests were made and from year to year on the same farms. These variations in yields were due largely to differences in amount and distribution of the rainfall for the growing season and to a lesser extent to differences in the productivity of the soil at the different locations.

The monthly rainfall in each of seven counties during the growing season for grain crops for the years 1923-1926 is given in Table 2.

TABLE 2.—Precipitation during each month of the growing season near the station in each of seven counties in Minnesota where flax-wheat experiments were conducted, 1923-1926¹

County, station, and year	Precipitation (inches)						Normal for the locality
	April	May	June	July	August	Total	
Ramsay (St. Paul):							
1923.....	2.20	2.28	4.23	2.51	1.92	13.10	17.22
1924.....	3.32	1.47	7.24	1.73	6.51	20.27	
1925.....	1.27	2.26	5.77	4.28	.16	13.76	
1926.....	.53	1.37	3.85	2.92	4.27	12.74	
Goodhue (Red Wing):							
1923.....	1.16	1.64	4.66	2.63	3.76	13.90	17.17
1924.....	2.96	1.78	3.84	3.84	7.20	19.62	
1925.....	1.88	1.12	9.90	3.14	.50	16.54	
1926.....	1.48	1.20	2.86	1.66	4.17	11.37	
Faribault (Winnebago):							
1923.....	1.00	2.93	6.25	.71	5.00	16.49	19.05
1924.....	1.08	1.72	5.24	.75	6.07	15.44	
1925.....	2.08	.67	8.00	3.26	.86	14.90	
1926.....	.90	2.37	3.00	1.80	2.53	10.75	
Renville (Bird Island):							
1923.....	3.26	2.74	4.25	2.15	1.93	14.32	10.29
1924.....	2.10	2.22	2.93	1.58	7.20	16.03	
1925.....	2.30	1.49	5.64	2.11	.71	15.25	
1926.....	.82	2.90	2.23	3.43	4.70	14.17	
Stevens (Morris):							
1923.....	2.18	1.74	3.50	3.42	1.21	12.05	10.30
1924.....	2.99	1.29	5.40	1.95	3.75	15.38	
1925.....	2.43	.93	5.99	3.62	.88	13.75	
1926.....	.12	2.02	1.39	1.45	4.12	9.10	
Clay (Moorhead):							
1923.....	1.28	1.85	6.73	2.34	2.83	15.03	16.25
1924.....	4.01	.78	4.37	1.25	2.99	13.40	
1925.....	1.69	1.98	5.62	4.35	.25	14.19	
1926.....	.08	1.93	2.09	2.92	1.83	8.85	
Polk (Crookston):							
1923.....	1.10	1.33	3.34	5.62	1.63	13.01	14.42
1924.....	5.10	2.81	1.58	2.64	1.65	13.78	
1925.....	2.70	4.60	6.82	.86	1.46	16.53	
1926.....	.14	2.16	3.43	1.28	1.49	8.50	

¹ Rainfall data for Wilkin County were not obtained.

That the yield of the combination crops as compared with that of the crops grown alone is influenced greatly by the amount as well as by the distribution of the rainfall during the growing season is made clear by an examination of the rainfall data for Goodhue and Faribault Counties, as given in Table 2, and the relative yields in these two counties for the same years, which are given in Table 3.

In both Goodhue and Faribault Counties the rainfall for April and May, 1923, was somewhat below the average. The June rainfall in Goodhue County was slightly above, and in Faribault 1.57 inches above the average. As a result of the exceptionally heavy

rainfall in Faribault County in May and June, the growth of the plants in the tests was greater than normal. During July there was practically no rainfall at this location, and the heavy growth of plants, particularly in the combination crops, lacked water to complete the luxuriant vegetative growth and produce the large crop of seed of which it gave promise. Hence, at this location, the combination crops yielded at a lower rate than the crops grown alone. In Goodhue County, where there was a fair amount of rain in July, the combination crops from the 42-pound flax seedings showed a considerable advantage over the crops grown alone.

TABLE 3.—Annual acre yields of the combination crops and of flax grown alone, in Goodhue and Faribault Counties, Minn., expressed as percentages of the yield of flax seeded alone at 42 pounds per acre

Crop and rates of seeding per acre (pounds)		Acre yields as percentages of yield of flax seeded alone in—							
		Goodhue County (Heinrichs farm)				Faribault County			
		1923	1924	1925	1926	1923	1924	1925	1926
Wheat 15	Flax 42	108.8	98.9	105.7	97.5	77.1	95.3	113.0	91.7
	Flax 28	99.7	94.1	105.2	103.2	53.0	94.3	124.7	82.1
Wheat 30	Flax 42	112.3	95.6	113.3	114.0	73.3	101.3	128.5	103.6
	Flax 28	93.1	91.7	102.4	112.7	78.9	88.8	126.2	103.3
Wheat 45	Flax 42	101.7	99.1	122.9	111.5	92.1	99.7	127.0	106.3
	Flax 28	90.4	103.2	100.1	105.7	81.9	93.9	114.6	94.6
Oats 32	Flax 42		96.0	96.0	108.9		112.5	90.3	90.0
	Flax 28		93.1	94.4	105.7		100.7	103.4	88.3
Oats 10	Flax 42			197.6	100.4			98.5	93.3
	Flax 28			97.1	103.8			97.4	95.0
Flax alone	42	100	100	100	100	100	100	100	100
	28	101.6	92.0	93.8	93.6	92.4	95.9	96.3	83.8

In 1924 the total rainfall for April and May in Faribault County was lower than normal, and again there was an exceptionally heavy rainfall in June and practically none in July. Table 3 shows results for the combination crops in the tests in this county which are practically the same as those in 1923. In Goodhue County the rainfall for April and May was somewhat lower than normal, but the total rainfall for June and July was ample for a good crop if the distribution had been fairly even. July was without effective rainfall until the 30th, when 2.32 inches fell. This shortage of rainfall throughout practically the entire month resulted in somewhat lower average yields from the combination crops than were obtained from the crops grown alone.

The rainfall in April, 1925, was nearly normal, and that for May was less than normal in both counties. However, the rainfall in June was exceptionally heavy, being more than twice the normal in Goodhue County and nearly twice the normal in Faribault County, and that in July was practically normal. As shown in Table 3, the wheat-flax combinations produced exceptionally good yields at both locations as compared with the crops grown alone.

In Faribault County the rainfall for July, 1926, was again deficient, and practically all of it fell during the last few days of the month. However, owing to the moderate rainfall in the previous months, the

vegetative growth was not so luxuriant as in 1923 and 1924, when exceptionally heavy rainfall in June preceded the droughts in July, and hence the reduction in yield due to the drought was not so great. Three of the rates of seeding of the wheat-flax combination yielded higher than the crops grown alone, as is shown in Table 3.

The rainfall in Goodhue County in 1926 was lower than normal in each month of the growing season, but well enough distributed so that a moderate vegetative growth was made and the grain matured without serious check. Under these conditions all of the combination crops except one showed some increase in yield over the crops grown alone.

Taking into consideration all of the results, it appears that an abundance of moisture, particularly in June and July, favors the combination crop. The exceptional increase in yields obtained by McKee (5) from the combination crops as compared with the crops grown alone under irrigation confirms this conclusion.

Relatively low rainfall, such as prevailed in Goodhue and Stevens Counties throughout the growing season for grain in 1926, resulted in moderate acre yields, with the advantage in favor of the combination crops.

An abundance of moisture in the early part of the growing season, resulting in luxuriant vegetative growth, followed by drought during the last month of the growing season, puts the combination crops at a disadvantage as compared with the same crops grown alone at ordinary rates of seeding.

YIELD OF EACH CROP IN COMBINATIONS LOWER THAN THAT OF THE SAME CROP GROWN ALONE

In Goodhue County, where a considerable acreage of the wheat-flax combination crop is grown each year, some growers have held that the yields of flax obtained from the combination crops are as large as when flax is grown alone and that the wheat yield is extra.

The average yields for each combination and for the crops grown alone at all locations for each year are given in Table 4. The average of all the tests does not show a yield of flax, wheat, or oats in any of the combinations as high as that from the same crop grown alone. Inspection of the results for the individual years at each location, which are not included here, shows that in only 6 cases out of a total of 288 trials did the flax yields in combinations equal the yields from the flax grown alone in the same tests. What have been thought to be the usual results actually occurred, therefore, in only 2.1 per cent of the tests, or about once in 50 trials.

EFFECT OF VARYING THE RATE OF SEEDING OF WHEAT, OATS, AND FLAX IN COMBINATIONS ON THE YIELDS OF EACH CROP

The yields of the combination crops and of the crops grown alone have been so arranged in Table 4 that comparisons may be made readily of the yields (1) of wheat and of oats, sown at the same rates, with flax at 42 and at 28 pounds per acre, (2) of wheat and oats, sown at different rates, with flax at 42 and at 28 pounds, (3) of flax sown at 42 and at 28 pounds with the same rates of seeding of wheat and oats, (4) of flax sown at 42 and at 28 pounds with different rates of seeding of wheat or oats, and (5) of flax sown alone at 42 and at 28 pounds per acre.

TABLE 4.—Average acre yields in bushels of wheat and flax mixed and oats and flax mixed grown at various rates of seeding compared with the yields of the same crops grown alone in nine localities (eight counties) in Minnesota for the 3-year period 1924-1926

Crop and rates of seeding per acre (pounds)	Ramsey County		Goodhue County				Faribault County		Renville County	
	Wheat or oats	Flax	Featherstone farm		Heinrichs farm		Wheat or oats	Flax	Wheat or oats	Flax
			Wheat or oats	Flax	Wheat or oats	Flax				
Wheat 15 {Flax 42 Flax 28	8.6 8.5	0.6 5.9	7.1 7.6	15.2 13.6	6.0 7.9	13.7 12.4	4.4 5.2	18.1 17.1	5.6 6.2	12.2 11.5
Difference	.1	.7	-.5	1.6	-1.9	1.3	-.8	1.0	-.0	.7
Wheat 30 {Flax 42 Flax 28	13.1 14.0	4.8 4.6	10.4 12.4	12.6 11.3	10.2 11.2	11.2 9.2	8.3 9.0	15.6 14.0	7.7 8.9	10.5 9.2
Difference	-.9	.2	-2.0	1.3	-1.0	2.0	-.7	1.6	-1.2	1.3
Wheat 45 {Flax 42 Flax 28	16.3 19.6	3.4 3.3	13.8 14.2	10.7 8.8	13.9 14.7	8.5 7.0	11.3 10.7	12.2 10.7	10.7 11.0	8.4 7.6
Difference	-3.3	.1	-.4	1.9	-.8	1.5	.8	1.5	-.3	.8
Oats 32 {Flax 42 Flax 28	39.5 39.5	2.6 2.5	41.5 41.9	8.8 7.7	42.8 46.7	6.5 5.1	34.8 39.3	11.0 8.6	27.4 30.3	7.3 7.4
Difference	.1	.1	-.4	1.1	-3.9	1.4	-4.5	2.4	-2.9	-.1
Oats 16 {Flax 42 Flax 28	28.2 20.9	5.3 4.0	18.2 21.6	14.6 12.7	35.8 34.4	10.0 9.0	24.2 32.0	16.7 14.5	17.8 22.1	13.4 12.4
Difference	-1.7	.7	-3.4	1.9	1.4	1.0	-8.4	2.2	-4.3	1.0
Wheat alone 90	25.6		25.4		21.6		18.7		18.3	
Oats alone 64	64.2		65.8		67.4		66.7		53.5	
Flax alone {42 28		9.0 7.9		10.7 19.9		18.6 17.4		23.0 21.3		16.0 14.4
Difference		1.1		-.2		1.2		1.7		1.6

Crop and rates of seeding per acre (pounds)	Stevens County		Wilkin County		Chy County		Poik County		Average	
	Wheat or oats	Flax	Wheat or oats	Flax	Wheat or oats	Flax	Wheat or oats	Flax	Wheat or oats	Flax
Wheat 15 {Flax 42 Flax 28	7.0 8.3	7.5 5.8	3.4 3.7	8.5 7.4	3.4 3.8	5.9 4.9	13.8 12.8	7.0 6.5	0.6 7.1	10.5 9.6
Difference	-1.3	1.7	-.3	1.1	-.4	1.0	1.0	.5	-.5	1.0
Wheat 30 {Flax 42 Flax 28	10.5 11.3	5.0 4.3	5.2 0.9	6.3 5.7	6.3 7.5	5.6 4.1	18.2 18.1	4.8 3.9	10.0 11.0	8.5 7.4
Difference	-.8	.7	-1.7	.6	-1.2	1.5	.1	.9	-1.1	1.1
Wheat 45 {Flax 42 Flax 28	12.2 12.2	4.7 3.7	7.8 10.5	4.7 3.9	8.8 9.0	4.2 2.8	20.7 21.8	3.4 2.3	12.8 13.5	6.7 5.6
Difference	0	1.0	-2.7	.8	-.2	1.4	-1.1	1.1	-1.0	1.1
Oats 32 {Flax 42 Flax 28	22.6 23.1	4.4 3.4	23.5 21.7	4.1 4.2	25.1 28.3	4.7 4.0	44.2 45.7	3.4 2.7	33.5 35.3	5.9 5.1
Difference	-.5	1.0	1.8	-.1	-4.2	.7	-1.5	.7	-1.8	.8
Oats 16 {Flax 42 Flax 28	17.3 15.4	4.1 4.0	9.3 10.0	4.4 4.3	11.7 11.2	5.7 4.9	27.0 28.3	5.7 4.4	21.0 22.8	8.8 7.9
Difference	1.9	-.8	-.7	.1	.5	.8	-1.3	1.3	-1.8	.9
Wheat alone 90	18.2		15.4		12.0		25.0		20.0	
Oats alone 64	30.5		35.9		38.6		54.9		53.0	
Flax alone {42 28		11.1 10.1		10.6 9.2		9.6 7.6		12.9 12.4		14.4 13.3
Difference		1.0		.8		2.0		.5		1.1

¹ Two-year average.

YIELDS FROM THE VARIOUS RATES OF SEEDING OF WHEAT AND OATS IN COMBINATIONS

On the basis of the 3-year averages, wheat sown at the rate of 15 pounds per acre with flax at 42 and at 28 pounds yielded 6.6 and 7.1 bushels, respectively, an average of 6.9 bushels. (Table 4.) Where the rate of seeding of wheat in the combination was increased to 30 pounds the average yields were 10 and 11 bushels, respectively, an average of 10.5 bushels. The yields of wheat were increased to 12.8 and 13.8 bushels, an average of 13.3 bushels when the rate of seeding of wheat in the combinations was 45 pounds. The average yield of wheat where the seeding rate was 45 pounds in the combinations was nearly twice that from the 15-pound seeding rate and 2.8 bushels higher than that from the 30-pound seeding rate. With each increase in the rate of seeding of wheat there was a significant increase in the yields of this crop in the combinations.

Oats sown at the rate of 16 pounds per acre in the two combinations with flax yielded at the rate of 21 and 22.8 bushels per acre, an average of 21.9 bushels. This is a 2-year average, and therefore is not comparable with the 3-year average yields from the combinations with 32 pounds of oats sown per acre, which produced yields of 33.5 and 35.3 bushels, respectively, an average of 34.4 bushels.

EFFECT ON WHEAT AND OAT YIELDS OF VARYING THE RATE OF SEEDING OF FLAX IN THE COMBINATIONS

The average yields of wheat from the combinations where the rate of seeding of flax was 28 pounds per acre were somewhat higher in nearly every instance than where the rate of seeding of flax was 42 pounds per acre. Where the seeding rate of the wheat in the combinations was 15 pounds the difference of 0.5 bushel between the two average yields of 7.1 and 6.6 bushels is not significant. When the seeding rate of wheat is as low as 15 pounds a difference of 14 pounds in the seeding rate of flax in the combinations did not affect materially the yields of wheat.

When the seeding rates of wheat in the combinations were raised to 30 and 45 pounds per acre, respectively, the 3-year average acre yields of wheat were 1.1 and 1 bushel lower where the flax seeding was 42 pounds than where it was 28 pounds per acre. These differences in yield are significant and indicate that where the seeding rates of the wheat in the combinations are as high as 30 and 45 pounds, respectively, the competition of the flax plants from the 14 pounds of additional seed does lower the wheat yields materially.

Fourteen pounds of additional flaxseed per acre lowered the acre yields of oats 1.8 bushels where the rate of seeding of oats was 16 pounds and also lowered them 1.8 bushels where the rate of seeding was 32 pounds. These differences in yields probably are not significant.

