



Durum wheat variety research is a team effort at North Dakota State University. Here three cooperating researchers view a potential new durum variety in the NDSU agronomy greenhouse. Left to right are: Dr. James D. Miller, USDA research plant pathologist; Dr. James S. Quick, NDSU durum breeder; and Dr. David E. Walsh, cereal chemist at NDSU.

Three New Durum Varieties . . .

CROSBY, BOTNO and RUGBY

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"Crosby," "Botno" and "Rugby" are durum varieties cooperatively developed and released by the North Dakota Agricultural Experiment Station and the Agricultural Research Service, U. S. Department of Agriculture. These new varieties combine excellent agronomic characteristics that will lead to more efficient durum production in the United States. All are highly resistant to stem rust. The excellent milling and spaghetti characteristics of these new varieties will assure millers, processors, and consumers of high-quality pasta products.

Crosby, Botno and Rugby durum wheats were developed and jointly released December 27, 1973, by the North Dakota Agricultural Experiment Station and the Agricultural Research Service, U. S. Department of Agriculture.

Higher yield, stiffer straw, and earliness, combined with high quality and disease resistance, have been among the major objectives of

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the durum improvement program for North Dakota and adjoining states. The variety Leeds successfully overcame the small kernel disadvantage of Lakota and Wells durums and provided additional straw strength and stem rust resistance, but did not have increased yielding ability. Rolette possesses additional earliness, and Ward provides higher yield, stronger straw and greater disease resistance than Leeds. Botno represents a combination of higher yield, earliness and higher spaghetti color than Rolette. Rugby has a broader resistance to stem rust and a higher spaghetti color than any ND-USDA durum yet produced. Crosby provides a yield advantage over Ward

when compared over the entire regional testing area and at certain locations in North Dakota.

Crosby yielded equal to Ward in North Dakota, and outyielded all varieties in regional tests grown in North Dakota, South Dakota, Minnesota and Montana during 1970-73. Crosby was similar to Leeds in appearance and disease reactions, but had a slightly higher kernel weight and a slightly lower test weight. The name "Crosby" was taken from the name of the county seat of Divide county, an important durum-producing county in northwestern North Dakota, where Crosby appears well adapted.

Botno has a major advantage of earliness. It was equal to Rolette in days to head, height, lodging and reactions to diseases. Botno outyielded Rolette by about five per cent in regional tests grown in North Dakota, Minnesota, South Dakota and Montana during 1970-73. Botno was lower than Rolette and similar to Ward in test and kernel weight in North Dakota, and was superior to Rolette and equal to Ward in overall quality. The name "Botno" was taken from the name "Bottineau", an important durum producing county in north central North Dakota where earliness is of major importance.

The yield of Rugby has been equal to Ward in North Dakota, and slightly higher than Ward in regional tests. Rugby yielded 11 per cent more than Leeds in North Dakota tests. Rugby had a slightly higher kernel weight and a slightly lower test weight than Leeds. Rugby was equal to Ward in disease resistance in North Dakota and had a broader range of stem rust resistance in international tests. The overall quality of Rugby is excellent and it had the highest spaghetti color score of any variety in North Dakota tests from 1971 to 1973. The name "Rugby" was taken from the name of the county seat of Pierce county, an important durum-producing county near the center of the major durum growing area.

Breeding History of Crosby

Crosby, CI 17282, was selected from the cross Langdon*2/St464//Leeds made in the greenhouse at Fargo in April, 1963. Langdon and Leeds are ND-USDA developed durum varieties which were commercially important during the 1956-62 and 1966-73 periods, respectively. St464 is a stem rust resistant introduction from Ethiopia (mideast Africa). The final cross resulting in Crosby was made to combine stem rust resistance with early maturity, reduced height and excellent spaghetti quality.

Crosby was bulked in the F5 generation in 1967 as an F4-derived line and entered in preliminary yield trials in North Dakota in 1968 under

the designation D6715. The original cross and early generation selection were made by K. L. Lebsock, formerly Research Agronomist, ARS-USDA, at North Dakota State University. Performance testing and initial increase were directed by J. S. Quick.

