

## GROWING FLAX IN NORTH DAKOTA

By

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Successful flax production is usually the result of several factors operating together: favorable weather, a good soil and good farm practices.

Man can not influence the weather or change his soil basically, but he can through good soil management and farm practices lessen the unfavorable effects of poor soil structure and low rainfall. Through his field operations he has considerable control over the condition of his soil, the seed bed which he provides, its tilth, moisture reserve and the amount of weed competition which the crop may have to face. These and other practices, such as time of seeding and choice of varieties, can have a large influence on the stand and yield of a crop.

A cropping program which includes a legume, or mixture of a legume and grass, insures a soil richer in available fertility, in root fiber and organic matter and as a result is in better tilth, better physical condition. Such a seed bed is less subject to crusting and will have a larger capacity for absorbing and holding moisture.

### Cultural Practices

Competition from weeds is one of the most serious problems to successful flax production. Weeds compete with flax for available moisture and fertility. In periods of low rainfall this extra plant growth, and the moisture which it takes from the flax, can mean the difference between a poor or a good crop. In the same way weed competition can aggravate a deficiency in soil nutrients.

### Plan Ahead For the Flax Field

Cultural and soil management practices for the control of weeds must usually begin a year or more before the flax is to be sown. The most successful flax farmer is one who manages his fields so that weed competition is always at a minimum and then, in his cropping program, he sows flax following the crop where weed competition would be the least. Usually this is after corn or some other intertilled crop, provided the cultivations kept the weeds in check. It may also be grassland, if this has been down to grass long enough to permit rotting of the buried weed seeds. A firm seed bed and early sowing to permit the crop to develop under relatively moderate temperatures is generally preferable.

Spring plowing is a common practice on the lighter soils and insures relatively clean flax. When sown in this manner the soil should be plowed, well packed and the flax sown the same day. Some growers when sowing on summer fallow prefer to plow the fallow in the spring, pack and seed immediately.

### What About Flax on Stubble?

Under some conditions relatively good results have been obtained where flax was sowed on burned over stubble fields, and with little or no seedbed preparation. This practice, however, should be limited to stubble land where the crop had followed a well kept fallow and which produced a heavy growth that effectively smothered weeds, leaving a heavy stubble for snow catch and a good spring burn. A soil relatively free from surface-borne weed seeds and a firm seed bed which this method provides, together with better surface moisture condition for prompt and even germination because of the winter snow catch are some of the advantages of this practice. Sowing in this manner on weedy fields, or where there may be a heavy grasshopper infestation, is not advisable. Similarly on light soils that blow badly, burning stubble may be inadvisable.

### Diseases of Flax

Plant diseases which the flax crop must contend with can in part be controlled by field practices. Another and more effective means is the use of resistant varieties where these are available. The wilt organism lives over in the soil. Once present in the soil it may live there for an indefinite period. Using varieties resistant to wilt is the most practical means of control. **The rust and pasmo organisms are carried over in the soil from year to year on the stubble and trash of a diseased flax crop.** If this stubble and trash could be completely destroyed, as by fall or early spring burning, or completely buried by plowing so that the winter spores could not germinate, and then only seed free from diseased bits of straw was used, the source of infection would be greatly reduced.

While these practices will be helpful in retarding and reducing the amount of disease, they can not insure complete protection since **rust and pasmo disease spores may also be carried by air currents from adjacent or more distant fields.** For rust protection resistant varieties now available offer a more certain and practical means of control. Varieties with high resistance to pasmo, however, are not available and for protection against this disease it is important that practices which include field sanitation be followed. Flax should **not** be sown in the same field in successive years. Diseased flax stubble and straw should be destroyed to hold down early infection. Early seeding and the use of varieties that combine rust resistance with maximum tolerance to pasmo are other practices that will be helpful in retarding the development of this disease.

### Which Variety to Grow

There are several good varieties of flax to choose from. Some are early ripening. Others require a longer season to ripen but may yield better if growing conditions are favorable. Most varieties now available have satisfactory resistance to flax wilt, also have a high degree of resistance to races of flax rust common

to this area, grow up to good height for convenient harvesting and yield well. No variety, however, is superior in every respect, nor should it be expected to be superior in yield under all conditions. The brief descriptions and comments presented here, based on observations from comparative tests conducted<sup>1</sup>, are intended as an aid to growers in choosing the variety which he believes will best meet his requirements and for the conditions under which the crop is to be grown.

