

**WINTER RYE RATE OF  
SOWING, ROW SPACING,  
VARIETAL MIXTURES,  
AND CROSSES**



**AGRICULTURAL EXPERIMENT STATION  
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## Winter Rye Rate of Sowing, Row Spacing, Varietal Mixtures, and Crosses

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Rye grain was harvested on 84,000 Minnesota acres in 1969. Additional acreage was used for pasture, green manure, winter cover, and establishment of cover on roadsides. The long straw and lodging susceptibility of most varieties tend to restrict grain production to droughty soils and discourage use of nitrogen fertilizer and irrigation. Most agronomic research on rye has been confined to variety development and testing. Very little research data are available on how to grow rye in the Upper Midwest. Farm practices in rye production are based on experience and research with other small grains.

Rye is unique among small grains grown in Minnesota because annual weeds have difficulty surviving under its vigorous, early spring growth. This suggests that rates of sowing could vary more for rye than for wheat, oats, and barley without seriously increasing weed growth. Rye is commonly sown in the Upper Midwest at a rate of 84 pounds (6 pecks) per acre. Comparison of this rate with those commonly used for wheat, oats, and barley indicates that rye is sown at the greatest number of seeds per acre. Experience in variety testing led the Minnesota Agricultural Experiment Station to use 70 pounds per acre as the standard rate. Any further reduction requires research. In addition to the advantage of lower seed cost per acre, low rates of sowing might reduce lodging, but yield reduction and greater weed growth are potential hazards.

The usual drill row spacing for small grains and flax is 6 inches, but 7-inch spacing is also common. Johnson and Robinson<sup>1</sup> found that weed growth was greater in 7-inch than 6-inch rows of oats or flax, but there was little difference between the two spacings of wheat or barley. The lack of annual weed problems in rye suggests that considerably wider row spacings could be used. Wide row spacings might reduce lodging by permitting more light to penetrate the foliage and thus produce shorter, stronger straw.

Another unique characteristic of rye is cross pollination caused by self-sterility and wind-borne pollen; other common small grains are self-pollinated. This characteristic of rye allows intervarietal crossing to occur naturally, and seed harvested from a mixture of two varieties will include hybrid seed and a mixture of the two parents.

Since the midfifties, high yielding varieties such as Pearl, Elk, Von Lochow, Tetra Petkus, Sangaste, and Dominant have been available. However, they lack the dependable winterhardiness of the lower yielding Caribou, Antelope, Dakold, and Emerald varieties. If mixtures of a winterhardy variety with a less hardy, higher yielding variety produced satisfactory yields after severe winters and high yields after

mild winters, such mixtures would be of value to farmers and seed companies. Use of a strong-strawed variety to hold up a higher yielding, weak-strawed variety is another potential advantage of mixtures.

Four objectives of this research were: (1) to determine if lower rates of sowing and/or wider row spacing reduce lodging while maintaining yield and weed control at acceptable levels, (2) to compare the performance of varietal mixtures, crosses, and pure varieties, (3) to compare sowing two varieties in alternate rows vs. sowing a drill box mixture of the two varieties, and (4) to learn if succeeding generations of intervarietal crosses changed in agronomic performance.

### Experimental Procedure

Trials were conducted on Minnesota Agricultural Experiment Station fields at Rosemount from 1963-69, at Waseca from 1966-69, and at Lambert, Morris, and Grand Rapids from 1964-69. Soil types were Waukegan silt loam at Rosemount, Webster silty clay loam at Waseca, Webster silt loam at Lambert, Barnes silty clay loam at Morris, and fine sandy loam at Grand Rapids. Perennial weeds were not serious in these trials. Trials were in large fields away from fences or other barriers that would cause abnormal snow cover. Sowing dates varied from September 5-25 except that wet soil delayed planting until October 15, 1968 at Waseca.



Plots of 42-inch, 18-inch, and 6-inch row spacings in April.

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<sup>1</sup> V. Johnson and R. G. Robinson. 1952. Drill spacings—6- vs. 7-inch—compared. *Minn. Farm and Home Sci.* 9(3):14.