Breeding History of Botno and Rugby

Botno, CI 17283, and Rugby, CI 17284, were selected from the cross D6062/D6142, made in the greenhouse at Fargo in April, 1963. This same cross resulted in the release of "Ward." D6062 is Langdon/3/Ld357//CI7780/Ld362, a mid-early selection slightly shorter than Leeds, having moderate resistance to stem rust, and slightly lower kernel weight, test weight, yield and color score than Leeds. D6142 is Br180/W1s, a selection derived from the same F2 plant as Leeds. D6142 had higher yield, and shorter straw than Leeds. It had high test and kernel weights, excellent stem rust resistance and stiff straw. D6142 was slightly below Leeds in spaghetti color and kernel weight. CI 7780 is an introduction from Ethiopia (mid-east Africa) resistant to stem rust in the field during the 1952 epidemic. Ld357 and Ld362 have the varieties Heiti, Stewart, Carleton, Mindum and Nugget in their pedigrees. The cross that produced Botno, Rugby and Ward was made to combine characteristics of both parents and also resulted in transgressive earliness, straw strength and yield performance.

Botno and Rugby were bulked in the F5 generation as F4-derived lines. Botno and Rugby were first entered in preliminary yield trials in 1968 under the designations D6721 and D6722, respectively. The original cross and early generation selection were made by K. L. Lebsock, formerly Research Agronomist, ARS-USDA, at North Dakota State University. Performance testing and initial increase were directed by J. S. Quick.

Performance Trials

Crosby, Botno and Rugby have been tested in North Dakota in small plot trials since 1968 and in larger drill strip field plots at North Dakota Agricultural Experiment Stations from 1971 to 1973. They were evaluated in the Uniform Regional Durum Yield Trials in North Dakota, Minnesota, South Dakota, Montana and Manitoba from 1970 to 1973.

Crosby, Rugby and Ward had similar yields over a 4-year period at North Dakota stations, and ranked higher than Botno, Rolette and Leeds (Table 1). Crosby, Botno, Rugby and Ward had similar test weights and ranked slightly below Rolette and Leeds. Kernel weights of the three new varieties and Ward were intermediate between those of Rolette and Leeds. Botno was sim-



Figure 2. Harvesting the seed increase field of Crosby durum on the Branch Experiment Station at Langdon in 1973.

ilar to Rolette in days to head (an indicator of relative maturity) and more than two days earlier than Leeds. Rugby was one day later than Ward, and Crosby was slightly earlier than Leeds and Ward. Botno was about two inches shorter than Leeds and about equal to Rolette. Crosby and Rugby were about equal in height. Botno and Rugby were equal to Ward in lodging resistance, while Crosby was equal to Leeds and less resistant to lodging than the other varieties.

Grain yields of the three new varieties compared with Rolette and Ward grown four years at several North Dakota Branch Stations are shown in Table 2. Crosby had a slight yield advantage over Ward at Williston, Dickinson, Fargo and Carrington (irrigated) and averaged equal to Ward over all locations. Rugby had a slight yield advantage over Ward in Carrington tests and averaged about equal to Ward over all locations. Ward was the highest yielding variety at the Langdon

Table 1. Agronomic Performance of Crosby, Botno and Rugby Compared with Ward, Rolette and Leeds Grown at Several Locations in North Dakota in Four Years, 1970-1973.

Character	Station Years	Crosby	Botno	Rugby	Ward	Rolette	Leeds
Agronomic							
Yield, bu/a	30	49.4	47.8	49.3	49.5	45.9	43.4
Test weight, lb/bu	30	61.8	61.8	61.7	61.5	62.3	62.4
1,000 kernel wt., g	21	42.0	42.5	42.0	42.9	44.6	40.5
Days to head	28	61.0	59.2	62.4	61.4	58.9	61.5
Height, in	28	36.0	34.5	36.1	35.8	34.7	36.9
Lodging, %	28	6.2	3.0	2.7	3.5	3.8	5.8

Table 2. Grain Yields (bu/a) of Five Durum Wheats Grown in North Dakota in Four Years, 1970-1973.

Variety	Carrington							Mean	% of Ward
	Langdon*	Minot	Williston	Irrig.	Dry	Fargo	Dickinson		
No. of tests:	5	6	2	4	3	4	6	30	
Rolette	53.9	47.9	28.3	61.0	35.7	53.4	31.4	45.9	92.7
Ward	60.8	52.4	29.9	64.3	35.8	57.4	33.2	49.5	100.0
Crosby	58.3	50.7	30.8	65.1	35.6	58.9	34.3	49.4	99.8
Botno	54.7	50.4	29.6	60.8	38.9	58.3	31.9	47.8	96.6
Rugby	59.2	51.6	29.4	65.0	37.4	57.9	33.0	49.3	99.6

*1970-72 only, due to hail loss in 1973.

and Minot stations. Botno was higher yielding than Rolette at all stations except Carrington (irrigated) where they were essentially equal. Botno was the highest yielding variety on dryland at Carrington.