The reaction of a variety to a disease can be described in relative terms only. How does it compare with other varieties? Varieties appearing to have little or no resistance are said to be susceptible. A variety said to be immune is considered not subject to attack from the particular disease. In all instances these terms are with reference to races or strains of the disease known to occur in this area. No varieties now available have a high degree of resistance to pasmo and they differ mainly in degree of susceptibility to the disease.

Some varieties have seed that is more easily injured in threshing than others, or the seed coat breaks open early permitting disease organisms to enter, frequently destroying the germ. The yellow seed varieties now grown and some of the very large brown seeded varieties show this weakness most. If used they should be checked for germination and the seed treated with Ceresan before sowing to give maximum protection to the young sprout.

**Bison**, which for several years was the principal variety grown, has excellent resistance to wilt, fair tolerance to pasmo but lacking in resistance to those races of rust now common in this area. Bison is a good yielding variety when not rusted, matures mid-early, has good height, blue flower, mid-size brown seed. Lacking in resistance to rust its use is limited chiefly to areas with little or no danger from rust. Since it is the variety most extensively grown until recently, and one many flax growers are still familiar with, it is used here as one of the standards for comparison.

**Table 1.—How some of the older varieties have compared in yield at the several stations for the years grown**  
(Bushels per acre)

Variety	Fargo	Edgeley	Langdon	Dickinson	Williston	Minot
	1927-46	1940-46	1940-46	1942-46	Irrig. 1941-46	1945-46
<b>Bison</b> .....	15.9	10.5	13.3	8.6	19.5	8.7
<b>Buda</b> .....	16.0	12.0	16.0	8.2	.....	8.9
<b>B. Golden</b> .....	17.7	11.6	14.6	9.8	26.4	8.7
<b>Walsh</b> .....	.....	11.7	13.8	.....	.....	9.3

<sup>1</sup>Trials at Dickinson in cooperation with the Division of Cercal Crops and Diseases, R. W. Smith in charge. Trials at Edgeley, Langdon, Minot and Williston under supervision of superintendents, J. P. Tiernan, V. Sturlaugson, G. N. Geiszler and Arlon Hazen, respectively.

**"Golden", Viking or B. Golden**, are very similar, if not identical. This flax has short straw, a large pink blossom and produces fairly large bright yellow seed, high in oil yield and iodine number. "Golden" ripens later and less uniformly than most varieties, is moderately resistant to wilt, highly resistant or essentially immune, to the races of rust known to occur in this area, but is very susceptible to pasmo. This flax is an excellent yielder, when conditions are reasonably favorable, but lack of plant height for convenient harvesting and less ability to withstand weed competition, plus its susceptibility to pasmo are serious disadvantages. R 522 (C.I. 977), the increase of a single plant selection from B. Golden, is taller but later ripening than the parent variety, is highly rust resistant, an excellent yielder but susceptible to pasmo. This yellow seeded selection has been released for production on farms in the irrigation districts of northwestern North Dakota.

**Koto** is from a cross (Russian x Argentine) x Bison. It has blue flowers, brown seeds with height and maturity about the same as Bison. Koto seed is about equal in size or slightly smaller than Bison, has a slightly lower oil content, but the oil has a higher iodine number. Koto is immune to many races of rust, but susceptible to some races now occurring in this area. While it has been superior to Bison, under the rust conditions prevailing the last few years, it lacks in resistance when compared with the other resistant varieties now available. Koto has satisfactory resistance to wilt, is about as tolerant to pasmo as Bison and Buda, and appears to be an excellent yielding variety. It should find considerable use in those sections of the State where the rust hazards are not so great.

**Victory** is from a Czechoslovakian flax crossed with Argentine, and a selection from this crossed with Smoky Golden. This variety as it is now in production is somewhat variable in type, ripens mid-late, has a large white flower, large brown seed of satisfactory oil content and high iodine number. Victory is moderately resistant to wilt, highly resistant to rust<sup>1</sup> and rather susceptible to pasmo. Victory is a good yielding variety when not severely damaged by pasmo. Early sowing to better "escape" severe pasmo infection or high temperatures is recommended.