Plots were 65 feet long and consisted of twelve rows for 6-inch row spacings, six rows for 12-inch spacings, four rows for 18-inch spacings, and three rows for 42-inch spacings. Plots of alternate spacings had two rows 6 inches apart spaced 18 inches from adjacent pairs of two rows 6 inches apart.



On the left, a plot of 18-inch row spacing and on the right, alternated 18- and 6-inch spacing.

All plots were sown with a grain drill. Rates of sowing ranged from 42 to 70 pounds (3-5 pecks) per acre and were based on seed weighing 2.4 grams per hundred seeds of at least 90 percent germination.

Varietal mixtures were made of equal numbers (not weight) of seed of the component varieties and were of two types. Intra-row mixtures were made by mixing the two varieties before placing them in the grain drill. Alternate-row mixtures were made by placing seed of one variety in alternate compartments of a partitioned grain drill box. Seed of the other variety was placed in the remaining compartments so that the varieties alternated in rows 6 inches apart. Because the rate of sowing lever on a drill gives the same fluted feed exposure at each feed opening and the two varieties required different exposure to sow equal numbers of seeds, seed of the faster feeding variety was mixed with cracked corn. The proportion of cracked corn to rye seed was adjusted by trial and error until the drill setting delivered equal numbers of seed of the two varieties.



On the left, Von Lochow x Caribou cross; in middle, intra-row mixture; and on the right, alternate-row mixture.

The alternate-row method was also used to sow the crossing plots so that differential winterkill of the two varieties could be detected and the seed not used for planting. However winterkill did not occur and seed was harvested in bulk from each crossing plot. Both the original crossing plots and succeeding generations were isolated by over 700 feet from other rye.

Caribou and Frontier varieties were used in the rate of sowing and row spacing trials. Both are very winterhardy. Caribou is medium in yield and poor in lodging resistance; Frontier is high yielding and very poor in lodging resistance. Von Lochow, which is high in yield and lodging resistance but fair to poor in winterhardiness, was used in mixtures and crosses with Caribou and Frontier. WR5, an experimental variety of medium to high yield and excellent lodging resistance and winterhardiness, was used in mixtures with Von Lochow. Rate of sowing for crosses and intra- and alternate-row mixtures was 70 pounds per acre, based on seed weight of 2.4 grams per 100.

Grain yields are based on air-dry grain of 56 pounds per bushel, and lodging data on a scale of 1 (erect) to 9 (flat).

The LSD (5%) figure given under the yield columns in the tables is a statistical measure of variability. If the LSD is low relative to average yields, the trial results are considered more reliable than if the LSD is relatively high. LSD is an abbreviation for least significant difference, but should be so interpreted only when the trial consists of two treatments.

## Experimental Results

Rye gave satisfactory control of annual weeds without spraying or cultivation at all sowing rates and row spacings, except 42 inches. At 42 inches, one cultivation was necessary in some trials.



Rye in rows 42 inches apart did not always give satisfactory weed control.

At a sowing rate of 42 pounds per acre, yield decreased as row spacing increased from 6 to 18 to 42 inches (table 1). Rye in 18-inch rows also yielded less than rye sown at 56 or 70 pounds per acre in 6-inch rows (tables 1-5). All trials were harvestable and, contrary to expectations, 18-inch row spacing failed to show an economically important advantage in lodging resistance over 6-inch spacing in any trial. Rye in 18-inch row spacing averaged about 1 inch shorter, 1 day later, and slightly lower in bushel weight than rye in 6-inch spacing. Rye grown in 18-inch spacings of groups of two rows 6 inches apart, at sowing rates of 42 and 56 pounds, also failed to equal the yields obtained in 6-inch spacing (tables 4-5).

Twelve-inch row spacing produced higher yields and bushel weights than 18-inch spacings but lower yields than 6-inch spacing (table 5).

Yields, bushel weights, and other agronomic characteristics did not differ significantly among 42-, 56-, or 70-pound per acre rates in 6-inch spacings (tables 1, 2, 5).



On the left, a plot of 6-inch row spacing and on the right, 12-inch spacing.