Agronomic data from the Uniform Regional Trials in North Dakota, South Dakota, Minnesota, Montana and Manitoba (Table 3) indicate that Crosby, Botno and Rugby yielded equal to or higher than all other varieties. Test weights of Crosby, Botno and Rugby were intermediate between those of Ward and Rolette. Their kernel weights were intermediate between those of Ward and Leeds. Crosby was similar to Leeds in lodging, height and days to head. Rugby and Botno were equal to Ward in lodging resistance. Rugby was one day later in heading and one inch taller than Ward. Botno was similar to Rolette in height and was one day later in heading.

Disease Resistance

Crosby, Botno and Rugby have been highly resistant to the prevalent and nonprevalent North American stem rust races in seedling tests (Table 4). They have shown resistance to races 15B-2 and 15B-6 prevalent in North Dakota and to cultures

of 32, 113 and 151 from Mexico and Texas. All three varieties have additional resistance not found in Wells and Leeds. Most seedlings of Crosby and Botno and all seedlings of Rugby were resistant to orange mutant race 9, which was virulent on most seedlings of Leeds. All were resistant to mutant race 15, which is virulent on Wells.

In the field, adult plants of the three varieties were highly resistant to race 15B in North Dakota, races 32 and 151 in the Puerto Rico nurseries and to the cultures artificially inoculated in the 1971 International Spring Wheat Rust Nursery grown in North America. With the exception of races 9, 15 and 87 which were not used, these cultures represent the races listed in Table 4. Crosby, Botno and Rugby were resistant in the 1970-73 Uniform Regional Durum Nurseries grown in North Dakota, Minnesota, Montana and Manitoba. Furthermore, when exposed naturally to diverse stem rust races in the 1971 International Spring Wheat Rust Nursery, these varieties showed high levels of resistance at many locations in the world. Rugby had the lowest coefficient of infection, indicating it had the broadest level of resistance among the 810 wheats grown in 30 wheat-producing countries.

Table 3. Agronomic Data from Uniform Regional Trials in North Dakota, South Dakota, Minnesota, Montana and Manitoba in 1970-1973.

Entry	Days to head	Height in	Lodging %	Kernel wt. g/1000	Test wt. lb/bu	Yield bu/a
No. of tests:	33	33	32	13	40	40
Crosby	61.1	37	13	40.9	61.7	46.8
Rugby	62.2	37	9	41.7	61.6	46.1
Botno	59.7	35	8	41.5	61.6	45.6
Ward	61.3	36	9	42.2	61.3	45.5
Wells	61.9	37	20	34.1	61.4	43.4
Rolette	58.8	35	13	44.1	62.3	43.4
Wascana	62.7	38	37	43.4	59.8	42.9
Hercules	60.3	36	15	44.6	61.3	41.3
Leeds	61.3	37	13	39.8	62.3	41.0

Table 4. Seedling Reactions of Eight Durum Wheats to 12 Races of the Stem Rust Fungus, *Puccinia graminis* f. *sp. tritici*.

Variety	Race and varietal reaction*											
	9**	11	15**	15B	17	29	32	38	56	87	113	151
Crosby	R	R	R	R	R	R	R	R	R	R	R	R
Botno	R	R	R	R	R	R	R	R	R	R	R	R
Rugby	R	R	R	R	R	R	R	R	R	R	R	R
Ward	R	R	R	R	R	R	R	R	R	R	R	R
Rolette	MR	R	R	R	R	R	MR	R	R	R	MR	MR
Leeds	SMS	R	R	R	R	R	R	R	R	R	R	R
Wells	MR	R	S	R	R	R	R	R	R	R	R	R
Mindum	S	S	S	S	S	SMR	SMR	S	R	S	S	SR

*R - resistant, MR - moderately resistant, MS - moderately susceptible, S - susceptible.

**The cultures of races 9 and 15 virulent on Leeds and Wells, respectively, have not been found in the physiologic race survey in the United States but may be potential future threats.

Botno was similar to Leeds in its moderately susceptible and moderately resistant reactions to leaf rust in the seedling and adult stages, respectively. Crosby and Rugby were moderately resistant to leaf rust at both growth stages. Botno was similar to Rolette in resistance to leaf spotting diseases and less resistant than the other varieties. All varieties were moderately resistant to blackpoint.

Milling and Spaghetti Quality

Quality data for Crosby, Botno and Rugby and three check varieties, Ward, Rolette and Leeds, are averages of 16 field trials grown during

the crop years 1971, 1972 and 1973 (Table 5). In test weight and wheat grade the three new varieties were similar to Ward.