**B-5128** from a cross Golden x Rio, is highly resistant or immune to those races of flax rust common to this area. Compared with Bison it is less resistant to wilt, and more susceptible than Bison to pasmo, although more tolerant than "Golden", Victory or Renew. B-5128 grows fully as tall as Bison, has a blue flower, and a larger brown seed. The oil content and drying quality of the oil, as measured by the iodine number, is about the same as Bison. It is an excellent yielding variety under reasonably favorable conditions, but being late in blossoming and ripening, may be at a disadvantage in some years. Recommended mainly for eastern and northern

<sup>1</sup>About 25 percent of the divergent plant lines in this variety appear susceptible to certain races of rust which have been found in North Dakota.

sections of the State where summer moisture conditions are more dependable or ripening temperatures more moderate. Early sowing is urged so that the crop will be more advanced should high summer temperatures or late drought occur. When sown late it will come into blossom as the days rapidly become shorter and, if moisture conditions are good, will continue to blossom indefinitely.

**Table 2.—How the rust resistant varieties have compared in yield with Bison and with each other at the several stations for the years tested.**  
(Bushels per acre)

Variety	Fargo 1941-47	Edgeley 1943-47	Langdon 1943-47	Dickinson 1943-47	Williston		Weighted average 30 Sta. yrs.
					Irrig. 1943-47	Minot 1945-47	
<b>Bison</b> .....	16.2	10.7	14.4	8.1	23.6	10.4	14.2
<b>B. Golden</b> .....	18.4	12.8	13.6	9.6	28.2	10.2	16.0
<b>Koto</b> .....	18.3	11.9 <sup>a</sup>	15.6	8.8	26.9	12.9	16.1
<b>Victory</b> .....	18.5	15.6	15.8	9.4	26.9	13.1	16.9
<b>B-5128</b> .....	19.8	16.2	17.2	10.5	29.9	10.5	18.0
<b>Renew</b> .....	17.6	15.2	15.6	8.3	.....	.....	.....

<sup>a</sup>Calculated yield for 1947.

**Renew** is from a cross Newland x (19x112E) and is highly resistant to those races of rust common to this area. Compared with Bison, Renew is more susceptible to pasmo, lacks some in resistance to wilt, but should be sufficiently resistant for most farm conditions. Renew grows about as tall and matures about the same time, or slightly earlier than Bison; has a blue flower, and a slightly smaller, dark brown seed. This variety will probably find its largest use in the southern and western sections of the State where rust resistance and early maturity are desired. Where seed of Dakota is available it might well take the place of Renew.

**Royal** is a selection from Crown made at the University of Saskatchewan, Saskatoon, Canada. Royal is moderately resistant to wilt and rust but susceptible to pasmo; grows about as tall as Bison, ripens slightly later, has a blue flower, medium large seed of satisfactory oil content but lower iodine number than Bison. Royal seed is characterized by a yellow or yellowish-white shading on the broad end of the seed. In comparable tests, Royal yields have generally been satisfactory, although somewhat erratic. Royal appears to be more resistant to frost in the spring than most varieties. Only moderate rust and wilt resistance and low iodine number are its principal disadvantages.

**Crystal** developed at the Minnesota Agricultural Experiment Station is from a cross Bison x Ottawa 770B. This variety is moderately resistant to wilt, highly resistant to rust and compares favorably with Bison and Buda in tolerance to pasmo. Crystal grows mid-tall, has a small white blossom, ripens mid-late and a greenish yellow seed with satisfactory oil yield and iodine number. Crystal appears somewhat more resistant to spring frosts than other varieties except Royal. In North Dakota tests to date it has not yielded as well as some of the other rust resistant varieties.

**Sheyenne** is a rust resistant selection from a cross, Ottawa 770B x Buda, developed and released cooperatively in 1945 by the Division of Cereal Crops and Diseases, U. S. Department of Agriculture and the North Dakota Agricultural Experiment Station. This new variety ripens earlier than other varieties now grown, has blue flowers, brown seed, and grows about as tall or only slightly less tall than Bison. Sheyenne seed is slightly smaller and its oil yield slightly under Bison but the iodine number is better than in Bison.