EFFECT ON FLAX YIELDS OF VARYING THE RATE OF SEEDING OF WHEAT AND OATS

With each increase in the rate of seeding of wheat and oats there was a significant lowering of the average acre yields of flax. (Table 4.)

In the combination where wheat was sown at the rate of 15 pounds per acre, the flax yields averaged 10.5 and 9.5 bushels, respectively, an average yield of 10 bushels per acre for the two combinations.

This is 2 bushels higher than the average yield of flax in the two combinations where the rate of seeding of wheat was 30 pounds, and 3.8 bushels higher than the average flax yield from the two combinations where the rate of seeding of wheat was 45 pounds.

Where the rate of seeding of oats in the two combinations was 16 pounds per acre, the yields of flax were 8.8 and 7.9 bushels, an average of 8.4 bushels. This yield is 2.9 bushels higher than where the rate of seeding of oats was 32 pounds.

With each increase in the seeding rate of wheat and oats in the combinations there was a significant reduction in the acre yields of flax.

EFFECT OF INCREASING THE SEEDING RATE OF FLAX ON THE YIELDS OF FLAX IN THE DIFFERENT COMBINATIONS

In the wheat-flax combinations, the acre yield of flax from the 42-pound rate of seeding is without exception higher than that from the 28-pound rate. (Table 4.)

Where the seeding rate for the wheat was 15 pounds per acre, the yield of flax from the 42-pound seeding was 10.5 bushels and from the 28-pound seeding rate 9.5 bushels, a difference of 1 bushel. Where the rates of seeding of wheat in the combinations were 30 and 45 pounds, respectively, the acre yields of flax from the 42-pound rate of seeding averaged in each case 1.1 bushels higher than the yields from the 28-pound rate, and this same difference obtained where flax was sown alone at the 42-pound and 28-pound rates of seeding.

The yields from the 42-pound rate of seeding of flax in the combinations with oats at the 16-pound and 32-pound rates, respectively, were 0.9 bushel and 0.8 bushel higher than from the combinations where the seeding rate of flax was 28 pounds.

The 42-pound rate of seeding of flax either alone or in the combinations with wheat used in these experiments showed consistently higher average yields of flax than the 28-pound rate of seeding. In the oat-flax combinations the advantages in favor of the 42-pound seeding rate for flax were not so consistent as in the wheat-flax combinations. The advantage in favor of the 42-pound seeding rate of flax ranged from an average of 1 to 1.1 bushels, for flax grown alone and in combinations with wheat, to 0.8 and 0.9 bushel, in the combinations with oats.

The consistency of the higher average yields per acre of flax in the combinations and alone from the 42-pound as compared with the 28-pound seeding rate of flax indicates that the former rate is the one to use in the State, provided these differences are significant. As indicated in Table 5, the difference of 1.1 bushels in favor of the average yield from the 42-pound rate for flax alone as compared with the yield from the 28-pound seeding is significant, being more than four times its probable error. On the Featherstone farm in Goodhue County, the average yield from the 42-pound seeding for flax alone was not higher than the yield from the 28-pound seeding for flax.

The 3-year average yields of wheat at three rates, 15, 30, and 45 pounds per acre, in combination with flax at 28 and 42 pounds at nine locations in Minnesota are shown graphically in Figure 2. The acre yields of wheat and flax grown alone are included for comparison.

COMPARATIVE YIELDS OF CROPS GROWN IN COMBINATION AND ALONE

Comparisons have been made of the wheat, oat, and flax yields in the various combinations, and attention has been called to the variations in the yields and proportions of each of the crops in the combinations brought about by differences in the rates of seeding.

In order to compare the total yields of the crops grown in combination with the crops grown alone, all yields were converted to a flax basis as outlined on page 5. The 3-year average yields on this basis for each location are given in Table 5. For each location the differ-

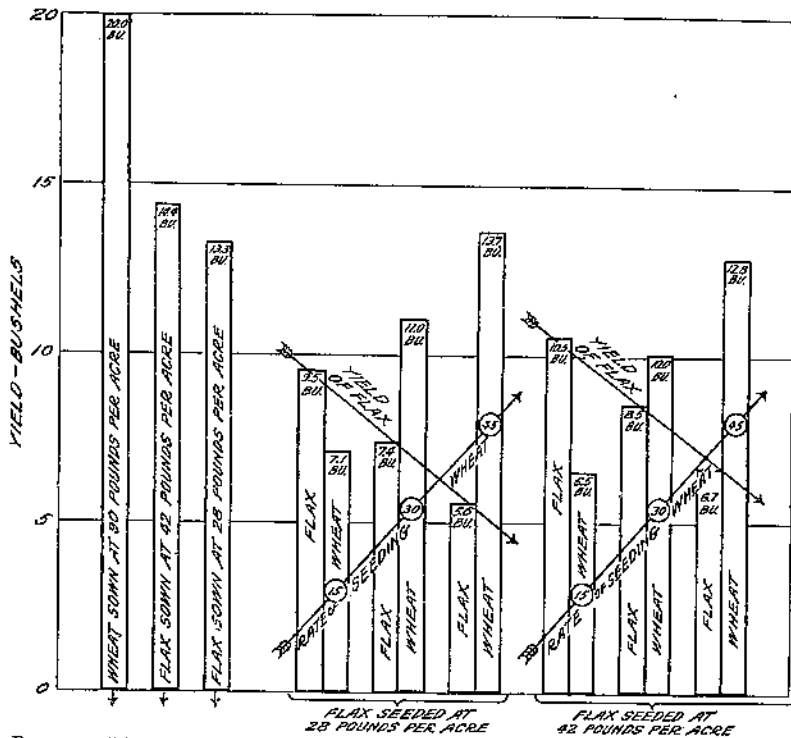


FIGURE 2.—Diagram showing the 3-year (1924-1926) average acre yields of wheat and of flax, seeded at two rates, and of the flax-wheat mixtures at nine localities in Minnesota. Increasing the rate of seeding wheat in combination with flax results in higher yields of wheat and lower yields of flax. Increasing the rate of seeding of flax in combination with wheat results in lower yields of wheat and higher yields of flax.

ences in the yields for each pair of combinations, differing only in the rate of seeding of flax, indicates whether the higher seeding rate of flax has resulted, on the average, in an increase or decrease in total yield.

In the two combinations with the 15-pound seeding of wheat, the 42-pound seeding of flax resulted in some increase in total average yield at seven of the nine locations. The average difference for all locations is less than three times its probable error and hence is not considered significant.

Although in a large majority of cases the combinations with wheat sown at 30 and 45 pounds and oats at 16 and 32 pounds per acre show some advantage in total yield in favor of the 42-pound seeding for flax, none of the 3-year average differences for all locations are considered significant.

TABLE 5.—Average acre yields of combination crops and of wheat, oats, and flax grown alone converted to a flax basis, in nine localities (eight counties) in Minnesota for the 3-year period 1924-1926

Crop and rates of seeding per acre (pounds)	Average acre yields (bushels)										Increase (+) or decrease (-) compared with flax alone at 42 pounds
	Ramsey County	Goodhue County		Fairbairn County	Kenaville County	Stevens County	Wilkin County	Clay County	Polk County	3-year average	
		Featherstone farm	Heinrichs farm								
Wheat 15 { Flax 42	9.6	20.5	18.9	23.3	16.7	11.8	10.6	8.7	14.5	14.9±0.19	+0.5
Flax 28	8.8	19.2	19.2	23.4	16.6	10.8	9.8	7.9	13.4	14.3±.18	-1
Difference	.8	1.3	-.3	-.1	.1	1.0	.8	.8	1.1	.6±.26	
Wheat 30 { Flax 42	9.4	20.3	20.0	25.8	16.8	11.4	9.5	10.7	14.7	15.4±.20	+1.0
Flax 28	9.4	20.4	19.0	24.9	16.6	11.1	10.1	10.2	13.8	15.1±.19	+0.6
Difference	-.2	-.1	1.0	.9	.2	.3	-.6	.5	.9	.3±.28	
Wheat 45 { Flax 42	8.8	21.1	20.8	25.9	17.5	12.0	9.8	11.5	14.6	15.8±.20	+1.4
Flax 28	10.3	19.3	19.8	23.5	17.3	11.0	10.0	10.3	14.1	15.1±.19	+1.7
Difference	-1.5	1.8	1.0	2.4	.2	1.0	-.8	1.2	.5	.7±.28	
Oats 32 { Flax 42	9.0	20.7	18.2	23.1	15.2	10.7	10.3	10.3	13.0	14.6±.19	+1.2
Flax 28	8.0	19.8	17.9	22.5	16.1	9.9	9.9	10.5	13.0	14.3±.18	-1
Difference	0	.9	.3	.6	-.9	.8	.4	-.2	.0	.3±.26	
Oats 16 { Flax 42	9.6	19.9	19.7	24.0	19.5	8.2	7.3	8.5	13.0	14.5±.19	+1
Flax 28	9.2	19.0	18.4	25.2	19.8	8.6	7.3	7.8	12.0	14.1±.18	-1.3
Difference	.4	.9	1.3	-.6	-.3	-.4	0	.7	1.0	.4±.26	
Wheat alone 90	9.0	19.7	18.7	23.9	16.0	11.1	10.0	9.6	12.0	14.4±.18	
Oats alone 64	9.0	19.7	18.7	23.0	16.0	11.1	10.0	9.6	12.0	14.4±.18	
Flax alone { 42	9.0	19.7	18.7	23.0	16.0	11.1	10.0	9.6	12.0	14.4±.18	
28	7.6	19.9	17.4	21.3	14.4	10.1	9.2	7.6	12.4	13.3±.17	
Difference	1.4	-.2	1.3	1.7	1.6	1.0	.8	2.0	.5	1.1±.25	
Probable error of experiment percentage	5.7	2.2	2.3	3.0	3.2	2.4	3.0	4.1	3.3	1.3	

¹ 2-year average, 1925-1926.

Although apparently there are no significant differences in the total yields from the combinations where the seeding rate of the wheat was the same and that of the flax varied, a different condition is found when the yields of the combinations from the 30-pound wheat and 42-pound flax and the 45-pound wheat and 42-pound flax are compared with the yields from the flax grown alone at the 42-pound seeding. The average yields from these two combinations are higher by 1 ± 0.26 and 1.4 ± 0.26 bushels, respectively, than the yields from the flax grown alone at the 42-pound seeding rate. These differences are 3.8 and 5.4 times their probable errors and apparently are significant.

The two combinations with seeding rates of 30 and 45 pounds of wheat and 28 pounds of flax each yielded 0.7 ± 0.26 bushel higher than the flax grown alone. This difference is practically three times its probable error.

The two combinations with the seeding rates of 30 pounds of wheat and 42 pounds of flax and 45 pounds of wheat and 42 pounds of flax

may be considered as having yielded at a definitely higher total rate than the crops grown alone. Since the two other combinations with seeding rates of 30 and 45 pounds of wheat and 28 pounds of flax and the one with the seeding rate of 15 pounds of wheat and 42 pounds of flax come so near to equaling the other two in acre yield, they also may be regarded as having yielded at higher rates than the flax grown alone from the 42-pound seeding rate. The yield from the combination with the wheat at 15 pounds and flax at 28 pounds as



FIGURE 3.—A sheck of the flax-wheat mixed crop, showing the well-formed bundles made by the blinder

seeding rates and that from the oat-flax combinations were about the same as the flax alone at the 42-pound seeding rate. (Fig. 3.)

YIELDS ON THE PERCENTAGE BASIS

The average yields of the crops grown in combination and alone, reduced to a flax basis, have been given in Table 5, and the differences in yields on that basis have been discussed.

In order to further facilitate comparisons of the average yields from the combination crops and the crops grown alone, each of the yields given in Table 4 has been computed as a percentage of the yield of the crops grown alone. These yields, on a percentage or relative basis, are given in Table 6. Comparisons of the yields from any combination at any location may be readily made through the use of the relative yields as given in this table. On the basis of the 3-year average yields per acre from all locations, the combinations from the seeding of 45 pounds of wheat and 42 pounds of flax and

from the seeding of 30 pounds of wheat and 42 pounds of flax yielded 8.9 and 6.2 per cent higher, respectively, than flax grown alone. As is brought out in the discussion of the yields in Table 5, these combinations yielded at a definitely higher rate than the crops grown alone.

TABLE 6.—Average acre yields of combination crops converted to a flax basis and expressed in percentages of the yields of flax grown alone at the 42-pound rate of seeding, in nine localities (eight counties) in Minnesota for the 3-year period 1924-1926

Crop and rates of seeding per acre (pounds)	Percentages of the yield of flax grown alone										
	Ramsey County	Goodhue County		Faribault County	Renville County	Stevens County	Wilkin County	Clay County	Polk County	Averages	
		Peabersson farm	Hehrichs farm							3-year period 1924-1926	4-year period 1923-1926
Wheat 15 ¹ (Flax 42)	106.9	104.1	100.7	100.3	107.0	106.12	109.0	92.0	112.4	104.0	100.3
Flax 28	95.9	97.6	100.9	100.4	105.5	100.7	96.9	82.6	103.9	98.3	
Difference	11.0	6.5	-2	-1	1.5	5.4	9.1	9.4	8.5	5.7	
Wheat 30 ¹ (Flax 42)	100.3	103.3	107.7	111.2	108.0	105.7	93.9	111.7	114.1	106.2	
Flax 28	101.0	103.8	102.3	106.1	105.5	104.8	90.7	105.0	107.4	104.0	103.9
Difference	-1.3	-0.5	5.4	5.1	2.5	.9	-5.8	6.7	6.7	2.2	
Wheat 45 ¹ (Flax 42)	93.1	103.9	111.1	111.0	112.2	109.2	98.2	119.5	113.9	108.9	
Flax 28	111.5	98.1	106.8	101.0	109.6	101.4	105.6	109.8	109.8	105.9	106.1
Difference	-17.4	10.8	4.3	10.0	2.6	7.8	-7.4	9.7	4.1	3.0	
Oats 32 ¹ (Flax 42)	98.9	105.5	96.0	100.6	99.5	97.0	100.0	107.4	103.2	101.4	
Flax 28	100.4	100.4	96.8	97.5	101.9	90.1	99.4	111.6	103.9	100.2	
Difference	-1.5	5.1	-2	3.1	-2.4	7.8	.6	-4.2	2.3	1.2	
Oats 16 ¹ (Flax 42 ¹)	112.2	100.9	107.0	95.9	94.6	99.5	85.1	106.4	100.2	100.2	
Flax 28 ¹	103.4	95.9	100.5	96.2	95.9	103.9	83.7	97.8	91.5	97.4	
Difference	2.8	5.0	6.5	-0.3	-1.3	-4.4	-0.6	8.6	8.7	2.8	
Wheat alone 00	100	100	100	100	100	100	100	100	100	100	100
Oats alone 61	100	100	100	100	100	100	100	100	100	100	100
Flax alone ¹ 42	100	100	100	100	100	100	100	100	100	100	100
28	80	101.2	93.2	92.7	96.8	92.7	89.7	76.5	90.6	91.3	92.5
Difference	11	-1.2	6.8	7.3	3.2	7.3	10.3	23.5	3.4	8.7	7.5

¹ 2-year average.

PERCENTAGE OF FLAX IN THE SEED SOWN AND IN THE CROP HARVESTED

The different combination crops are listed in Table 7, and the percentage of flax in the seed sown is given for each.

The 3-year average percentage of flax in the crops harvested from each combination crop is given for each location. Differences in the average percentages of flax in the crops harvested from each two combinations, in which the seeding rate for the wheat or oats was the same but the seeding rate of the flax varied, are given for each location.

In the six wheat-flax combinations the average percentage of flax in the crops harvested ranged from 9.4 to 14.8 per cent less than in the seed sown.