**Table 1. Effect of sowing rate and row spacing on Caribou at Rosemount in 1963-64 and at Lambertton, Morris, and Grand Rapids in 1964**

Sowing rate per acre	Row spacing	Grain yield per acre	Date heading	Date mature	Height	Lodging	Weight 100 seed	Bushel weight
pounds	inches	bushels	May	July	inches		grams	pounds
70	6	40.1	26	14	53	3.9	2.1	56.0
42	6	39.9	26	14	52	3.3	2.1	56.0
42	18	35.7	27	15	51	2.5	2.1	55.6
42	42	20.9	28	16	46	1.9	2.1	55.2
LSD 5%		2.1						

**Table 2. Effect of sowing rate and row spacing on Caribou at Rosemount in 1963-65 and at Lambertton, Morris, and Grand Rapids in 1964-65**

Sowing rate per acre	Row spacing	Grain yield per acre	Winterkill	Date heading	Date mature	Height	Lodging	Weight 100 seed	Bushel weight
pounds	inches	bushels	percent	May	July	inches		grams	pounds
70	6	41.3	5	30	19	53	3.6	2.2	55.9
42	6	40.6	7	30	19	52	3.2	2.2	56.0
42	18	34.7	6	31	20	51	2.8	2.2	55.7
LSD 5%		2.1							

**Table 3. Effect of sowing rate and row spacing on Caribou at Rosemount in 1963-66; Lambertton, Morris, and Grand Rapids in 1964-66; and Waseca in 1966 and on Frontier at all locations in 1967**

Sowing rate per acre	Row spacing	Grain yield per acre	Winterkill	Date heading	Date mature	Height	Lodging	Weight 100 seed	Bushel weight
pounds	inches	bushels	percent	June	July	inches		grams	pounds
70	6	46.9	4	1	21	52	3.6	2.3	56.1
42	18	38.8	4	3	22	50	3.6	2.3	55.7
LSD 5%		1.3							

**Table 4. Effect of sowing rate and row spacing on Caribou at Rosemount in 1965-66; Waseca, Lambertton, Morris, and Grand Rapids in 1966; and on Frontier at all locations in 1967**

Sowing rate per acre	Row spacing	Grain yield per acre	Winterkill	Date heading	Date mature	Height	Lodging	Weight 100 seed	Bushel weight
pounds	inches	bushels	percent	June	July	inches		grams	pounds
70	6	49.9	5	3	20	52	3.7	2.4	56.2
42	18	40.6	6	4	21	51	4.0	2.4	55.6
42	18 <sup>1</sup>	41.5	6	4	21	51	4.0	2.4	55.8
56	18 <sup>1</sup>	42.8	5	3	21	51	3.8	2.3	55.8
LSD 5%		1.6							

<sup>1</sup> Alternated with 6-inch.

**Table 5. Effect of sowing rate and row spacing on Caribou in 1966 and Frontier in 1967 at five locations**

Sowing rate per acre	Row spacing	Grain yield per acre	Winterkill	Date heading	Date mature	Height	Lodging	Weight 100 seed	Bushel weight
pounds	inches	bushels	percent	June	July	inches		grams	pounds
70	6	52.0	2	3	24	52	3.5	2.4	56.3
56	6	52.6	2	3	24	52	3.7	2.4	56.3
56	12	48.6	2	3	24	51	3.8	2.4	56.1
42	18	42.5	2	4	24	51	3.9	2.4	55.8
42	18 <sup>1</sup>	43.2	2	4	24	51	3.8	2.4	55.9
56	18 <sup>1</sup>	44.0	2	3	24	50	3.6	2.3	55.9
LSD 5%		1.6							

<sup>1</sup> Alternated with 6-inch.

Intra- and alternate-row mixtures of Caribou and Von Lochow varieties did not differ significantly in yield or other agronomic characteristics (tables 6-7).

Caribou-Von Lochow mixture yielded as much as Von Lochow and more than Caribou on an average of four years and five locations (table 8). When only trials with some winterkill were averaged, the mixture yielded the same as Caribou but more than Von Lochow.