Sheyenne is highly resistant or immune to the races of rust known to exist in the country; is highly wilt resistant and has a fair degree of tolerance to pasmo. Ripening early, Sheyenne should not be expected to yield as high in some years as some varieties that ripen later and have a higher capacity for yield. However, it may yield more consistently on the lighter soils, and in those areas of the State where earliness is desirable in order to "escape" high summer temperatures or late summer drouths.

**Dakota** is the product of cooperative research between the Bureau of Plant Industry, U. S. Department of Agriculture and the State Experiment Stations in the flax producing area. Dakota is from a cross Renew x Bison, made by A. C. Dillman, and is the increase of an F<sub>3</sub> selection grown in the cooperative trials at Fargo. This new variety first released in 1946 has good resistance to wilt, and the rust reaction of the Renew parent. In its reaction to pasmo Dakota rates about average.

Dakota ripens about the same time or slightly earlier than Bison, grows about as tall, has blue flowers and brown, slightly smaller seed. In oil content Dakota averages about one percent lower than Bison, but in iodine number the oil is rated distinctly superior to Bison. This variety has good plant type and in tests to date has yielded satisfactorily over a wide area.

**Arrow** released by the Montana Experiment Station, is another selection from the same cross, Renew x Bison, which produced Dakota. Arrow has good wilt and rust resistance and otherwise many of the characteristics of Dakota. Slightly lower in iodine number than Dakota.

**Table 3.—How Dakota Sheyenne and Royal have compared in yield with other new varieties and Bison**

(Bushels per acre)

Variety	Williston				Minot	Weighted average 24 Sta. yrs.	
	Fargo 1943-47	Edgeley 1943-47	Langdon 1944-47	Dickinson 1944-47			Irrig. 1945-47
Bison .....	16.6	10.7	12.6	8.4	25.6	10.4	13.7
B. Golden .....	16.5	12.8	10.8	10.3	27.5	10.2	14.3
Koto .....	17.6	11.9 <sup>a</sup>	13.4	8.9	27.0	12.9	14.9
Victory .....	16.8	15.6	12.9	9.1	27.1	13.1	15.4
B-5128 .....	18.5	16.2	14.5	10.0	29.7	10.5	16.3
Dakota .....	18.3	14.8	14.3	9.2	26.7	14.2	15.9
Sheyenne .....	16.6	14.7 <sup>a</sup>	12.1	9.0	23.0	10.8	14.3
Royal .....	16.0	13.4	13.9	9.7	.....	14.0	.....
Crystal .....	14.9	13.7	13.0 <sup>a</sup>	.....	.....	.....	.....
Arrow .....	18.0	.....	.....	9.9 <sup>a</sup>	.....	.....	.....

<sup>a</sup>Calculated yield one year.

**Minerva**—developed and released from the Minnesota Experiment Station is a selection from a cross C. I. 649 x Bison and back crossed to Bison three times. Minerva grows up to good height, matures relatively late, has satisfactory wilt and rust resistance, blue flowers and a dark yellow seed that is high in oil and iodine number. In our tests to date Minerva yields have been satisfactory but not outstanding. In 3 years at Fargo when rust was not a factor, Minerva yielded about the same as Bison but less than Dakota or B-5128. In 1947 at Edgeley Bison carried considerable rust and Minerva yielded distinctly better, about the same as B-5128, and less than Dakota. At Langdon in 1947 it compared in yield with Bison, but yielded slightly lower than some of the other rust resistant varieties.

**Others**—Buda and Walsh are still grown to some extent but offer no advantages not also available in the newer varieties. Buda has excellent wilt resistance, but is only moderately resistant to rust. Walsh is highly resistant to rust, moderately resistant to wilt, susceptible to pasmo and rather erratic in yield behavior. Walsh has a very large seed, with satisfactory oil yield but low iodine value. Several other varieties now available offer as much or more rust protection and yield more dependably.