TABLE 7.—Percentage of flax in the seed of the combination crops sown and in the crops harvested in nine localities (eight counties) in Minnesota for the 3-year period 1924-1926

Crop and rates of seeding per acre (pounds)	Percentage in the seed sown	Percentages of flax in crops harvested										Difference between proportion in seed sown and crop harvested
		Ramsey County	Goodhue County		Furbault County	Renville County	Stevens County	Wilkin County	Clay County	Polk County	3-year average	
			Featherstone farm	Heinrichs farm								
Wheat 15 (Flax 42)	73.7	42.6	67.5	67.3	78.1	63.1	50.5	71.9	61.8	33.9	59.6	-14.1
(Flax 28)	65.1	42.1	62.8	62.4	73.6	60.0	40.8	67.5	58.0	33.9	55.7	-9.4
Difference	8.6	.5	4.7	4.9	4.5	3.1	9.7	4.4	3.8	0	3.9	
Wheat 30 (Flax 42)	58.3	30.2	55.7	51.9	62.5	52.5	33.1	57.6	46.9	21.3	45.5	-12.8
(Flax 28)	48.3	27.4	47.6	44.5	57.9	46.3	28.0	47.0	34.0	17.3	38.9	-9.4
Difference	10.0	2.8	6.1	7.4	4.6	6.2	5.1	10.6	12.0	4.0	6.6	
Wheat 45 (Flax 42)	49.3	20.1	43.9	37.4	50.0	40.7	28.7	35.9	30.8	14.1	33.5	-14.8
(Flax 28)	38.4	15.1	38.5	31.8	49.2	37.4	23.8	27.7	24.0	9.4	28.5	-9.9
Difference	9.9	5.0	5.4	5.6	.8	3.3	4.9	8.2	6.8	4.7	5.0	
Oats 32 (Flax 42)	58.7	11.7	30.3	23.5	35.5	31.7	32.0	27.7	34.2	16.6	27.0	-29.7
(Flax 28)	46.7	9.9	26.8	17.9	27.1	29.2	26.0	29.4	30.0	14.5	23.5	-23.2
Difference	10.0	1.8	3.5	5.6	8.4	2.5	6.0	-1.7	3.6	2.1	3.5	
Oats 16 (Flax 42)	72.4	29.6	59.2	39.7	54.9	56.0	38.0	41.8	54.1	38.4	45.7	-26.7
(Flax 28)	63.6	24.1	61.8	38.8	44.4	50.1	41.8	40.3	50.3	33.6	41.7	-21.9
Difference	8.8	5.5	7.4	.0	10.5	5.9	-3.8	1.5	3.8	4.8	4.0	

¹ 2-year average.

The percentages of flax sown in the 16-pound and 32-pound combinations of oats are practically the same as for the combinations sown with 15 and 30 pounds per acre of wheat. However, the percentages of flax in the harvested crops of the oat-flax combinations are distinctly lower than the percentages of flax in the crops harvested from the wheat-flax combinations. Plants of Victory oats bear a considerable number of leaves above the general height level of the flax plants, whereas most of the leaves of Marquis wheat plants are at the level of or below the inflorescences of the flax plants. Owing largely to this difference, flax has a better opportunity when growing with wheat than with oats.

In practically every trial where the wheat or oat seeding rate was the same the average percentage of flax in the combination crops harvested from the 42-pound seeding for flax was higher than in the crops harvested from the 28-pound seeding.

The percentages of flax in the combination crops averaged lower for the trials in Polk and Ramsey Counties than at the other localities.

Where seed of the crops grown together is to be used for sowing combination crops again, it is advisable to separate the seed, and after removing any weed seeds that may be in either one mix them again in the proportions desired. Another way is to separate a

weighed sample of the grain from the crop harvested to determine the proportions of the wheat and flax and then add as much flaxseed as is necessary to bring it up to the desired proportion.

EFFECT OF WEEDS

Where many weeds grow up in flax sown alone, they compete with the flax in much the same way as the wheat or oats sown in the combination crops and thus reduce the yields. As an average for a 2-year period, extensive yield determinations made by removing adjacent heavily and lightly weed-infested square-yard areas of flax from a number of different fields showed an average acre yield of 2.3 bushels of flax less on the heavily weed-infested areas.

Wheat sown at the rate of 30 to 45 pounds per acre with flax eliminates weeds very largely, except wild oats and such perennial weeds as quack grass and sow thistle. The wheat in the combinations lowers the yields of flax, but produces a part of the total crop valuable in itself. Wheat sown at 15 pounds per acre in combination with flax does not produce a stand heavy enough to control weed growth as effectively as do seedings of 30 or 45 pounds per acre.

The yields given in Tables 4 and 5 for Ramsey County in particular and the values per acre given in Table 9 for the same location indicate that it is practicable to grow the wheat-flax combination crop on land that is too weedy to grow flax alone and to secure from it a return higher than from the flax crop grown alone under unfavorable conditions.

WEIGHT PER BUSHEL AND PER 1,000 KERNELS

In Goodhue, Faribault, and Wilkin Counties the wheat in the combination crops tested enough higher in bushel weight to make a difference of one market grade. At the other locations the test weights of the wheat in the combination crops averaged about the same as the weight of the wheat grown alone.

The weight in grams per 1,000 kernels of wheat grown alone and in the combinations was lower in Stevens, Wilkin, Clay, and Polk Counties than at the other locations, owing largely to some damage from black stem rust. The wheat in the combination crops from all locations averaged 25.45 grams per 1,000 kernels and that grown alone 24.07 grams per 1,000 kernels, a difference of 1.38 grams in favor of that grown in the combination crop. The oats in the combination crops averaged 27.06 grams per 1,000 kernels and those grown alone 25.93 grams per 1,000 kernels, a difference of 1.13 grams in favor of the combination.

In the combinations with wheat, the flax averaged 4.27 grams per 1,000 seeds and in those with oats 4.30 grams per 1,000 seeds. Flax grown alone averaged 4.23 grams per 1,000 seeds.

STRAW YIELDS PER ACRE

The average yields of straw per acre for each of the combination crops and for each crop grown alone are given in Table 8.

In Minnesota, No. 1 flax straw during the past five years has had an average market value of \$11 per ton and No. 2 straw a value of \$9 per ton, laid down at the points where used. Under the present rules No. 1 flax straw must average 10 inches in length, and in the No. 2

grade it must average 6 inches in length. No. 1 straw may contain up to 5 per cent and No. 2 up to 10 per cent of weeds. Higher percentages of weeds result in dockage.

TABLE 8.—Average acre yields of straw from the combination crops and the crops grown alone in seven localities (six counties) in Minnesota for the 3-year period 1924-1926

Crop and rates of seeding per acre (pounds)	Average acre yields of straw (tons)							3-year average
	Ramsey County	Goodhue County		Faribault County	Renville County	Wilkin County	Clay County	
		Featherstone farm	Hainrichs farm					
Wheat 15—(Flax 42	1.4	1.9	1.8	1.8	1.7	1.2	1.3	1.6
Flax 28	1.5	1.7	1.8	1.7	1.7	1.2	1.2	1.6
Wheat 30—(Flax 42	1.5	1.9	1.8	2.0	1.7	1.2	1.4	1.6
Flax 28	1.6	1.8	1.9	1.9	1.6	1.2	1.4	1.6
Wheat 45—(Flax 42	1.5	1.9	1.9	2.0	1.7	1.4	1.6	1.7
Flax 28	1.6	1.9	1.9	1.9	1.7	1.3	1.7	1.7
Oats 32—(Flax 42	1.4	1.9	1.9	2.1	1.6	1.3	1.5	1.7
Flax 28	1.5	1.8	1.8	2.1	1.6	1.1	1.6	1.6
Oats 16—(Flax 42 ¹	1.6	1.6	1.8	2.2	1.8	1.2	1.4	1.6
Flax 28 ¹	1.6	1.5	1.7	2.1	1.7	1.5	1.2	1.6
Wheat alone 90	2.0	1.6	1.7	2.1	1.5	1.5	1.5	1.7
Oats alone 64	1.8	1.5	1.6	2.0	1.6	1.3	1.7	1.7
Flax alone—(42	1.4	1.6	1.6	1.7	1.5	1.1	.8	1.4
28	1.3	1.6	1.6	1.7	1.4	1.0	.8	1.3

¹ Two-year average.

Within a radius of approximately 200 miles from points where flax straw is used, freight charges range around \$3 per ton. The hauling expense from farm to station is approximately \$3 per ton, and the baling costs \$3 per ton. The 5-year average value of No. 1 flax straw in the stack on the farm therefore has been about \$2 per ton. Baling and hauling flax straw offers some employment during part of the winter for men and teams at fair wage rates.

If flax is grown as a combination crop with wheat, oats, or barley, the straw can not be used by the industries that provide a market for pure flax straw.

ADVANTAGES AND DISADVANTAGES OF COMBINATION CROPS NOT SHOWN IN YIELDS

The wheat-flax and oat-flax combination crops are no more difficult to cut with the binder, to shock, and to stack than wheat or oats grown alone. For growers who do not care to grow flax alone, the combinations offer the opportunity to secure some of the benefits of the relatively higher price for flax than for the other crops, whenever that relationship exists, without the necessity of growing flax alone.

The only disadvantage of the combination crop is the necessity of separating the grain making up the mixture. The great differences in size make this easy to accomplish by means of the ordinary fanning mill. In Goodhue County, where a large acreage of the combination crop is grown each year, the mixed grain is stored in granaries as it

comes from the threshers, and before the grain is marketed the separation is made at a cost of approximately 2 cents per bushel of mixed grain.

ACRE VALUES OF THE CROPS GROWN IN COMBINATION AND ALONE

The farm prices of flax, wheat, and oats in Minnesota on December 1 of stated years are given in Table 1.

The 3-year average gross values per acre at these prices are given in Table 9 for each location and for all locations. The 5-year average gross values per acre for each grain in the combinations and for each crop grown alone, with the totals, also are given in this table. Gross values per acre for the combinations and for the crops grown alone may be computed for any other period of years by using the yields per acre given in Table 4 and the prices on December 1 for the period of years selected.

TABLE 9.—Average gross acre values of combination crops in comparison with the same crops grown alone in nine localities (eight counties) in Minnesota for the 3-year period 1924-1926

Crop and rates of seeding per acre (pounds)	Farm value per acre on Dec. 1											5-year average ¹		
	Ramsey County	Goodhue County		Faribault County	Renville County	Stevens County	Wilkin County	Clay County	Polk County	3-year average	Wheat or oats	Flax	Total	
		Featherstone farm	Helrichs farm											
Wheat 15 (Flax 42..... Flax 28.....)	\$25.9 24.5	\$42.6 39.4	\$37.9 37.5	\$45.6 45.0	\$34.3 33.3	\$26.0 23.7	\$23.0 21.1	\$17.5 15.6	\$33.4 31.0	\$31.8 30.1	\$7.9 8.4	\$22.5 20.2	\$30.4 28.6	
Difference.....	1.4	3.2	.4	.6	1.0	2.3	1.9	1.9	2.4	1.7	-.5	2.3	1.8	
Wheat 30 (Flax 42..... Flax 28.....)	28.0 29.0	40.6 40.4	37.5 34.7	45.1 42.5	33.2 31.9	25.5 24.2	20.4 21.6	20.3 18.8	34.3 32.1	31.7 30.6	11.9 13.2	18.1 15.8	30.0 29.0	
Difference.....	-1.0	.2	2.8	2.6	1.3	1.3	-1.2	1.5	2.2	1.1	-1.3	2.3	1.0	
Wheat 45 (Flax 42..... Flax 28.....)	29.2 32.9	41.2 37.3	36.5 34.5	41.4 37.3	32.6 31.2	26.3 23.9	20.4 21.1	20.8 17.8	34.4 33.6	31.4 30.0	15.2 16.4	14.3 11.9	29.5 28.3	
Difference.....	-3.7	3.9	2.3	4.1	1.4	2.4	-.7	3.0	.5	1.4	-1.2	2.4	1.2	
Oats 32 (Flax 42..... Flax 28.....)	18.9 19.4	34.0 31.6	29.7 28.0	36.8 32.9	25.7 20.8	18.1 16.6	17.9 17.3	19.4 19.4	23.5 22.4	24.9 23.7	12.1 12.7	12.6 10.9	24.7 23.6	
Difference.....	-.5	2.4	1.7	3.9	-1.1	2.1	.5	0.0	1.1	1.2	-.6	1.7	1.1	
Oats 16 (Flax 42..... Flax 28.....)	20.3 18.2	36.7 33.5	32.4 29.8	43.9 42.2	34.2 33.8	13.9 15.1	11.8 11.7	15.4 13.5	20.3 17.8	25.4 24.1	7.6 8.2	18.7 16.8	26.3 25.0	
Difference.....	2.1	3.2	2.6	1.7	.4	-1.2	.1	1.9	2.5	1.3	.6	1.9	1.3	
Wheat alone 90.....	33.8 19.3	33.0 23.7	29.1 24.3	24.1 23.0	23.6 18.7	23.6 14.8	20.0 13.7	15.5 15.0	32.5 20.4	26.0 19.2	23.8 19.1	-----	23.8 19.1	
Flax alone (42..... 28.....)	19.9 17.3	43.2 43.6	41.4 38.5	50.4 45.9	35.1 31.3	24.9 22.7	22.1 20.2	21.4 17.1	28.6 27.4	31.9 29.5	-----	30.7 28.3	30.7 28.3	
Difference.....	2.6	-.4	2.8	3.5	3.8	2.2	1.9	4.3	1.2	2.4	-----	2.4	2.4	

¹ Based on average (1923-1927) farm prices on Dec. 1 in Minnesota.

² 2-year average, 1925-1926.

Flax alone at the 42-pound seeding rate averaged for all locations \$2.40 higher in gross value per acre for both the 3-year and the 5-year periods than flax at the 28-pound seeding rate. Deducting 75 cents for the 14 pounds of additional seed sown and 15 cents for the additional harvesting and threshing expense, there was left an additional income per acre of \$1.50 from the 42-pound seeding as compared with the 28-pound rate.

On the Featherstone farm in Goodhue County the gross values per acre for the flax sown alone at the 28-pound and the 42-pound rates were practically equal. In Polk and Wilkin Counties the additional gross income from seeding 42 pounds as compared with 28 pounds of flax per acre was only \$1.20 and \$1.90 per acre, respectively. At each of the other locations, the additional gross income per acre from the 42-pound as compared to the 28-pound seeding was decidedly in favor of the heavier rate, varying from \$2.20 to \$4.30.

For the crops grown alone, the comparative gross values per acre depend on the relative yields per acre and values per bushel. Flax has been relatively higher in price than wheat and oats during the 3-year and 5-year periods under consideration and hence has the advantage over wheat and oats on a value-per-acre basis where the comparative yields are not out of line. In Polk and Stevens Counties, for the 3-year period, the acre yield of wheat was nearly twice that of flax alone and in Ramsey County nearly three times that of flax alone. With this large advantage in acre yield, wheat even at a relatively lower price per bushel averaged nearly as high as flax in Stevens and Wilkin Counties, slightly higher than flax in Polk, and decidedly higher in Ramsey County in gross value per acre.

In Ramsey County the comparatively low yields of flax alone were due to weed competition. Weeds were a factor, also, in reducing yields in the combinations in which wheat was sown at the 15-pound rate and oats at the 16-pound rate.

Although the wheat-flax combinations, with the exception of that in which the seeding rate was wheat 15 pounds and flax 28 pounds, may be considered as having averaged higher in total yield than the crops grown alone, as shown in Table 5, the gross returns per acre are slightly lower than for the flax alone. This is due to the fact that the wheat and flax and the oats and flax grown together compete with each other, and the yields of both are lowered. The proportion of the grain of each crop of the total yield varies with conditions during the growing season. With the average price of wheat at \$1.19 and of flax at \$2.13 per bushel, in any of the wheat-flax combinations grown, the yield and value of the flax was lowered more in comparison with the average yield and value per acre of the flax grown alone from the 42-pounds per acre seeding rate than the value of the yield of wheat in the same combination. Seeding 30 and 45 pounds of wheat with 42 pounds of flax resulted in significantly higher total yields per acre than were obtained from flax alone. However, in these combinations the wheat, which averaged relatively lower in price than flax, reduced the yields of flax to such an extent that a lower total gross value per acre was secured from a higher total yield per acre.

If the average price of wheat for the 3-year and the 5-year periods had been relatively as high as that of flax, the gross returns per acre

for the crops grown in combination and alone would bear more nearly the same relation to each other as their yields per acre.

The wheat and oats, both in the combinations and alone, gave yields relatively higher in Ramsey, Goodhue, and Polk Counties than at the other locations. This is shown in Table 4. With the relatively low yield of flax alone as the base in Ramsey and Polk Counties and the wheat yields in the combinations relatively high, the combination crops and the wheat alone show higher values per acre than the flax alone. In Polk County, the wheat-flax combinations with the heavier seeding rate of flax show some increase in value per acre over wheat grown alone. In Ramsey County the wheat-flax combinations with the 30-pound and the 45-pound seeding rates for wheat produced yields of the highest values at this location, but still not higher than the value per acre of wheat grown alone.