Neither Frontier nor Von Lochow exceeded the yield of their mixture at any location in 1968, and at Rosemount, Von Lochow was significantly lower in yield (table 8). Similarly neither WR5 nor Von Lochow exceeded their mixture in yield at any location in 1968-69. At Grand Rapids and on the average of all locations, WR5 produced significantly lower yields than the mixture. In other agronomic characteristics shown in table 9, the mixtures tended to be intermediate between their two component varieties.

**Table 6. Yields of intra- and alternate-row mixtures of Caribou and Von Lochow at five locations, 1965-67**

Location	Intra-row	Alternate-row	LSD 5%
Rosemount	33.6	35.7	3.9
Waseca <sup>1</sup>	58.9	60.6	7.2
Lamberton	37.6	35.5	9.3
Morris	42.1	37.5	6.2
Grand Rapids	75.8	74.2	6.3
Average 5 locations	49.6	48.7	3.0

<sup>1</sup> No 1965 trial.

**Table 7. Average of five locations for characteristics of intra- and alternate-row mixtures of Caribou and Von Lochow, 1965-67**

Characteristic	Intra-row	Alternate-row
Winterkill, percent	15	16
Date heading	June 3	June 3
Date mature	July 24	July 24
Height, inches	51	50
Lodging	2.7	2.3
Weight 100 seed, grams	2.5	2.4
Bushel weight, pounds	56.1	55.8

**Table 8. Yields of varieties and their mixtures at five locations**

Variety	Rosemount	Waseca <sup>1</sup>	Lamberton <sup>2</sup>	Morris	Grand Rapids	Average <sup>5</sup> locations
1965-68						
Caribou	35.8	52.5	36.5	42.5	63.8	46.2
Mixture	35.8	54.5	37.6	46.2	71.4	49.1
Von Lochow	35.8	63.3	24.1	40.2	82.5	49.2
LSD 5%	3.2	5.6	9.3	5.2	5.2	2.7
Trials of Caribou, Von Lochow, and mixture where some winterkill occurred (Rosemount 1965, 1968; Lamberton 1965, 1967; Morris 1965-67; Grand Rapids 1967)						
Caribou	36.6	—	39.1	40.9	68.2	46.2
Mixture	28.3	—	39.6	42.1	70.9	45.2
Von Lochow	20.1	—	16.3	30.6	81.3	37.1
LSD 5%	4.9	—	13.7	6.2	11.6	4.9
Frontier, Von Lochow, and mixture 1968						
Frontier	47.3	43.9	—	61.5	70.4	55.8
Mixture	47.4	47.3	—	68.9	69.4	58.3
Von Lochow	40.2	48.5	—	68.9	74.0	57.9
LSD 5%	5.6	8.6	—	8.9	8.9	4.1
WR5, Von Lochow, and mixture 1968-69						
WR 5	54.8	52.2	59.7	68.1	57.9	58.5
Mixture	57.0	53.7	61.1	73.7	67.9	62.7
Von Lochow	52.6	58.2	64.7	71.6	70.6	63.5
LSD 5%	4.1	9.7	4.7	6.5	5.6	2.9

<sup>1</sup> No 1965 trial.

<sup>2</sup> No 1968 data.

**Table 9. Average of five locations for characteristics of varieties and mixtures**

Variety	Winterkill	Date heading	Date mature	Height	Lodging	Weight 100 seed	Bushel weight
	percent	June	July	inches		grams	pounds
1965-68							
Caribou	5	1	23	51	3.0	2.3	55.8
Mixture	13	2	24	50	2.7	2.5	55.9
Von Lochow	30	4	26	47	1.6	2.9	56.3
1968							
Frontier	2	1	28	52	4.5	2.6	56.0
Mixture	5	2	29	51	3.1	2.7	56.0
Von Lochow	19	5	31	47	1.8	2.8	55.1
1968-69							
WR5	4	3	28	47	1.4	2.4	53.5
Mixture	8	3	29	49	1.6	2.5	54.5
Von Lochow	17	3	31	49	1.8	2.7	55.3

Caribou-Von Lochow and Frontier-Von Lochow crosses tended to be intermediate in yield between their parents (table 10). However, when only trials with some winterkill are considered, the Caribou-Von Lochow cross yielded as much as Von Lochow and more than Caribou. In other agronomic characteristics shown in table 11, the crosses were intermediate between their parents except they tended to equal the hardier parent in winterhardiness.