**Table 4—A classification of the leading flax varieties with respect to some plant and seed characteristics and their reaction to important diseases. Listed in order of earliness.**

Variety	Color		Rel. seed size.	Relative maturity	Resistance to disease <sup>1</sup>		
	Blossom	Seed			Wilt	Rust	Pasmo
<b>Sheyenne</b>	blue	brown	med.	early	v. good	excel.	fair
<b>Renew</b>	blue	dk. brown	med.	mid-early	fair	excel.	poor
<b>Dakota</b>	blue	brown	med.	mid-early	v. good	excel.	fair-
<b>Koto</b>	blue	brown	med.	mid-early	v. good	fair	fair
<b>Bison</b>	blue	brown	med.+	mid-early	v. good	poor	fair
<b>Arrow</b>	blue	brown	med.	mid-early	v. good	excel.	fair
<b>Buda</b>	blue	brown	small	mid-late	v. good	fair	fair
<b>"Golden"</b>	pink	yel.	med.+	mid-late	fair	excel.	v. poor
<b>Walsh</b>	blue	brown	v. large	mid-late	fair	excel.	poor
<b>Crystal</b>	white	dk. yel.	med.+	mid-late	fair	excel.	poor
<b>Victory</b>	white	brown	large	mid-late	fair+	excel.	poor
<b>Royal</b>	blue	brown	med.+	mid-late	fair	fair+	fair-
<b>B 5128</b>	blue	brown	large	late	fair+	excel.	fair-
<b>Minerva</b>	blue	dk. yel.	large	late	v. good	excel.	fair

<sup>1</sup>Refers to reaction to those races now common to this area. None of the flax varieties have satisfactory resistance to pasmo.

### Summary

Competition from weeds is the most serious obstacle to successful flax production. Cultural practices for control of weeds should usually begin a year or more before the flax is to be sown.

The successful flax farmer is one who manages his fields so that the available fertility is maintained at a satisfactory level

and weed competition is always at a minimum. In his cropping program he then sows flax following the crop where the weed competition would be the least.

Early sowing in a firm seed bed is usually preferable for flax.

Rust resistant varieties like Dakota, B-5128 and Victory should have preference in areas where the rust hazard may be most serious. Sheyenne, early ripening, but highly rust resistant, appears suited best to the more southern section of the State. Koto and Royal yield well but are less resistant to rust, therefore, suited to a more limited area.

## EFFECT OF ORGANIC AMENDMENTS ON CROP YIELDS AT MANDAN, NORTH DAKOTA

By

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Experiments were started at the Northern Great Plains Field Station in 1914 to determine the effects of applying barnyard manure and plowing under green manure on crop production. The area on which studies were established was broken from native sod in 1913.

Three-year triplicate rotations of corn, wheat, and oats and four-year rotations which included summer fallow were used. Manure was applied to a different crop in each replication of the three-year rotations and to the fallow in the four-year rotations. Wet rotted manure was applied at the rate of 20 tons per acre. Sweet clover was seeded with the crop following corn and turned under the second year at time of plowing for summer fallow. Winter rye was seeded in the stubble of the crop following corn and plowed at the same time as sweet clover.

### Effect of Soil Treatments on Gain or Loss of Nitrogen and Organic Carbon

Analyses of the total nitrogen and organic carbon in the surface two feet of certain plots were made in 1944 to determine the cumulative effects

**Table 1.—Effect of 30 years cropping on total nitrogen and organic carbon of selected rotations, Northern Great Plains Field Station, Mandan, N. Dak.**

Crop Sequence and Treatment	Loss or gain as percentage of calculated original value					
	Total Nitrogen			Organic Carbon		
	0-6 inches	6-12 inches	12-24 inches	0-6 inches	6-12 inches	12-24 inches
Corn-Wheat-Oats						
Check .....	-34	-13	-8	-37	-14	-9
Manure .....	0	+10	+6	-7	+9	+6
Corn-Wheat-Fallow-Oats						
Check .....	-30	-12	-4	-34	-11	-3
Manure .....	-7	+4	+6	-12	+5	+6
Sw. clover gr. manure...	-29	-9	-2	-33	-10	-3
W. rye gr. manure.....	-32	-14	-8	-36	-14	-12

<sup>1</sup>Agronomist, Division of Soil Management and Irrigation, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Dept. of Agriculture; in cooperation with the North Dakota Agricultural Experiment Station.