In Goodhue, Faribault, and Renville Counties the flax yields and values per acre were high relative to those of wheat, both alone and in the combinations. The gross values per acre of the wheat-flax combination crops were slightly lower than those of the flax grown alone, but distinctly higher than those of the wheat and the oats grown alone.

The yields from the 16-pound oat-flax combinations are averages for two years only and hence are not strictly comparable to the yields obtained from sowing the oats at the 32-pound rate in combination with flax. With a few exceptions the oat-flax combination crops had a lower total value per acre than the wheat-flax combinations. This is due in part to the fact that oats is not so well suited as wheat to growing in combination with flax and in part to the lower relative price per bushel of oats as compared with the price of flax for the 3-year and the 5-year periods.

The oat-flax combinations produced crops having a higher gross value per acre than were obtained from the oats grown alone.

SUMMARY OF RESULTS IN MINNESOTA

The results, with a few exceptions, indicate that adequate moisture supply throughout the growing season favors increases in yields of the combination crops over the same crops grown alone. The presence of enough moisture in the soil during the early part of the growing season to permit luxuriant vegetative growth followed by low precipitation during the time the grain is filling is unfavorable for the combination crops as compared with the same crops grown alone.

The yields obtained over the 3-year period show definitely that flax yields in the combination crops average considerably lower than yields from the flax grown alone. In only six cases, or 2.1 per cent, out of a total of 288 separate trials were the flax yields in the combination crops equal to the yields of the flax grown alone.

Flax sown alone at 42 pounds per acre averaged 1.1 bushels higher in acre yield than flax from the 28-pound seeding. After deducting for the extra quantity of seed sown and the additional threshing expense, the gain from the heavier seeding rate was \$1.50 per acre at the average farm price for the 3-year period.

The yields of wheat and oats in the combination crops increased as the seeding rate of wheat and oats increased, but not in the same proportions.

In the combination crops where the seeding rate of the wheat and oats was the same, somewhat higher yields of wheat and oats were

obtained where the rate of seeding of flax was 28 pounds as compared with 42 pounds per acre.

Where the rate of seeding rate of flax in the combination crops was the same the higher yields of wheat and oats were obtained where these grains were sown at the higher rates.

In the combination crops of wheat and flax the 42-pound rate of seeding of flax produced practically the same increases in yields of this crop over the 28-pound seeding rate that were obtained where the flax was grown alone at the two rates of seeding. In the oat-flax combinations this advantage of the 42-pound over the 28-pound seeding rate for flax was somewhat less.

The combination of wheat and flax at a seeding rate of 45 and 42 pounds, respectively, per acre yielded a total of 1.4 bushels per acre more than flax alone at the 42-pound seeding rate. This is an increase of 9.7 per cent in yield. Four of the other five wheat-flax combinations produced increased yields of 0.5 to 1 bushel, or 3.5 to 6.9 per cent, over the yield of flax grown alone.

The average percentage of flax in the combination crops harvested varied considerably for the several locations and for different years. On an average, the decrease in the flax percentage in the crops harvested below that in the seed mixture sown was approximately twice as great in the oat-flax as in the wheat-flax combinations. When the grain from combination crops is used for seeding, it is always advisable to make a percentage determination of the seeds present in an average sample and add the quantities of flax necessary to bring the proportions up to what has been found to be necessary for the best results.

Where weeds other than wild oats and lamb's-quarters, or such perennial weeds as quack grass or sow thistle, reduce the yields of flax grown alone, the addition of 30 to 45 pounds of wheat or 32 pounds of oats to the flax will practically eliminate the weeds, and yields of higher acre values will be produced.

The average test weights of the wheat and oats grown in the combinations at four out of nine locations were higher than for the same crops grown alone.

The wheat and oats grown in the combination crops weighed somewhat heavier per 1,000 kernels than when grown alone at the usual rates of seeding. The differences between the weights per 1,000 seeds of flax grown in the combinations and alone were small, but consistently favored the combination cropping.

Where the flax was grown alone at the 42-pound seeding rate, the acre yields of straw varied from 0.83 ton in Clay County to 1.7 tons in Faribault County, with an average for all locations of 1.4 tons.

The combination crops are as easily harvested, shocked, and stacked as wheat or oats grown alone. Therefore, growing the combination crops eliminates the objections that some growers have to raising flax alone.

Although four of the wheat-flax combinations averaged significantly higher in yield than the flax alone at the 42-pound seeding rate, the gross values per acre are either equal to or slightly lower than those for the flax alone at that rate of seeding. The relatively high price of flax as compared with that of wheat offsets the advantage in total yield of the wheat-flax combination crops.

The 3-year average gross values per acre of the wheat-flax combinations are higher than the values per acre of the oat-flax combinations

for the same period and, with a few exceptions, higher than the values per acre of the wheat alone or the oats alone.

The 3-year average gross values per acre of the oat-flax combination crops are distinctly higher at each location than the values per acre of the oats alone at the same locations. As long as oats remain at a relatively low price as compared with flax, many growers in the southern and western parts of the State can profit by substituting either clear flax or one of the combinations on much of the acreage now devoted to growing oats alone.

EXPERIMENTS IN NORTH DAKOTA

By T. E. STOA, *Assistant Agronomist, North Dakota Agricultural Experiment Station*

The North Dakota Agricultural Experiment Station conducted experiments with flax-wheat mixtures as early as 1898 (7). The results during the years 1898 to 1902 were not such as to encourage the practice of mixed cropping. Wilt-resistant varieties were then unknown, and some of the difficulty of obtaining satisfactory flax yields can be attributed to the destruction of flax stands by the flax-wilt disease. Late seeding also caused low yields. Early seeding of flax was believed inadvisable at that time, and where the mixture was grown seeding was usually delayed until it was thought safe for flax. The result was that both crops suffered, and yields were not satisfactory.

At Dickinson and Mandan preliminary trials with the seeding of flax with wheat, oats, and barley were conducted in 1917 and 1918. Drought and Russian thistle affected yields in both years, the development of the flax plants being restricted because of the competition from the companion crop and the Russian thistle. At Fargo, in 1919, N. D. R. No. 114, a wilt-resistant variety of flax, and Marquis wheat were seeded. The seeding, however, was later than desirable, and with stem rust prevalent the wheat rusted badly.

The apparent success of flax-wheat cropping in southeastern Minnesota, where this cropping method is more common, aroused a great deal of interest among growers in North Dakota. In 1923 the experiment station undertook a more complete study of this method to determine its adaptability to North Dakota conditions. In that year flax-wheat trials were established by the State at Fargo, Dickinson, and Williston, and by the United States Department of Agriculture at Mandan. In addition to the trials in the experiment station fields, a number of tests were conducted in cooperation with farmers in different parts of the State. Wilt-resistant flax was used where the flax disease might be a factor, and usually Marquis or Kota was used as the standard variety of common wheat. Seasonal conditions were fairly good during the years 1923 to 1925 and again in 1927, though summer droughts prevailed in some areas, especially in 1925. In 1926 the spring was cold and dry. Strong winds from day to day were unfavorable to the early development of crops. In much of the State serious drought conditions continued through the summer. The April to August rainfall record for Fargo, Dickinson, and Mandan is set forth in Table 10. A summary of the flax-wheat trials is reported under the individual headings for each station.

RESULTS AT FARGO

Results for four years are available at Fargo³ and the data are presented in Table 11. Flax in the mixture was seeded at two rates (20 and 28 pounds per acre), to which wheat was added in three different quantities (15, 30, and 45 pounds per acre, except that in 1927 the trial was reduced to two rates for the mixture). The check plots of flax and of wheat seeded alone were sown at the rate considered standard for this region, flax 28 pounds and wheat 75 pounds. The appearance of the mixed crop is shown in Figure 4.

Favorable yields and comparisons were obtained in 1923, 1926, and 1927. In 1925 excessive June rains reduced all stands and subsequent yields in this field, wheat being injured to a greater extent than flax.



FIGURE 4.—A mixed crop of flax and wheat grown on sweet-clover sod near Buffalo, N. Dak., in 1921. The yield per acre was 5.9 bushels of flax and 16.1 bushels of wheat.

There was some frost damage in the spring of 1926 and some injury from drought and high wind.

For the three years, 1923, 1925, and 1926, flax alone averaged 12 bushels per acre. When seeded at the same rate, but with 15 pounds of wheat added, the average acre yield was reduced to 8 bushels. As a higher proportion of wheat was used in the mixture the flax yields were correspondingly reduced. With 30 pounds of wheat added, 5.1 bushels of flax was produced, and with 45 pounds of wheat added the yield of flax was 3.1 bushels. The yields of wheat increased from 8.2 bushels to 14.9 bushels per acre as the rate of seeding increased.

For the four years including 1927 the average acre yield of flax alone was 13.6 bushels and that of wheat alone 27.6 bushels. Where 15 pounds of wheat were added to the flax, the flax yield was 8.7 bushels, and when 30 pounds of wheat were added the flax yield was reduced to 5.7 bushels.

³ Comparisons in 1924 were abandoned because of uneven stands.

TABLE 10.—Seasonal (April to August) rainfall at Fargo, Dickinson, and Mandan, N. Dak., for the 5-year period 1923-1927 compared with the mean seasonal rainfall for that region.

Station and year	Precipitation (inches)						Normal for the locality ¹
	April	May	June	July	August	Total	
Fargo:²							
1923.....	1.28	1.85	6.73	2.34	2.83	15.03	15.48
1924.....	4.01	.68	4.37	1.25	2.99	13.30	
1925.....	1.99	1.98	5.82	4.35	.25	14.19	
1926.....	.03	1.93	2.99	2.82	1.83	8.85	
1927.....	2.53	3.63	4.28	1.01	2.02	13.47	
Dickinson:							
1923.....	1.55	1.40	4.49	4.67	.82	12.99	11.08
1924.....	1.03	1.12	3.28	2.69	.77	8.87	
1925.....	1.26	.89	4.31	1.29	1.30	9.05	
1926.....	.46	2.90	1.92	1.16	1.58	8.00	
1927.....	2.10	5.07	2.12	2.93	1.29	14.11	
Mandan:							
1923.....	1.85	1.18	1.94	4.12	1.15	10.24	11.40
1924.....	1.08	.41	5.56	2.07	2.85	12.07	
1925.....	.94	1.18	7.34	.33	1.31	11.10	
1926.....	.13	2.41	1.20	2.10	1.31	7.24	
1927.....	1.37	6.65	2.00	2.37	3.16	15.55	

¹ Available Weather Bureau records up to and including 1923.
² Observations recorded at Moorhead, Minn.

TABLE 11.—Annual and average acre yields, relative yields, air-dry weight of weeds, and gross acre incomes from five mixtures of flax and wheat and from flax and wheat grown separately, at Fargo, N. Dak., for the four years, 1923 and 1925-1927.

Crop and rate of seeding per acre (pounds)	Acre yield						Relative yield	Acre weight of weeds ³	Average gross income per acre		
	1923	1925	1926	1927 ⁴	Average				Card price ⁵		Farm price ⁶
					1923, 1925, 1926	1923 and 1925-1927			1923, 1925	1923 and 1925-1927	
	Bush.	Bush.	Bush.	Bush.	Bush.	Bush.			Per cent	Pounds	Dollars
Flax 20.....	8.8	5.4	7.0	7.1	7.1	7.1	98	867	24.33	23.81	
Wheat 15.....	10.9	3.4	9.7	8.0	8.0	8.0					
Flax 20.....	5.9	3.4	5.1	4.8	4.8	4.8	102	918	24.07	24.44	
Wheat 30.....	17.9	5.0	15.6	12.8	12.8	12.8					
Flax 28.....	11.5	5.8	6.7	10.8	8.0	8.7	104	696	28.60	30.31	25.91
Wheat 15.....	10.8	3.0	10.7	19.3	8.2	11.0					
Flax 28.....	6.2	4.2	4.8	7.9	5.1	5.7	105	884	25.81	31.16	25.29
Wheat 30.....	16.8	3.0	19.3	30.0	13.0	17.3					
Flax 28.....	3.0	3.0	3.3	3.1	3.1	3.1	95	809	23.73	23.29	
Wheat 45.....	19.6	2.8	23.0	14.0	14.0	14.0					
Flax alone 28.....	18.5	7.3	10.2	18.3	12.0	13.6	100	1,045	25.68	27.81	24.96
Wheat alone 75.....	22.0	5.9	34.0	48.3	20.6	27.6					

¹ Stands in 1924 were injured by frost and weeds and were otherwise so uneven as not to be comparable, hence the test was not completed. Conditions in 1925, brought about by excessive June rains, were particularly harmful to wheat, hence the low average wheat yields that year.
² Only two mixtures were grown in 1927.
³ Average for 1925 and 1926; very few weeds in 1927.
⁴ Calculated on the basis of local card price on Dec. 1 each year for No. 1 dark northern spring wheat and No. 1 flax.
⁵ Based on the average (1923-1926) yield and the 5-year (1923-1927) average farm price of \$2.08 per bushel for flax and \$1.13 per bushel for wheat on Dec. 1 in North Dakota.

The relative yields of the mixtures as compared with the yields of flax alone and wheat alone varied from 98 to 105 per cent, not a consistent and hardly a significant increase. The highest relative yields were obtained where flax was seeded at 28 pounds and 15 or 30 pounds of wheat were added.

The factor of weeds generally was less as the quantity of wheat in the mixture was increased. Wheat tended to reduce the weed growth, and it also reduced the flax stand. According to an average of determinations made in 1925 and 1926, in the plot of wheat grown alone the air-dry weight of weeds per acre was 783 pounds, and where flax was grown alone the air-dry weight of the weeds was 1,045 pounds. The quantity of weeds in the mixtures varied from 696 to 918 pounds per acre. The weeds were not weighed in 1923. Observations in that year, however, indicated that weed growth was less as the quantity of wheat was increased. In 1927 as the result of having a good seed bed and favorable growing conditions for the crop there were very few weeds in all plots.

Stand counts showed a wide variation from year to year in the number of plants produced, although the seeding had been at the same rate. Plant counts were made just preceding maturity. These data are given in Table 12. In 1926 the average number of flax plants per acre, where flax was seeded alone, was 876,000; in 1923 there were 1,994,000. The condition of the seed bed and seasonal conditions are of great importance in determining the thickness of the stand which will result from any reasonable rate of seeding.

TABLE 12.—Annual and average numbers of flax and wheat plants and of wheat heads per plant in the flax-wheat mixture trials at Fargo, N. Dak., 1923-1927 (excluding 1924)

Crop and rate of seeding per acre (pounds)	Number of flax plants (thousands per acre)					Number of wheat plants (thousands per acre)					Average number of wheat heads per plant:			Average, 1923, 1925, 1926			
	1923	1925	1926	1927	Average		1923	1925	1926	1927	Average		1923		1925	1926	
					1923, 1925, 1926	1923 and 1925-1927					1923, 1925, 1926	1923 and 1925-1927					
Flax 20 {	Wheat 15	982	1,020	744		918		182	110	130		134		3.58	2.20	2.42	2.75
	Wheat 30	895	824	384		701		313	202	145		220		3.22	1.95	3.12	2.76
Flax 28 {	Wheat 15	1,527	1,304	726	1,089	1,186	1,162	160	113	136	268	139	157	3.29	2.30	2.92	2.84
	Wheat 30	1,278	1,418	628	1,065	1,108	1,087	478	194	260	334	311	317	2.86	1.45	2.10	2.14
	Wheat 45	1,133	1,251	545		976		668	237	367		404		2.18	1.18	2.18	1.84
Flax alone 28					1,534	1,509						816	776	2.69	1.27	1.40	1.58
Wheat alone 75								887	688	662	653						

1 Head counts not made in 1927.

Adding wheat to the flax reduced the number of flax plants which developed and matured in about the ratio that the wheat was added.

The number of wheat plants per acre in a mixture with flax, averaged 134,000 where 15 pounds of wheat were seeded and 404,000 where 45 pounds of wheat were seeded. The number was 816,000 where wheat was seeded alone at 75 pounds. The average number

of wheat heads produced per plant, however, was higher where the wheat was seeded at the lower rate and lowest where wheat was seeded alone at the higher rate.