The comparison of mixtures and crosses of Caribou-Von Lochow and Frontier-Von Lochow in tables 12-13 shows that crosses and mixtures did not differ significantly in any agronomic characteristic.

Succeeding generations from crosses of Caribou-Von Lochow and Frontier-Von Lochow made by the alternate-row method did not differ significantly in yield or other agronomic characteristics when tested in the same yield trials (tables 14-15).

**Table 10. Yields of varieties and their crosses at five locations**

Variety	Rosemount	Waseca	Lamberton <sup>1</sup>	Morris	Grand Rapids	Average 5 locations
1966-69						
Caribou	38.8	49.9	42.5	48.6	57.4	47.4
Cross	44.7	57.6	48.8	57.1	63.2	54.3
Von Lochow	52.0	64.5	45.7	58.8	77.1	59.6
LSD 5%	2.9	6.0	9.0	4.5	4.6	2.6
Trials of Caribou, Von Lochow, and mixture where some winterkill occurred (Rosemount 1968; Lamberton 1967; Morris 1966-67; Grand Rapids 1967, 1969; Waseca 1969)						
Caribou	43.3	41.9	44.1	47.3	57.8	46.9
Cross	48.1	59.6	48.5	50.0	65.4	54.3
Von Lochow	40.2	67.8	32.6	45.9	74.3	52.2
LSD 5%	5.6	17.3	26.1	6.2	6.5	6.6
1968-69						
Frontier	49.3	53.5	61.0	62.3	63.7	58.0
Cross	54.6	49.0	63.5	69.1	66.6	60.6
Von Lochow	52.6	58.2	64.7	71.6	70.6	63.5
LSD 5%	4.1	9.7	4.7	6.5	5.6	2.9

<sup>1</sup> No 1968 data.

**Table 11. Average of five locations for characteristics of varieties and crosses**

Variety	Winterkill	Date heading	Date mature	Height	Lodging	Weight 100 seed	Bushel weight
	percent		July	inches		grams	pounds
1966-69							
Caribou	4	May 31	22	52	2.9	2.3	55.6
Cross	7	May 31	23	51	2.5	2.5	55.9
Von Lochow	17	June 3	24	48	1.7	2.8	56.1
1968-69							
Frontier	6	May 30	28	54	5.0	2.4	55.6
Cross	6	May 31	29	53	3.9	2.5	56.1
Von Lochow	17	June 3	31	49	1.8	2.7	55.3

**Table 12. Yields of intervarietal crosses and mixtures at five locations**

Variety	Rosemount	Waseca	Lamberton <sup>1</sup>	Morris	Grand Rapids	Average 5 locations
Caribou-Von Lochow cross and mixture, 1966-68						
Cross	44.6	56.9	43.2	54.2	66.8	53.1
Mixture	42.9	54.5	40.2	51.5	68.0	51.4
LSD 5%	3.4	5.6	13.3	5.1	5.7	3.3
Frontier-Von Lochow cross and mixture, 1968						
Cross	50.6	47.1	—	73.1	71.6	60.6
Mixture	47.4	47.3	—	68.9	69.4	58.3
LSD 5%	5.6	8.6	—	8.9	8.9	4.1

<sup>1</sup> No 1968 data.

**Table 13. Average of five locations for characteristics of intervarietal crosses and mixtures**

Variety	Winterkill	Date heading	Date mature	Height	Lodging	Weight 100 seed	Bushel weight
	percent	June	July	inches		grams	pounds
Caribou-Von Lochow cross and mixture, 1966-68							
Cross	6	1	23	51	2.4	2.5	56.0
Mixture	5	2	23	51	2.6	2.5	55.9
Frontier-Von Lochow cross and mixture, 1968							
Cross	2	2	29	52	3.3	2.6	56.4
Mixture	5	2	29	51	3.2	2.7	56.0