The average gross income per acre during the three years ended in 1926, based on local card prices for No. 1 grade of grain, as given in Table 13, was \$25.68 from flax and \$24.21 from wheat. (See Table 11.) The acre income from the mixtures varied from \$23.73 to \$26.60. For the four years the average gross acre income from flax alone was \$27.81, and that from wheat alone was \$31.44; from flax at the regular rate with 15 pounds of wheat added it was \$30.31; and from the mixture, when 30 pounds of wheat were added, it was \$31.16.

TABLE 13.—Annual local card prices for flax and wheat at Fargo, Dickinson, and Mandan and average North Dakota farm prices on December 1, 1923-1927

Year	Fargo		Dickinson		Mandan		State average farm price	
	Flax	Wheat	Flax	Wheat	Flax	Wheat	Flax	Wheat
1923.....	\$2.19	\$0.97	\$2.10	\$0.93	\$2.13	\$0.96	\$2.12	\$0.86
1924.....	2.38	1.36	2.30	1.28	2.33	1.31	2.27	1.26
1925.....	2.29	1.49	2.21	1.50	2.24	1.53	2.23	1.31
1926.....	1.94	1.25	1.85	1.21	1.88	1.24	1.93	1.17
1927.....	1.87	1.10	1.80	1.04	1.83	1.07	1.85	1.04
Average.....	2.13	1.23	2.05	1.19	2.08	1.22	2.08	1.13

RESULTS AT DICKINSON⁴

Comparisons during five years at Dickinson are presented in Table 14. Flax was seeded at the rate of 15 and 25 pounds and wheat at 10, 20, and 30 pounds per acre in the mixture. Climatic conditions during the years 1923 to 1925 and 1927 were fairly good, though a late summer drought injured stands in 1925. In 1926 drought seriously affected all yields. The 5-year average acre yield of flax alone was 7.8 bushels and of wheat alone 17.7 bushels. In the mixtures, the yield of flax decreased as the proportion of wheat was increased. On the basis of relative yields, the yields of the mixed crop varied from 98 to 107 per cent of the flax or wheat seeded alone. Relative yields in 1927 were particularly favorable to the mixed crop because of low yields of flax when seeded alone and the high yields of wheat in the mixture. Previous to 1927 the relative yields for the mixed crop had varied from 90 to 100 per cent.

The average gross acre income based on card prices from wheat alone was \$21.26 and from flax alone \$16.28. The gross acre income from the mixtures varied from \$17.80 to \$19.82.

⁴ The experiments at Dickinson, N. Dak., were conducted under a cooperative agreement between the North Dakota Agricultural Experiment Station and the Office of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, and were under the direction of Ralph W. Smith, associate agronomist, Office of Cereal Crops and Diseases.

TABLE 14.—Annual and average acre yields, relative yields, and gross acre incomes from six mixtures of flax and wheat and from flax and wheat grown separately, at Dickinson, N. Dak., for the 5-year period 1923-1927

Crop and rate of seeding per acre (pounds)	Acre yields						Relative yield	Average gross acre income	
	1923	1924	1925	1926	1927	Average		Card price ¹	Farm price ²
	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels		Per cent	Dollars
Flax 15.....	8.9	5.7	4.9	3.2	1.5	4.8	101	18.50	17.89
Wheat 10.....	3.9	9.7	6.3	1.5	13.4	7.0			
Flax 15.....	8.7	4.0	3.1	1.8	1.5	4.0	99	18.29	17.81
Wheat 20.....	6.0	12.6	5.5	2.0	15.2	8.4			
Flax 15.....	5.9	3.8	3.6	1.1	.9	3.1	104	19.82	19.33
Wheat 30.....	10.2	10.2	7.9	3.2	17.2	11.4			
Flax 25.....	10.0	7.7	4.8	1.9	1.3	5.1	98	17.80	17.16
Wheat 10.....	3.4	8.5	3.7	1.1	12.4	5.8			
Flax 25.....	6.8	6.2	4.7	1.5	1.3	4.1	93	18.19	17.57
Wheat 20.....	4.0	13.8	4.8	1.3	14.6	8.0			
Flax 25.....	8.1	4.3	3.4	1.7	.6	3.8	107	23.07	19.58
Wheat 30.....	10.3	15.6	6.9	2.3	18.3	10.7			
Flax alone, 25.....	11.6	11.4	6.4	5.6	3.8	7.8	100	18.28	18.22
Wheat alone, 60.....	17.3	30.4	10.7	7.1	17.0	17.7	100	21.26	20.60

¹ Calculated on the basis of local card price on Dec. 1 each year for No. 1 dark northern spring wheat and No. 1 flax.

² Based on the average yield and the 5-year (1923-1927) average farm price of \$2.08 per bushel for flax and \$1.13 per bushel for wheat on Dec. 1 in North Dakota.

RESULTS AT MANDAN³

The flax-wheat trial at Mandan was a duplicate of the trial conducted at Dickinson. Comparisons for five years are available, and the data are presented in Table 15. During the years of the test, however, climatic conditions were somewhat less favorable at Mandan than at Dickinson, and yields were not quite so good. Drought at critical periods seriously affected all yields. The average acre yield of flax alone for the five years was 4.6 bushels and that of wheat alone 15.5 bushels. The flax yield in all years was low, on account of unfavorable crop conditions. The acre yields of flax where wheat was added averaged from 1.1 to 2.8 bushels. As at the other stations, flax yields were reduced as the proportion of wheat was increased in the mixture. The relative yield of the mixtures averaged from 93 to 110 per cent, being particularly high in 1927 because of low yields of flax (even where the flax was seeded alone) and comparatively high wheat yields in the mixtures. On the basis of gross acre income, wheat alone averaged \$19.31 and flax alone (because of abnormally low yields) only \$9.89. The mixture producing the highest average gross acre income (\$18.10) was flax at 15 pounds with wheat at 30 pounds.

Mixtures of oats and flax which were tried at Mandan were less satisfactory than the flax-wheat mixtures. The flax and oats had a tendency to separate in seeding, at least when small quantities of seed were used. On the other hand, the flax-oat mixture was more difficult to separate by means of the fanning mill in preparation for market. Views of one flax-wheat plot and one flax-oat plot are shown in Figure 5.

³ The experiments at Mandan, N. Dak., were under the direction of J. C. Brinsmade, Jr., assistant agronomist, Office of Cereal Crops and Diseases, and were conducted by that office at the Northern Great Plains Field Station in cooperation with the Office of Dry-Land Agriculture, both of the Bureau of Plant Industry, United States Department of Agriculture.

TABLE 15.—Annual and average acre yields, relative yields, air-dry weight of weeds, and gross acre incomes from six mixtures of flax and wheat and two mixtures of flax and oats, and from flax, wheat, and oats grown separately, at Mandan, N. Dak., for the 5-year period 1923-1927

Crop and rate of seeding per acre (pounds)	Acre yields						Relative yield	Acre weight of weeds	Average gross acre income	
	1923	1924	1925	1926	1927	Average			Card price ¹	Farm price ²
	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Per cent	Pounds	Dollars	Dollars
Flax 15.....	3.5	2.3	3.2	3.2	1.9	2.2	93	1,782	13.20	12.04
Wheat 10.....	5.0	10.3	10.0	1.4	5.9	6.6				
Flax 15.....	2.1	1.4	2.1	.1	1.4	1.4	99	1,159	16.42	14.78
Wheat 20.....	9.5	15.7	14.0	2.9	10.2	10.5				
Flax 15.....	1.6	1.2	1.5	.1	1.1	1.1	106	918	18.10	16.42
Wheat 30.....	12.2	13.4	17.6	2.9	11.7	12.5				
Flax 25.....	4.4	3.8	3.2	.3	2.4	2.8	103	1,357	14.01	12.94
Wheat 10.....	5.1	9.2	9.5	1.4	6.1	6.3				
Flax 25.....	3.2	2.3	2.5	.1	1.8	2.0	110	1,006	17.01	15.46
Wheat 20.....	7.8	15.7	14.4	2.5	10.0	10.0				
Flax 25.....	2.4	1.3	1.7	.1	1.3	1.4	108	996	17.53	16.13
Wheat 30.....	9.8	17.9	16.0	2.5	12.4	11.7				
Flax 20.....	5.2	4.5	3.2	.2	-----	3.3	107	1,115	-----	9.71
Oats 8.....	7.7	15.1	12.4	.5	-----	8.9				
Flax 20.....	3.7	2.3	2.9	.1	-----	2.3	104	928	-----	9.20
Oats 16.....	13.7	25.2	15.7	.4	-----	13.8				
Flax alone 25.....	7.0	6.7	5.5	.4	3.2	4.6	100	2,344	9.89	9.57
Wheat alone 60.....	15.9	25.3	18.3	4.9	13.3	15.5	100	557	19.31	17.52
Oats alone 48.....	31.0	42.1	29.7	2.1	-----	26.2	100	571	-----	8.38

¹ Calculated on the basis of local card price on Dec. 1 each year for No. 1 dark northern spring wheat and No. 1 flax.

² Based on the average yield and the 5-year (1923-1927) average farm price of \$2.08 per bushel for flax, \$1.13 per bushel for wheat, and \$3.32 per bushel for oats on Dec. 1 in North Dakota.

The effect of wheat, with its heavier foliage, in checking weed growth is shown very strikingly in the comparison of air-dry weeds per acre. During the five years the average quantity of weeds where flax was seeded alone was 2,344 pounds, or more than a ton of weeds per acre. Where wheat was seeded alone only 557 pounds per acre was produced. In the different mixtures the weeds varied from 1,782 pounds per acre, where the least quantity of wheat and the least quantity of flax were seeded, down to less than 1,000 pounds of weeds where the standard rate of flax was seeded and to which 30 pounds of wheat had been added. The amount of weed growth usually decreased as the quantity of wheat sown with the flax was increased. Russian thistle made up the bulk of the weed growth, both numerically and in dry weight. The other weeds usually present included two or three species of amaranthus, witch grass, and lamb's-quarters. These weeds, however, were not numerous.

As a complete record was made of the numbers and weights of weeds in the flax-cereal mixtures at Mandan, it seems desirable to report the results in some detail. Table 16 shows the numbers of weeds, flax, wheat, and oat plants in thousands per acre in each of the crops grown alone and in the mixtures. The numbers are based upon counts made in three representative square-yard areas in each of the triplicated plots, a total of nine such areas from each crop or mixture each year. During the course of the experiments a total of 468 square-

yard areas was harvested, and the different groups of plants (Russian thistle, other weeds, flax, and cereal) were counted, air-dried,

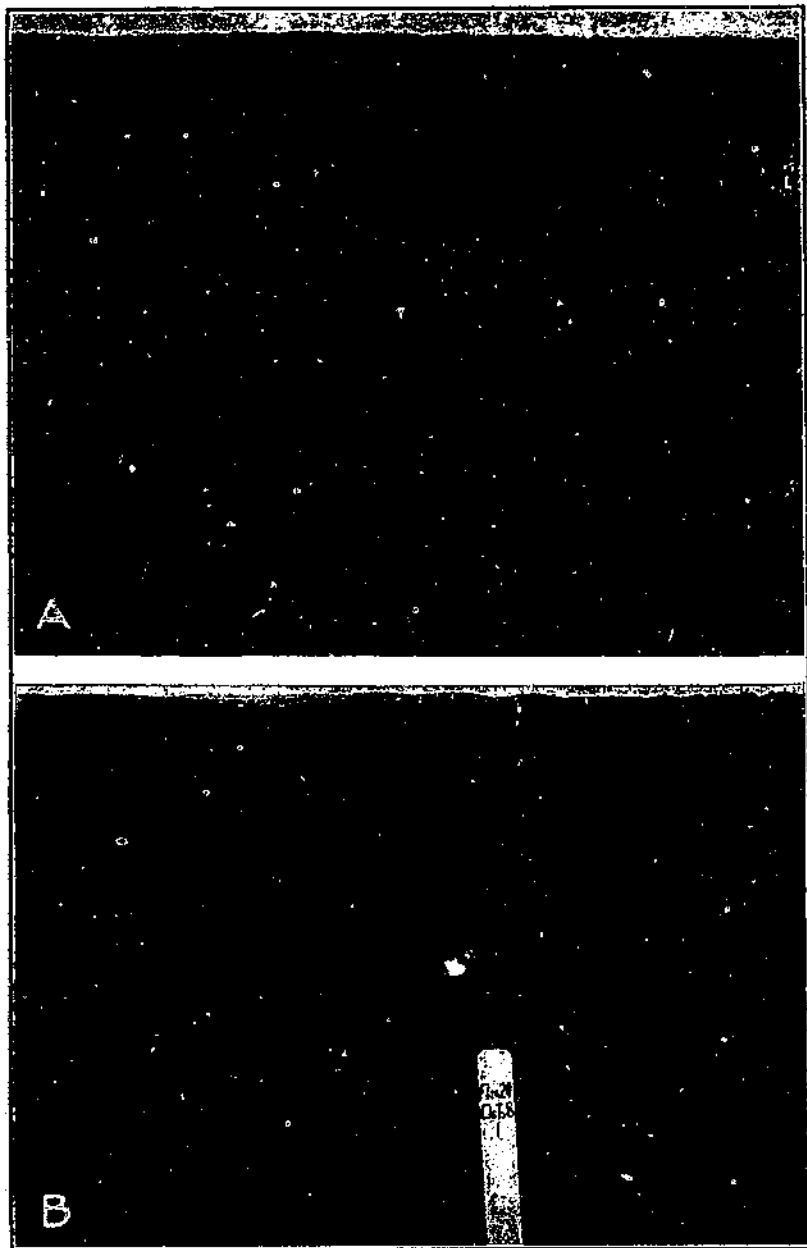


FIGURE 5.—A, Mixture of flax seeded at 25 pounds with Marquis wheat at 10 pounds per acre; B, mixture of flax seeded at 20 pounds with Victory oats at 8 pounds per acre. Northern Great Plains Field Station, Mandan, N. Dak., July 14, 1923

and weighed. The annual and average weights in pounds per acre of all weeds, flax, wheat, and oat plants are given in Table 17. These

weights include the grain or seed and the few roots that were pulled with the plants. A view of the dried weeds and flax from two such square-yard areas is shown in Figure 6.

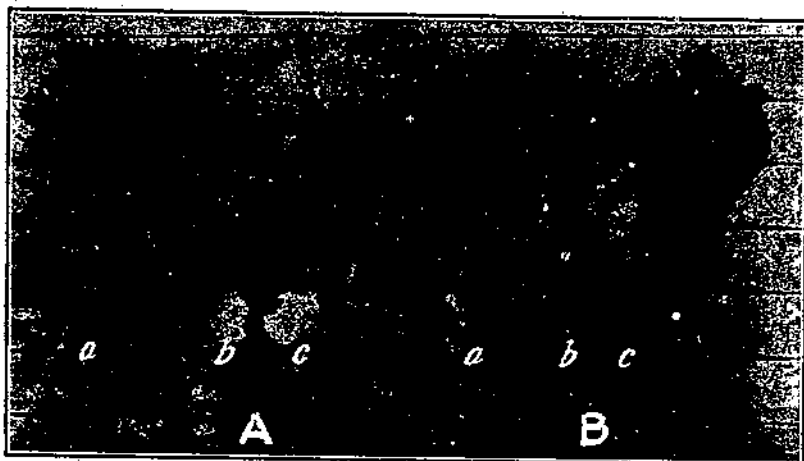


FIGURE 6.—Bundles of Russian thistles (a), of other weeds (b), and of flax (c), pulled from duplicate square-yard areas (A and B) in the flax seeded alone at 25 pounds per acre, at Mandan, N. Dak., in 1925. The average dry weight of Russian thistle was 2,255 pounds per acre, and the acre yield of flax was 6.5 bushels

TABLE 16.—Annual and average numbers of plants per acre of weeds and of flax, wheat, and oats in the flax-cereal mixtures and of flax, wheat, and oats grown separately at Mandan, N. Dak., 1923-1927

(In thousands—i. e., 000 omitted)

NUMBER OF WEEDS

Year	Crop and rate of seeding per acre (pounds) of—										
	Flax 15 and			Flax 25 and			Flax 20 and		Flax alone 25	Wheat alone 60	Oats alone 48
	Wheat 10	Wheat 20	Wheat 30	Wheat 10	Wheat 20	Wheat 30	Oats 8	Oats 16			
1923	709	653	538	759	489	374	559	451	551	298	343
1924	549	454	440	456	385	383	321	265	632	288	217
1925	285	250	130	164	157	133	315	186	293	153	148
1926	1,185	1,490	1,137	1,192	1,121	1,187	1,360	1,376	1,031	678	1,224
1927	2,640	2,189	2,033	1,774	1,729	1,721	-----	-----	2,485	1,945	-----
Average	1,074	1,009	857	869	774	760	639	570	999	606	483

NUMBER OF FLAX PLANTS

1923	947	852	869	1,353	1,497	1,297	1,571	1,389	1,728	-----	-----
1924	836	807	841	1,270	1,348	1,272	1,388	1,168	1,209	-----	-----
1925	618	681	562	898	891	1,045	886	1,056	1,063	-----	-----
1926	467	482	416	846	821	705	633	460	870	-----	-----
1927	244	171	224	444	309	328	-----	-----	362	-----	-----
Average	621	611	582	963	955	929	1,120	1,016	1,048	-----	-----

NUMBER OF WHEAT OR OAT PLANTS

1923	115	251	353	118	235	202	89	176	-----	810	428
1924	159	288	361	110	281	373	92	136	-----	650	488
1925	114	276	383	149	278	434	122	213	-----	599	796
1926	137	282	372	139	297	433	113	185	-----	803	564
1927	116	258	319	118	246	381	-----	-----	-----	481	-----
Average	128	272	358	126	269	377	104	178	-----	670	569

TABLE 17.—Annual and average weights in pounds per acre of air-dry weeds and of flax, wheat, and oat plants in the flax-cereal mixtures and of flax, wheat, and oats grown separately at Mandan, N. Dak., 1923-1927

(In thousands—i. e., 000 omitted)

WEIGHT OF WEEDS

Year	Crop and rate of seeding per acre (pounds) of—										
	Flax 15 and			Flax 25 and			Flax 30 and		Flax alone 25	Wheat alone 60	Oats alone 48
	Wheat 10	Wheat 20	Wheat 30	Wheat 10	Wheat 20	Wheat 30	Oats 8	Oats 16			
1923	1,570	966	715	1,298	788	704	900	644	1,433	253	421
1924	504	209	147	496	240	176	459	259	1,218	61	118
1925	953	763	454	808	769	517	1,006	805	2,255	633	321
1926	2,729	2,221	1,895	2,087	2,040	1,760	2,033	2,005	2,709	994	1,425
1927	3,093	1,636	1,389	2,120	1,191	925	—	—	4,044	846	—
Average	1,782	1,159	918	1,357	1,006	810	1,100	928	2,344	557	571

WEIGHT OF FLAX PLANTS

1923	866	612	456	951	709	683	1,266	931	1,837	—	—
1924	785	531	381	1,131	686	545	1,144	794	1,706	—	—
1925	1,134	632	525	1,197	801	685	1,108	1,096	2,639	—	—
1926	233	163	126	323	207	137	220	142	498	—	—
1927	422	200	227	648	331	269	—	—	909	—	—
Average	688	428	343	850	547	464	952	741	1,397	—	—

WEIGHT OF WHEAT OR OAT PLANTS

1923	902	1,402	1,554	776	1,106	1,342	465	996	—	2,274	2,139
1924	2,071	2,686	2,772	1,307	2,080	2,709	1,144	1,552	—	3,620	3,078
1925	1,786	2,541	2,522	1,734	2,432	2,517	1,255	1,749	—	3,199	2,903
1926	323	316	656	329	605	621	235	311	—	1,216	644
1927	2,028	3,414	3,991	1,952	3,337	3,726	—	—	—	4,207	—
Average	1,422	2,148	2,200	1,220	1,912	2,183	770	1,152	—	2,903	2,191

In 1924, the year of most favorable seasonal rainfall at Mandan (Table 10), the weights of weeds were lower than in any other year. In 1926, the driest season, the weight of weeds, chiefly Russian thistle, was greater than in any other year except 1927.

In 1927 the wheat and flax were damaged somewhat by hail on June 19, and this check in the growth of these crops allowed the thistles to make an unusually heavy growth. The weed growth was favored also by abundant soil moisture, due to the heavy rainfall in May.

RESULTS AT WILLISTON

In 1923 flax-wheat trials were conducted under irrigation at Williston. Flax seeded at 28 pounds with 45 pounds of wheat added yielded 3.5 bushels of flax and 10 bushels of wheat. Flax seeded alone at 28 pounds yielded 7.1 bushels, and wheat sown alone at 90 pounds yielded 15 bushels. Observations made indicated that wheat in the flax aided in checking the weeds. The relative yield of grain produced was 16 per cent higher in the mixture than in the plots seeded separately.

RESULTS OF COOPERATIVE TRIALS WITH FARMERS

During four years 46 field trials were conducted in cooperation with a number of farmers. All but 10 of these (4 in 1924 and 6 in 1925) were conducted in the eastern one-third of the State. In these trials the flax-wheat mixture, seeded at the regular rate of 28 pounds

of flax and 30 pounds of wheat, was checked against flax seeded alone and wheat seeded alone, these being seeded at the regular rate on the same land where the mixture was seeded and on the same day. The seed was furnished, already mixed, by the experiment station, and the crop was seeded according to directions furnished. Yields were determined from the harvesting of several quadrats in each plot, which material was shipped to the experiment station for threshing and yield determinations.

Nine of these cooperative trials were conducted in 1923, 17 in 1924, 16 in 1925, and 4 in 1926. (Table 18.) The average acre yield from the mixture in the four years was 4.11 bushels of flax and 10.64 bushels of wheat. The acre yield of flax alone was 10.28 bushels and that of wheat alone 16.87 bushels. On the basis of the yield of flax and wheat alone, the mixture produced 30 per cent more the first year, 1 per cent more the second year, 4 per cent more in 1925, and 11 per cent less in 1926 than the separate crops. The average gross acre income, based on relative December 1 farm values for each year, was \$21.20 for the mixture, \$21.81 for flax seeded alone, and \$19.79 for wheat seeded alone.

TABLE 18.—Summary of annual results of flax-wheat field trials conducted in cooperation with farmers in North Dakota, 1923-1926

Year	Fields	Acre yields (bushels)				Relative yield	Gross acre income ¹			
		Mixture		Flax alone	Wheat alone		Per ct.	Dollars	Dollars	Dollars
		Flax	Wheat							
	Number	Bushels	Bushels	Bushels	Bushels		Dollars	Dollars	Dollars	
1923	9	4.34	8.32	7.14	12.02	130	16.36	15.14	10.34	
1924	7	3.10	14.00	8.49	21.80	101	24.68	19.27	27.47	
1925	16	4.32	9.21	10.93	14.22	104	21.83	24.70	18.63	
1926	4	4.66	11.04	14.57	18.43	80	21.91	28.12	22.73	
Average		4.11	10.64	10.28	16.87	106	21.20	21.81	19.79	

¹ Based on the average farm price each year on Dec. 1 as reported by the United States Department of Agriculture. (Table 1.)

² Including general trial, field R, experiment station farm.

³ Not weighted.

DISCUSSION OF RESULTS IN NORTH DAKOTA

Averaging, by years, the results of all flax-wheat trials in North Dakota, both at experiment stations and under cooperation with farmers elsewhere, wherein flax was sown at the regular rate and to which from 10 to not exceeding 30 pounds of wheat were added, the following figures are arrived at (Table 19): In 17 trials a mixture of flax and wheat in 1923 produced an increase of 15 per cent over the flax and wheat seeded separately; in the 23 trials in 1924 there was an increase of 9 per cent; in the 24 trials in 1925 there was an increase of 5 per cent; in the 12 trials in 1926 there was a decrease of 16 per cent; and in the 8 trials in 1927 there was an increase of 13 per cent. The mixed crop showed unusually high relative yields in 1927 in western North Dakota, due largely to very low flax yields even when flax was seeded alone and to relatively high yields of wheat in the mixture.

TABLE 19.—Average acre yields, by years, of all flax-wheat trials wherein flax was sown at the regular rate and to which from 10 to not exceeding 50 pounds of wheat were added, in North Dakota, 1923-1927

Year	Trials	Acre yield					Relative yield	Gross acre income ¹		
		Mixture		Flax alone ²	Wheat alone ²	Per cent		Mixture	Flax alone	Wheat alone
		Flax	Wheat							
	Number	Bushels	Bushels	Bushels	Bushels		Dollars	Dollars	Dollars	
1923.....	17	5.39	8.40	0.24	14.81	115	18.71	10.59	12.74	
1924.....	23	3.40	13.59	8.94	19.81	169	25.18	19.51	24.93	
1925.....	24	4.14	8.09	0.38	14.35	105	20.74	21.20	18.80	
1926.....	12	2.99	7.16	8.06	15.15	84	14.15	15.50	17.73	
1927.....	5	3.38	15.38	7.29	23.44	113	22.21	13.25	24.38	
Average.....		3.86	10.71	8.50	17.51	105	20.21	17.80	19.72	

¹ Based on the average North Dakota farm price on Dec. 1 for each year.

² Properly valued where more than one mixture was grown.

On the basis of the average acre yield during these five years, flax in the mixture yielded 3.86 bushels, wheat 10.71 bushels, flax alone 8.50 bushels, and wheat alone 17.51 bushels. On the basis of these averages, the mixed crop showed a relative gain in yield of 5 per cent. The average gross acre income from the mixture was greater than the gross acre income from either wheat or flax seeded alone. The gross acre income from the mixed crop was \$2.35 higher than that from flax and 49 cents higher than that from wheat. In other words, an acre of the mixed crop on the above basis produced \$1.42 more in gross income per acre than an acre half of which was seeded to flax and half to wheat separately.

Consideration must be given, however, to the higher seed costs when the mixture is seeded, as the wheat used is in addition to the flax. With average seed prices, the cost per acre for seed when the mixture is sown will be from 50 to 75 cents more than for flax alone and about 25 cents more than for wheat alone.

SUMMARY OF RESULTS IN NORTH DAKOTA

Results from flax-wheat trials conducted during the years 1923 to 1927 are reported.

April to July rainfall was decidedly below normal in 1926 at Fargo, Dickinson, and Mandan. Rainfall was below normal in 1925 at Dickinson and Mandan, but excessive during June at Fargo. In 1924 low temperature reduced the effect of drought. Except for short periods of drought, moisture conditions were generally favorable in 1927. The mean temperature in 1927 was below normal.

Flax seeded alone at Fargo averaged 12 bushels per acre for the three years 1923, 1925, and 1926, and 13.6 for the four years 1923 and 1925-1927. The addition of wheat reduced the flax yields in proportion to the wheat added, and the wheat yields were increased in about the same proportion. Relative yields varied from 98 to 105 per cent. The highest relative yield was obtained where flax was seeded at the regular rate and 15 or 30 pounds of wheat were added. Weeds in general were reduced in proportion to the increased quantity of wheat in the mixture.

Less consistent results were obtained at Dickinson, and relative yields varied from 98 to 107 per cent. Previous to 1927 the relative yields were unfavorable to the mixture. For the 5-year period flax seeded alone averaged 7.8 bushels and wheat alone averaged 17.7 bushels per acre. In the mixture the yields of flax decreased somewhat in proportion to the increased yield of wheat.

At Mandan drought conditions affected yields more or less unfavorably in all years. Flax yields were reduced more than wheat yields. The average acre yield of flax alone was 4.6 bushels and of wheat alone 15.5 bushels. In the mixtures flax yields averaged from 1.1 to 2.8 bushels per acre. As at the other stations, flax yields decreased as wheat yields increased. Relative yields of the mixtures varied from 93 to 110 per cent, the yield of the mixed crop being particularly favorable in 1927 because of low yields of flax even when seeded alone and favorable wheat yields in the mixtures with flax.

Wheat aided very effectively in checking weed growth. Where wheat was seeded alone 557 pounds (air-dry) of weeds were produced per acre. Where flax was seeded alone 2,344 pounds of weeds were produced. In the mixed crop weeds varied from 918 to 1,782 pounds, the quantity of weeds increasing as the proportion of wheat added decreased.

Forty-six field trials were conducted in cooperation with farmers. The average acre yield of flax alone during these four years was 10.28 bushels and that of wheat alone 16.87 bushels. In the mixture the flax yield averaged 4.11 and wheat 10.64 bushels per acre. As compared with yields when the two crops were seeded separately, the yield of the mixed crop showed a small increase.

A summary of the 84 comparable experiments conducted during the four years in which flax was seeded at the regular rate of seeding with the addition of 10 to 30 pounds of wheat, shows an average acre yield of flax in the mixtures equal to 3.86 bushels and of wheat equal to 10.71 bushels. Flax alone averaged 8.50 bushels and wheat alone 17.51 bushels. The mixed crop showed a higher relative yield in four years and a lower relative yield in one year, the average increase being 5 per cent.

Farmers cooperating in carrying out flax-wheat trials have not generally felt that the increase in yield was sufficient to allow for the extra cost of seed and the inconvenience of seeding and of separating the two grains after threshing.

EXPERIMENTS IN MONTANA

By CLYDE MCKEE, Agronomist, Montana Agricultural Experiment Station

Extensive experiments with mixed flax and wheat have been conducted in Montana to determine the adaptability of the mixed crop to irrigated and dry or nonirrigated land. A comprehensive report of the results of flax-wheat mixtures under irrigation for the four years 1923-1926 has been published by the Montana station (5).

RESULTS UNDER IRRIGATION AT BOZEMAN

Bozeman is located in the Gallatin Valley at an altitude of about 5,000 feet. The soil is a fertile clay loam. The annual precipitation is about 18.7 inches. Only one irrigation was given the mixed crops each year. N. D. R. No. 52 flax and Marquis wheat were the varieties grown. The mixed crops ripened quite uniformly each year.

ANNUAL AND AVERAGE YIELDS AND INCOMES

Table 20 shows the annual and average acre yields in bushels and the relative yields from the mixed crops grown under irrigation at Bozeman during the 5-year period 1923-1927. Comparatively high yields of flax alone and of wheat alone were obtained every year. Somewhat irregular yields of some of the mixtures are shown in 1923 and in 1927. The high acre yields of flax alone and of wheat alone in 1927 (28.6 bushels of flax and 52.5 bushels of wheat) represent a relative yield higher than those of most of the mixtures that year. Mixtures of flax and wheat seeded at the rates of 42 and 30, 14 and 45, 42 and 45, 28 and 60, and 14 and 30 pounds per acre, respectively, produced yields ranging from 15 to 21 per cent over those of either flax or wheat alone.

TABLE 20.—Annual and average acre yields and relative yields from flax-wheat mixtures grown under irrigation at Bozeman, Mont., during the 5-year period 1923-1927

Crop and rate of seeding per acre (pounds)	Acre yield							Relative yield 1924-1927
	1923	1924	1925	1926	1927	Average		
						1923-1927	1924-1927	
	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Per cent</i>
Flax 14.....		9.1	8.2	6.4	8.4		8.0	108
Wheat 15.....		42.7	29.3	19.7	20.1		29.5	
Flax 14.....	2.3	6.1	6.1	5.0	7.1	5.3	6.1	115
Wheat 30.....	49.9	46.0	41.9	22.3	32.9	38.0	35.8	
Flax 14.....		4.0	3.2	3.6	0.3		4.4	119
Wheat 45.....		49.5	38.7	33.3	30.2		40.2	
Flax 14.....	.9	3.1	2.3	2.9	8.0	5.0	4.2	98
Wheat 60.....	51.7	32.0	38.1	36.3	24.0	36.2	32.3	
Flax 28.....		9.6	9.6	12.0	8.1		10.0	99
Wheat 15.....		24.3	16.6	21.0	27.5		22.4	
Flax 28.....	3.9	0.5	7.1	8.9	5.4	7.0	7.7	114
Wheat 30.....	35.1	31.3	25.3	37.3	36.0	33.0	32.5	
Flax 28.....		6.2	5.0	5.4	4.0		5.4	107
Wheat 45.....		34.0	28.9	30.0	41.7		33.7	
Flax 28.....	.9	5.3	4.3	5.0	3.6	3.8	4.6	117
Wheat 60.....	46.5	33.3	33.0	36.0	40.0	39.1	37.3	
Flax 42.....		12.3	10.7	15.0	12.2		12.0	112
Wheat 15.....		29.3	18.5	19.0	28.2		23.3	
Flax 42.....	4.6	9.1	8.5	11.1	9.4	8.0	9.5	121
Wheat 30.....	27.7	30.3	26.3	22.3	44.1	31.3	32.3	
Flax 42.....		5.1	6.3	10.4	6.7		7.1	118
Wheat 45.....		34.8	27.3	24.3	54.8		35.3	
Flax 42.....	2.0	3.8	5.7	5.7	3.1	4.2	4.0	94
Wheat 60.....	33.1	31.0	26.0	25.0	38.5	30.7	30.1	
Flax alone 25.....	25.1	18.0	19.3	25.0	28.6	23.6	23.2	100
Wheat alone 90.....	48.6	41.3	33.7	33.7	52.6	42.0	40.3	100

The gross income per acre (calculated by multiplying the acre yield by the farm price on December 1 of each year) furnishes a practical basis of determining the value of mixed cropping of flax and wheat. Table 21 presents the annual and average gross incomes per acre, based on the annual yields given in Table 20 and the December 1 farm price of flax and spring wheat in Montana, as shown in Table 1.