**Table 14. Yields at Rosemount of four generations of Caribou-Von Lochow cross made in 1965 and two generations of Frontier-Von Lochow cross made in 1967**

Generation planted	Years of trial		
	1967	1968	1969
Caribou-Von Lochow cross			
F1, 1965 crop	43.7	47.9	—
F2, 1966 crop	42.1	49.2	—
F3, 1967 crop	—	48.1	45.7
F4, 1968 crop	—	—	44.9
LSD 5%	2.3	5.6	6.0
Frontier-Von Lochow cross			
F1, 1967 crop	—	—	58.6
F2, 1968 crop	—	—	53.7
LSD 5%	—	—	6.0

**Table 15. Characteristics of generations of intervarietal crosses at Rosemount**

Generation planted	Winterkill	Date heading	Date mature	Height	Lodging	Weight 100 seed	Bushel weight
	percent		July	inches		grams	pounds
Caribou-Von Lochow cross, 1967 trial							
F1, 1965 crop	0	May 29	25	60	3.7	2.5	57.2
F2, 1966 crop	0	May 29	20	60	3.7	2.3	55.7
Caribou-Von Lochow cross, 1968 trial							
F1, 1965 crop	3	June 1	20	47	3.3	2.6	54.5
F2, 1966 crop	1	June 1	20	46	3.3	2.6	54.5
F3, 1967 crop	0	May 31	20	48	3.0	2.5	54.9
Caribou-Von Lochow cross, 1969 trial							
F3, 1967 crop	0	May 25	16	54	2.6	2.2	56.2
F4, 1968 crop	0	May 25	16	54	2.7	2.2	56.8
Frontier-Von Lochow cross, 1969 trial							
F1, 1967 crop	0	May 25	17	54	3.0	2.4	57.6
F2, 1968 crop	0	May 27	17	54	4.0	2.3	57.8

## Discussion and Conclusions

Rye sowing rates can be reduced considerably from the prevalent 84-pound per acre rate. Although yields from the 42-pound rate were not significantly lower than 70 pounds per acre, 56 pounds per acre is a reasonable recommendation for normal fields and seed prices. Lower rates might be used for expensive seed; higher rates might be needed where perennial weed control is an important consideration. These rates are based on seed of 2.4 grams per 100 seeds; proportionately higher rates should be used for larger seed and lower rates for smaller seed. Sowing rates should be increased if germination is less than 90 percent.

Rye should be sown in 6- or 7-inch drill rows. Although it can be grown in rows 12 or 18 inches apart without serious weed problems, yield is reduced and lodging is not importantly decreased.

On fields where winterkill of a high yielding variety is common, yield stability may be achieved by growing a mixture of the high yielding variety and a very hardy, medium yielding variety. Use of the mixture may result in a medium yield after severe winters, and a high yield after mild winters. The mixtures used in these trials did not show significantly greater lodging resistance than that of the poorer variety.

Mixtures sown as a drill box mixture performed as well as those sown by the alternate-row method. However, if one

variety has much greater seedling vigor than the other, the alternate-row method should be considered to reduce early intervarietal competition.

Varietal mixtures should not be made between diploid and tetraploid varieties. Cross pollination between diploid and tetraploid varieties drastically reduces yields. Tetra Petkus is the only tetraploid variety of winter rye presently grown in the Upper Midwest.

Intervarietal crosses made by the alternate-row method did not differ in agronomic performance from mixtures of the same varieties. These crosses are uncontrolled; i.e., all plants do not cross so the result is a mixture of hybrid and parental variety seed. Succeeding seed increases from these crosses are mixtures of hybrids, parents, and segregating germplasm. Succeeding generations from these crosses did not change significantly in agronomic performance. Therefore a farmer could make a varietal mixture once, and then use seed from several generations of increase for planting. However, following a severe winter, the mixture should be remade because plants with the less hardy germplasm could have winterkilled.

Farmers or seedsmen wanting to grow mixtures of new varieties with expensive seed could use the alternate-row method in an isolated seed plot to grow several years' supply of a particular mixture.



On the left, Von Lochow variety and on the right, Von Lochow x Caribou.