TABLE 21.—Annual and average gross acre incomes from flax-wheat mixtures and from flax and from wheat alone, grown under irrigation at Bozeman, Mont., during the 5-year period 1923-1927

Crop and rate of seeding per acre (pounds)	Gross acre value by years					Average gross acre income, 1924-1927	
	1923	1924	1925	1926	1927	Separately	Total
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Flax 14.....		20.11	18.94	11.84	14.70	16.17	51.56
Wheat 15.....		52.05	41.02	22.26	25.32	35.39	
Flax 14.....	4.44	13.48	13.42	9.25	12.43	12.15	55.35
Wheat 30.....	40.92	57.04	58.56	25.20	31.91	43.20	
Flax 14.....		10.17	7.04	6.66	11.03	8.73	50.53
Wheat 45.....		01.38	54.18	37.63	38.02	47.80	
Flax 14.....	1.74	6.85	5.06	5.37	15.05	8.08	46.93
Wheat 60.....	42.39	39.63	50.54	41.02	24.15	38.55	
Flax 28.....		21.22	21.12	23.87	14.18	20.10	46.05
Wheat 15.....		30.13	23.24	23.73	26.08	25.95	
Flax 28.....	7.53	21.00	15.62	16.47	9.45	15.64	53.47
Wheat 30.....	28.78	38.81	35.42	42.15	34.92	37.83	
Flax 28.....		13.70	11.00	9.99	8.58	10.82	50.06
Wheat 45.....		42.16	40.46	33.90	40.45	39.24	
Flax 28.....	1.74	11.71	9.46	9.25	6.30	9.18	62.60
Wheat 50.....	38.13	41.29	46.20	40.68	45.49	43.42	
Flax 42.....		27.18	23.54	27.75	21.35	24.96	52.24
Wheat 15.....		36.33	25.90	21.47	25.41	27.28	
Flax 42.....	12.74	20.11	18.70	20.54	16.45	18.95	56.40
Wheat 30.....	22.71	45.01	36.82	25.20	42.78	37.45	
Flax 42.....		11.27	13.86	19.24	11.73	14.03	54.53
Wheat 45.....		43.15	38.22	27.46	53.16	40.50	
Flax 42.....	5.02	8.40	12.54	10.55	5.43	9.23	44.34
Wheat 60.....	27.14	38.44	39.40	28.25	27.35	35.11	
Flax alone 28.....	48.44	41.77	42.46	47.92	50.05	45.55	45.55
Wheat alone 90.....	39.85	51.21	47.18	38.98	50.93	46.85	46.85

During the 4-year period 1924-1927, the average gross income per acre from flax alone was \$45.55 as compared with \$46.85 from wheat alone. The 14 and 45 pound mixture of flax and wheat produced an average gross return of \$56.53 per acre, exceeding that from flax alone by \$10.98 and that from wheat alone by \$9.68. The 42 and 30 and 14 and 30 pound flax-wheat mixtures produced during the four years average gross incomes of \$56.40 and \$55.35 per acre, respectively.

EFFECT OF RATE OF SEEDING UPON GROSS INCOMES

A careful analysis of the data obtained during the 4-year period 1924-1927 emphasizes the importance of the lighter rates of seeding when flax and wheat are combined. Material increases in the rate of seeding of wheat in the mixtures resulted in a sharp decrease in the yield of flax; likewise, an increase in the rate of seeding of flax produced some decrease in the yield of wheat. This is shown graphically in Figure 7.

The data now available indicate rather definitely that under conditions similar to those existing at Bozeman, it is not advisable to sow mixtures containing less than 30 or more than 45 pounds of wheat per acre.

The most economical gross incomes per acre have been obtained from mixtures of 14 and 30 and of 14 and 45 pounds of flax and wheat, respectively. However, the gross incomes from the 42 and 30 and the 42 and 45 pound mixtures have been about as large.

RESULTS UNDER DRY-LAND CONDITIONS AT MOCCASIN

Experiments with flax-wheat mixtures under dry-land conditions were conducted for six years at the Judith Basin Branch Station near Moccasin by cooperative agreement between the Montana

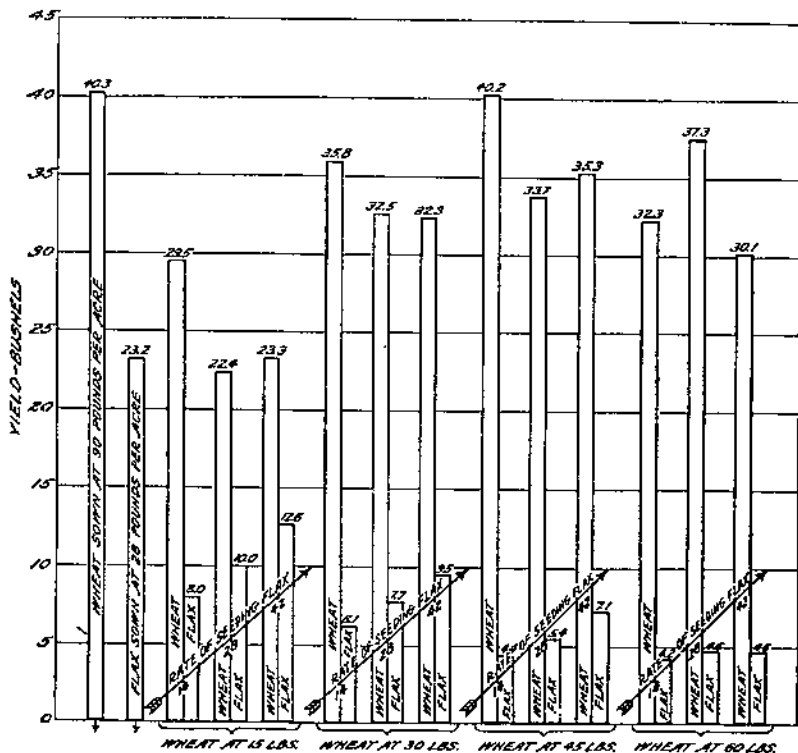


FIGURE 7.—Diagram based on the average yields under irrigation at Dozeman, Mont., for the 4-year period 1924-1927, showing that increasing the rate of seeding of wheat in the flax-wheat mixtures decreases the yield of flax materially and that increasing the rate of seeding of flax has less effect on the yield of wheat.

Agricultural Experiment Station and the Office of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture.

The mixed crops were grown regularly on fallow land under conditions of natural rainfall. The soil is a fertile dark loam, overlying a gravelly subsoil more or less cemented by deposits of lime. The altitude is nearly 4,000 feet, and the average frost-free period is 124 days. The seasonal precipitation (April to August, inclusive) and the annual precipitation for the crop year ended August 31 are given in Table 22.

The annual and average acre yields of four mixtures of flax and wheat and of each crop grown alone are shown in Table 23.

TABLE 22.—Monthly, seasonal, and annual rainfall at the Judith Basin Branch Station, Moccasin, Mont., for the 6-year period 1923-1928

Month	Precipitation (inches)						Mean (1923- 1927)
	1923	1924	1925	1926	1927	1928	
April.....	0.48	0.87	1.72	0.41	1.17	0.60	1.20
May.....	2.75	1.25	1.15	1.91	5.08	.53	2.45
June.....	5.39	3.37	4.07	1.95	2.47	3.86	3.19
July.....	3.29	1.39	.52	3.37	1.04	2.77	1.77
August.....	2.68	1.31	.88	1.09	1.74	.85	1.66
Total:							
Seasonal.....	14.41	8.19	8.34	9.33	11.50	8.01	10.37
Annual ¹	20.33	12.00	12.81	13.32	17.20	13.12	16.81

¹ Year ended Aug. 31.

TABLE 23.—Annual and average yields, relative yield, and gross income from flax-wheat mixtures and from the same crops grown alone at the Judith Basin Branch Station, Moccasin, Mont., during the 6-year period 1923-1928

Crop and rate of seeding per acre (pounds)	Acre yield							Relative yield	Gross acre income ¹	
	1923	1924	1925	1926	1927	1928	Average		Separately	Total
	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Percent</i>	<i>Dollars</i>	<i>Dollars</i>
Flax 15.....	7.5	3.2	1.4	3.6	3.6	5.8	4.2	99	8.39	23.57
Wheat 20.....	12.5	16.0	11.6	15.8	11.0	15.0	13.7		15.21	
Flax 15.....	5.8	2.7	1.8	3.5	2.3	5.0	3.5	100	8.96	25.72
Wheat 30.....	19.6	18.2	15.3	17.4	13.7	17.1	16.9		18.76	
Flax 25.....	8.8	3.8	2.3	4.8	3.4	7.7	5.1	101	10.15	23.36
Wheat 20.....	9.6	13.5	10.0	13.8	9.9	14.4	11.9		13.21	
Flax 25.....					2.4	6.2	4.3	-----	8.66	23.66
Wheat 30.....					11.8	15.4	13.6		15.10	
Flax alone 25.....	12.5	10.3	8.3	11.4	9.0	9.0	10.1	100	20.16	20.10
Wheat alone 60.....	32.5	24.2	16.7	23.3	17.5	28.3	23.7	100	26.31	26.31

¹ Based on the 5-year (1923-1927) average farm price on Dec. 1 in Montana.

The average acre yield of flax alone was 10.1 bushels and that of wheat alone 23.7 bushels. The 15 and 30 pound mixture yielded 3.5 bushels of flax and 16.9 bushels of wheat per acre and gave the highest relative yield (106 per cent and the highest gross income (\$25.72) of any of the mixtures. Neither flax alone nor any one of the mixtures produced a gross return as great as that from wheat alone. (Fig. 8.)

The highest yields were obtained in 1923, when the seasonal rainfall was about 3 inches above the average. Low average yields in 1925 were due largely to the scant rainfall (0.52 inch) in July of that year. In 1928, on the other hand, the favorable rainfall during June and July produced yields of the mixed crops above the average, although the rainfall in April, May, and August was much below the mean for those months.

EXPERIMENTS IN SOUTH DAKOTA⁶

The South Dakota Agricultural Experiment Station has conducted experiments with the mixed cropping of flax and wheat at Brookings

⁶ The authors are much indebted to the South Dakota Agricultural Experiment Station and to A. N. Hume, agronomist at that station, for the data presented in Table 24. The results for 1923 and 1924 have been published in South Dakota Bulletin 213 (4).

during the 5-year period 1923-1927. Flax (N. D. R. 114) seeded alone at 28 pounds per acre and Marquis wheat seeded alone at 75 pounds per acre were compared with a mixture seeded at the rate of 14 pounds of flax and 38 pounds of wheat per acre. Each crop and the mixture were grown in a single 1/10-acre plot each year. The annual and average yields are shown in Table 24.

The 5-year (1923-1927) average acre yield was 12.6 bushels for flax alone and 13 bushels for wheat alone. The mixture averaged 4.1 bushels of flax and 11.7 bushels of wheat. This is a relative yield of 122 as compared with 100 for flax and wheat grown alone.

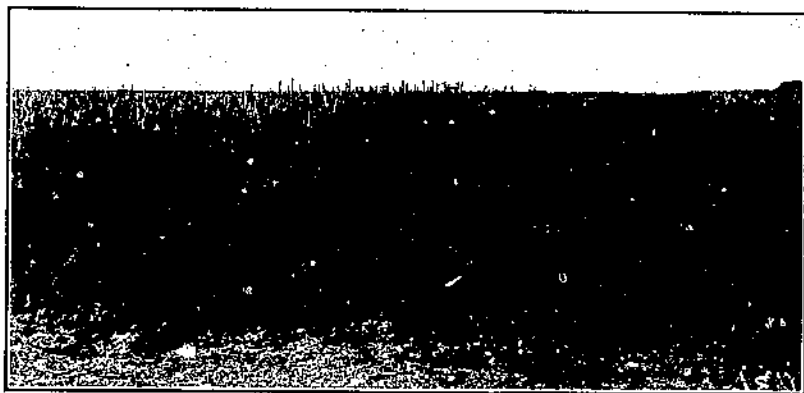


FIGURE 8.—A plot of mixed flax and wheat (15 and 30 pounds) (left) and flax alone (right) at Moccasin, Mont., 1924

TABLE 24.—Annual and average yields, relative yield, and gross income from a mixture of flax and wheat, from flax alone, and from wheat alone at the South Dakota Agricultural Experiment Station, Brookings, during the 5-year period 1923-1927

Crop and rate of seeding per acre	Acres yields ¹						Relative yield	Gross acre income ²
	1923	1924	1925	1926	1927	Average		
Mixed crop:	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Per cent	Dollars
Flax, 14 pounds.....	2.6	6.0	3.5	4.3	3.2	4.1		
Wheat, 38 pounds.....	4.8	15.5	15.5	11.0	11.5	11.7	122	21.55
Flax alone, 28 pounds.....	7.0	15.0	16.3	14.1	9.6	12.6	100	25.96
Wheat alone, 75 pounds.....	5.0	19.3	16.0	12.8	11.9	13.0	100	14.56

¹ Yields are from one plot one-tenth acre in size of each crop alone and of the mixture each year.

² Based on the average yield at the 5-year (1923-1927) average farm price on Dec. 1 of 200 cents per bushel for flax and 112 cents for wheat (Table 1).

In gross income per acre, flax grown alone returned \$25.96 per acre, the mixed crop \$21.55, and the wheat alone \$14.56 on the basis of the average yield and 5-year average farm price in South Dakota on December 1. Stem rust was a factor in reducing the yield of wheat in some years.

EXPERIMENTS IN WISCONSIN¹

The Wisconsin Agricultural Experiment Station has carried on experiments with mixed cropping of flax with wheat, oats, and barley

¹ The authors are much indebted to the Wisconsin Agricultural Experiment Station and to A. H. Wright, associate agronomist of that station, for the data shown in Table 25 and for a summary and discussion of the value of mixed cropping in Wisconsin.

at Madison, Wis., during the 5-year period 1923-1927 and also in cooperation with farmers in several localities in the State. Table 25 presents the annual and average acre yields, average relative yields, and average gross incomes per acre from flax, wheat, oats, and barley, and from one mixture of flax with each of these cereals at Madison during the 5-year period 1923-1927. Each crop of mixture was grown in duplicate plots of one-twentieth acre. The varieties grown were Chippewa flax, Marquis wheat, Pedigreed No. 1 oats, and Oderbrucker barley.

TABLE 25.—Annual and average acre yields, relative yields, and gross incomes from mixtures of flax with wheat, with oats, and with barley, and from each of these crops grown alone at the Wisconsin Agricultural Experiment Station, Madison, Wis., during the 5-year period 1923-1927

Crop and rate of seed- ing per acre (pounds)	Acre yield						Rela- tive yield	Gross acre income ¹	
	1923	1924	1925	1926	1927	Average		Sepa- rately	Total
	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Per cent	Dollars	Dollars
Flax 28.....	7.3	5.8	9.7	5.9	9.5	7.6	109	15.98	32.42
Wheat 35.....	9.3	18.3	15.7	15.0	8.5	13.8		18.46	
Flax 28.....	6.7	3.8	8.5	12.4	8.0	7.9	106	16.50	31.81
Oats 35.....	28.5	36.3	52.0	20.5	33.6	35.4		15.22	
Flax 28.....	5.4	8.9	5.5	8.1	6.9	6.0	103	12.69	32.82
Barley 48.....	20.1	39.0	44.8	26.5	16.3	29.3		20.22	
Flax alone 42.....	13.2	16.4	20.7	19.5	19.2	17.8	100	37.38	37.38
Wheat alone 90.....	19.5	28.0	28.8	19.6	9.2	20.6	100	24.93	24.93
Oats alone 80.....	64.8	42.3	70.0	65.8	54.4	57.5	100	24.73	24.73
Barley alone 96.....	33.3	43.0	57.0	43.3	34.8	42.0	100	29.39	29.39

¹ Based on the 5-year (1923-1927) average farm price in Wisconsin on Dec. 1, as follows: Flax \$2.10, wheat \$1.21, oats 43 cents, and barley 89 cents per bushel.

The 5-year average acre yield of flax grown alone was 17.8 bushels, that of wheat 20.6 bushels, that of oats 57.5 bushels, and that of barley 42.6 bushels. The average acre yield of flax in mixture with wheat was 7.6 bushels, with oats 7.9 bushels, and with barley 6 bushels. In relative yield the flax-wheat mixture was 109 per cent flax and oats 106 per cent, and flax and barley 103 per cent.

On the basis of results obtained in cooperation with farmers and from the data presented in Table 25, Professor Wright makes the following comments:

It appears that the tendency is toward higher yields from mixtures of flax and small grains than from the crops grown alone, although the increase is hardly significant. The results indicate that mixtures of flax and small grains may be expected to yield as well as the crops grown alone, but little or no increase of consequence should be expected. The experimental results indicate that flax can be grown equally as well with oats or with barley as with wheat. In farm practice in Wisconsin the only mixture which has attracted any considerable attention is the flax-wheat mixture. This is grown to some extent in Pierce County. In Jefferson and Waukesha Counties the flax-oats mixture is grown to some extent. Although the experiments were made in all the important grain-producing sections of the State, farmers generally have not become interested in mixtures of flax and small grains. On the other hand there is much interest shown in mixtures of such small grains as wheat and oats and oats and barley.

EXPERIMENTS IN OHIO²

The Ohio Agricultural Experiment Station has carried on experiments at Wooster, Ohio, with mixed cropping of flax with Marquis

² The authors are much indebted to the Ohio Agricultural Experiment Station and to L. E. Thatcher, associate agronomist at the Ohio station, for the data shown in Table 26.

spring wheat, Fulghum oats, and Oderbrucker barley during the five years 1923 to 1927, inclusive.

Three mixtures were grown, one each of flax with wheat, with oats, and with barley. Each mixture was seeded at the rate of 14 pounds (1 peck) of flax with 1 bushel of the grain. For comparison, each crop was grown alone, the grains being sown at 2 bushels per acre and flax at 28 pounds. After the experiments had been conducted for three years it was thought that flax should be sown at a heavier rate for the best results. This change was made in 1926 when flax alone was sown at 42 pounds per acre and at 28 pounds in the mixtures. Two additional mixtures also were added in 1926, namely, flax at 28 pounds and at 42 pounds with oats at 1 bushel per acre in each mixture. Average yields during the 5-year period 1923-1927 are given in Table 26.

TABLE 26.—Average acre yields of flax and cereal mixtures, percentage of each, and relative yield, at the Ohio Agricultural Experiment Station, Wooster, Ohio, for the 5-year period 1923-1927

Crop and rate of seeding per acre (pounds of flax, bushels of grain)	Acre yield		Percentage of each crop		Acre yield		Relative yield
	Grain	Straw	Flax	Grain	Flax	Grain	
	Pounds	Pounds			Bushels	Bushels	Per cent
Flax 14, ¹ wheat 1 bushel.....	1,257	2,513	14	86	3.1	18.0	99
Flax 14, oats 1 bushel.....	1,620	2,453	11	89	3.2	45.1	85
Flax 28, oats 1 bushel ²	1,438	1,870	16	84	4.1	37.7	84
Flax 42, oats 1 bushel ³	1,394	1,877	23	77	5.7	33.5	87
Flax 14, ¹ barley 1 bushel.....	1,840	2,425	8	92	2.6	30.2	113
Flax alone, 28 ¹ pounds.....	898	2,350	100	—	15.0	—	100
Wheat alone, 2 bushels.....	1,361	2,677	—	100	—	22.7	100
Oats alone, 2 bushels.....	2,072	2,704	—	100	—	64.8	100
Barley alone, 2 bushels.....	1,748	2,365	—	100	—	31.2	100

¹ 28 pounds in 1926 and 1927.

² For two years only, 1926 and 1927.

³ 42 pounds in 1926 and 1927.

The flax alone yielded 16 bushels per acre as an average for the 5-year period. Wheat yielded 22.7 bushels, oats 64.8 bushels, and barley 31.2 bushels. The yield of flax in the mixtures was 3.1 bushels with wheat, 2.6 bushels with barley, and 3.2 bushels with oats. In relative yield only the mixture of flax with barley (113) exceeded the yields of the crops grown alone, each of the crops grown alone being represented as 100, and this was due largely to a high yield of the mixed flax and barley in 1927. The relative yield of the flax-wheat mixture was 99 and of the one flax-oat mixture 85.

SEPARATING THE MIXED CROP

In Goodhue County, Minn., the usual practice is to store the mixed grain on the farm and separate it with a fanning mill before marketing it. Many farmers use a simple homemade separator of large capacity, having a single sieve about 40 inches wide and 60 inches long, agitated by an eccentric bearing attached to a crank shaft. A steel-wire sieve with meshes 16 by 4 per inch is satisfactory in separating the small-seeded flax from wheat. A sieve 14 by 4 may be necessary with very plump flaxseed or where a large-seeded variety is grown.

Where the flax-wheat crop is grown on a large scale it often is shipped to market to be separated before being offered for sale on the board of trade. In that case it is consigned to some commission firm having storage elevators with grain-cleaning machinery. After

being cleaned, the wheat, flax, and screenings are sold separately. This is the way Thomas D. Campbell, of Hardin, Mont., handles the mixed crop of flax and winter wheat grown by him. The usual charge for separating the mixed grain is 2 cents per bushel.

DISADVANTAGES OF THE MIXED CROP

The chief disadvantages of mixed cropping are as follows:

(1) The somewhat higher cost of seed because of the heavier rate of seeding usually recommended. In the mixed crop flax usually is sown at about the usual rate for the locality, with the addition of from one-third to one-half the usual quantity of wheat.

(2) The labor or cost of separating the mixed grain, which is estimated at about 2 cents per bushel of the mixed grain.

(3) The lower value of mixed straw. Where there is a market for clear flax straw for the manufacture of coarse fiber, tow for upholstering or insulating material, or for paper making, the farmer can obtain an additional income from his flax crop from that source, whereas the straw from the mixed crop has no market value. The mixed straw, however, has some value as feed for livestock and as bedding.

DISCUSSION AND SUMMARY

Flax and spring wheat are important cash crops in Minnesota, the Dakotas, and Montana. The results of the experiments reported in this bulletin indicate that under certain climatic conditions these crops can be grown together as a mixed crop to advantage. In order to compare the yields of the several mixed crops with the yield of flax and of wheat or other cereal grown alone under similar conditions in the same experiment, the yields are reduced to a percentage or relative yield basis, as explained under "Computing the yields" (p. 5). From the results of the experiments carried on, this summary attempts to answer the questions asked in the introduction:

(1) Does mixed cropping produce an increased yield, either in total grain or in relative yield, as compared with flax and cereals grown in pure stands? When rainfall and other weather conditions are favorable a somewhat higher relative yield per acre is obtained from the mixed crop than from the two crops grown separately. Adequate soil moisture during the entire growing season appears to favor a higher relative yield of the mixed crop as compared with the same crops grown alone. This is indicated by the generally favorable yields of the mixed crop as grown under the more humid conditions of Minnesota and under irrigation at Bozeman, Mont.

In Minnesota five flax-wheat mixtures yielded from 4 to 8.9 per cent higher in relative yield than flax alone seeded at 42 pounds per acre as an average for the three years (1924-1926) in nine locations. At Fargo, N. Dak., three mixtures of flax and wheat returned relative yields of 102 to 105 per cent, while two mixtures produced relative yields of 98 per cent. These results indicate that there was little or no advantage in mixed cropping from the standpoint of yield at that station. At Bozeman, Mont., flax-wheat mixtures grown under irrigation have generally produced higher relative yields than flax and wheat grown alone. As an average for four years (1924-1927) nine mixtures produced relative yields of 107 to 121 per cent, as compared

with yields of flax and wheat alone considered as 100 per cent, while three mixtures yielded slightly less than 100 per cent. Under dry-land conditions, as represented by the results at Mandan and Dickinson, N. Dak., and Moccasin, Mont., mixed cropping has not shown any appreciable advantage from the standpoint of acre yields over the same crops grown alone. The results indicate that the yields from the mixed crops are about the same under droughty conditions as yields from the crops grown separately.

(2) What effect does the rate of seeding have on the yield, quality, and proportion of each crop in the mixture? In general, the per-

centage of flax in the harvested crop is less than that in the mixture sown, whereas the percentage of wheat or oats harvested is greater than that sown. In Minnesota the six flax-wheat mixtures having from 38.4 to 73.7 per cent of flax in the seed sown produced on the average from 28.5 to 59.9 per cent of flax in the harvested crop, or from 9.4 to 14.4 per cent less flax than in the mixture sown. The flax-oat mixtures showed a greater decrease, ranging from 21.9 to 29.7 per cent. (Fig. 9.)

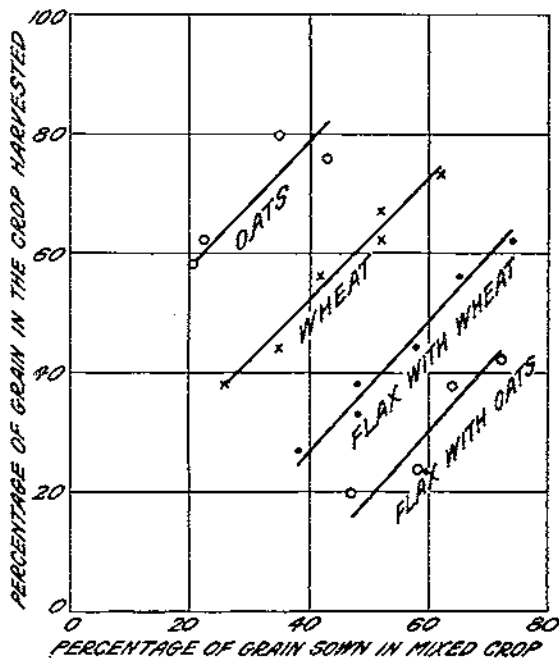


FIGURE 9.—Percentage of flax, wheat, and oats sown and the average percentage harvested in six mixtures of flax and wheat for the 3-year period 1924-1926 and four mixtures of flax and oats for the years 1925 and 1926 in eight counties in Minnesota.

At Bozeman, Mont., 12 mixtures of flax and wheat, in which the percentage of flax varied from 19 to 74

per cent of the mixed seed, produced from 10 to 34 per cent of flax in the harvested crops, a reduction of 9 to 40 per cent in the proportion of flax as compared with that sown. This is shown graphically in Figure 10. The same effect, a smaller proportion of flax in the harvested crop as compared with that sown, is shown in the results at Fargo, Mandan, and Dickinson, N. Dak., and at Moccasin, Mont.

The quality of the flax and wheat in the mixed crop, as determined by bushel weight and by weight of 1,000 seeds, was equal to or better than that of the crops grown separately. In many instances the bushel weight of wheat was greater in the mixed crop than in the crop grown separately. In some cases the difference was sufficient to make a difference of one market grade. In Minnesota the weight per 1,000 kernels of the wheat and oats in the mixed crops averaged somewhat heavier than in the crops grown alone. There was only a slight difference in the weight of 1,000 flax seeds.

(3) Does the mixed crop produce a greater acre income than flax or grain grown alone? The acre return depends largely on the relative market price of the crops grown. In Minnesota, flax grown alone has produced a higher acre return than either wheat or oats during the years covered by these experiments. On the basis of the average farm price on December 1 for the 5-year period 1923 to 1927, flax sown at 42 pounds per acre returned a gross acre value of \$30.70 and flax sown at 28 pounds per acre returned \$28.30. Spring wheat returned \$23.80 and oats \$19.10 per acre. The gross acre value of the flax-wheat mixed crops ranged from \$28.30 to \$30.40. The flax-oat mixed crops returned from \$23.60 to \$26.30.

At Bozeman, Mont., the gross acre values of the mixed crops generally were greater than those of wheat or flax grown alone.

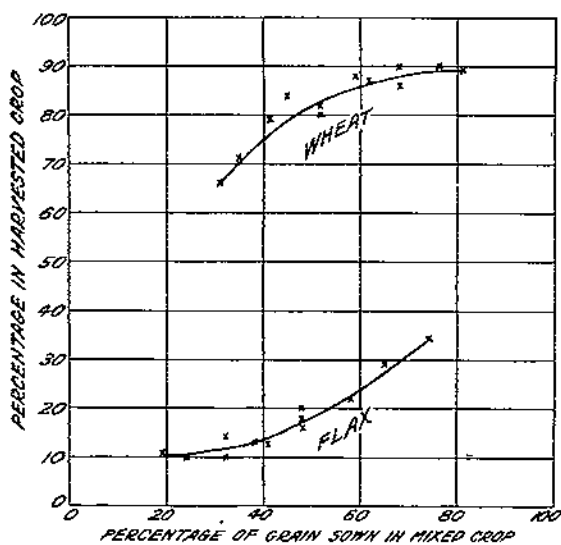


FIGURE 10.—Percentage of flax and of wheat sown and the average percentage harvested in 12 mixtures of flax and wheat grown under irrigation for the 4-year period 1924-1927 at Bozeman, Mont.

This was due to the relatively higher yields of the mixed crops. Only 1 of the 12 different mixtures grown produced an acre return less than that produced from wheat or flax grown separately.

At Fargo, N. Dak., the gross acre values of the mixed crops ranged from \$23.73 to \$26.60, as compared with \$24.21 for wheat grown alone and \$25.68 for flax grown alone, on the basis of the local market price on December 1 for each of the four years, 1923 to 1926, inclusive. On the basis of the acre values, there

was little or no advantage in growing the mixed crops at Fargo.

In the drier area, as represented by Mandan and Dickinson, N. Dak., and Moccasin, Mont., wheat generally made an acre return greater than that of flax alone or of any of the flax-wheat mixtures.

(4) Does the mixed crop check the growth of weeds as compared with their growth in flax grown in pure stands? The control of weeds is probably the chief advantage of the mixed crop. This method makes it possible to grow flax on land which is too weedy for flax alone.

The mixture of spring wheat, at about one-third the usual rate of seeding wheat, will check the growth of many of the common weeds, such as green and yellow foxtail, lamb's-quarters, amaranthus, and Russian thistle. Some of the perennial weeds, however, such as quack grass, sow thistle, Canada thistle, and wild oats are not controlled by mixed cropping. The reduced growth of Russian thistle in the mixed crop as compared with its growth in flax grown alone was very marked, as is shown by the results at Mandan.

(5) Does the mixed crop help control plant diseases such as flax wilt and stem rust of wheat? Mixed cropping had little effect, so far as could be observed, on the prevalence of leaf rust or stem rust of wheat. In some cases the more vigorous growth of the wheat plants, due to the thinner stand, produced somewhat heavier and plumper grain in the mixed crop than in the wheat grown alone. Early seeding, usually practiced with the mixed crop, probably is helpful in reducing the loss from flax wilt where common or unselected flax is grown. Wilt-resistant varieties of flax were used in the experiments reported, and there was little or no loss from wilt, either in the mixed crops or where flax was grown alone. Early seeding, combined with the shading effect of the wheat plants, prevents loss from heat canker, which sometimes causes damage in late-seeded flax. Neither heat canker, flax rust, nor pasmo was observed to do any injury to flax in the experiments here reported.

The greatest advantage of mixed cropping is observed when an epidemic of stem rust occurs, as in 1923 and 1927. Under such conditions the mixed crop is a partial insurance against heavy loss, because the flax in the mixed crop is not damaged and should yield a moderate return.

(6) What effect does growing the crops in combination have on the ease of handling the crop?

The mixed crops of flax and wheat and flax and oats are more easily handled in harvesting, shocking, and threshing than flax grown alone. Flax alone often is difficult to harvest and thresh because of the tendency of the straw to wind about the machinery of the harvester and to clog the screens of the separator. These difficulties are avoided in the mixed crops, which are as easily handled as wheat or oats.

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<i>Bureau of Plant Industry</i>	WILLIAM A. TAYLOR, <i>Chief.</i>
<i>Office of Cereal Crops and Diseases</i>	C. R. BALL, <i>Principal Agronomist, in Charge.</i>

END