Kernel vitreousness for Crosby, Botno and Rugby was 84, 83 and 85 per cent, respectively, which is adequate for good milling properties and well above the minimum requirements for the top U. S. grade. Crosby, Botno and Rugby had kernel sizes similar to Ward, smaller than Rolette and larger than Leeds. Of the three new varieties, Botno had the largest kernel size, with an average of 50 per cent of its kernels in the large category, and an average 1,000 kernel weight of 42.7 g.

Table 5. Average Grade, Milling, and Spaghetti Quality Data for Crosby, Botno and Rugby Compared with Ward, Rolette and Leeds in 16 Tests During 1971-1973.

Quality Factor	Crosby	Botno	Rugby	Ward	Rolette	Leeds
Test weight, lb/bu	61.7	61.8	61.6	61.6	62.2	62.4
Grade, U. S.	1 HAD	1 HAD	1 HAD	1 HAD	1 HyHAD	1 HyHAD
Vitreous kernels, %	84	83	85	84	82	90
Kernel distribution, %						
Large	46	50	49	52	55	45
Medium	50	46	48	46	41	52
Small	4	4	4	4	4	4
1,000 kernel weight, g	41.4	42.7	41.7	42.6	44.1	40.3
Wheat protein, %*	13.7	13.7	13.7	13.9	14.1	14.6
Semolina protein, %*	12.6	12.7	12.6	12.8	13.1	13.3
Semolina yield, %	55.0	55.2	55.1	55.6	54.8	54.0
Semolina specks/10 in ²	21	20	20	19	23	21
Spaghetti color**	9.3	9.1	9.4	9.3	8.9	9.2
Spaghetti firmness, g cm***	4.3	4.4	4.1	4.2	4.2	4.7

*Expressed on a 14% moisture basis.

**Higher score indicates more yellowness.

***Higher value indicates firmer cooked spaghetti.

The protein contents of Crosby, Botno and Rugby are considered adequate for the production of good quality pasta foods. Wheat protein averaged 13.7 per cent for each of the new varieties. This was slightly lower than that of Ward and Rolette and lower than that of Leeds. High protein is desirable in durum to maintain the nutritional quality and physical characteristics of pasta foods.

The milling performance of Crosby, Botno and Rugby was uniformly good. In experimental milling studies, Crosby, Botno and Rugby gave semolina yields of 55.0, 55.2 and 55.1 per cent, respectively. This was midway between the milling yields of Ward and Rolette. In commercial milling, yields are expected to be higher than in laboratory milling. Because the new varieties have larger kernels, their semolina milling yields will probably average slightly higher than that of Leeds. Speck counts, which indicate the number of bran and black particles in the semolina of Crosby, Botno and Rugby, were similar to those of the check varieties and indicate good milling qualities.

Pasta processing performance of the varieties was tested by extruding spaghetti for each sample from 16 variety trials. During the three-year test period, no unusual processing characteristics were noted for either the new varieties or the check varieties. In addition, no cracks or checkings were noted in the finished dried product. Color scores for Crosby, Botno and Rugby averaged 9.3, 9.1 and 9.4, respectively. These scores indicate bright yellow spaghetti similar in appearance to Ward and Leeds and superior to Rolette. Spaghetti cooking tests also showed that the three new varieties had good cooked spaghetti texture and tolerance to overcooking.

Seed Production

Seed increases of Crosby, Botno and Rugby began in 1970 when breeder seed stocks were produced from carefully rogued blocks of F8 plants increased for three generations as a bulk from a single F4 plant. The Langdon and Minot Branch Stations and the Casselton Agronomy Seed Farm participated in subsequent increases in 1971, 1972 and 1973. Parts of these increases were used to plant the 1973-74 Arizona winter increases. Seed of all varieties will be available for planting in 1974 by approved seed producers under contract to the North Dakota Agricultural Experiment Station.

Summary

Crosby, Botno and Rugby, new durum wheat varieties, have been jointly released by the North Dakota Agricultural Experiment Station and the Agricultural Research Service, U. S. Department

of Agriculture. Crosby has the advantage of high yield over a wide area of adaptation. It outyielded all durum varieties the past four years over a four-state area and is equal to Leeds in all other respects. Botno combines the earliness advantage of Rolette durum with higher yield and improved quality. Botno has outyielded Rolette by five per cent in North Dakota and neighboring states. Botno is similar to Rolette in other agronomic traits and disease reactions. Rugby is similar to Ward in yield performance in North Dakota and the regional testing area; however, it has higher spaghetti color and broader resistance to stem rust and is one day later. All varieties are highly resistant to stem rust and moderately resistant to leaf rust, leaf spotting and blackpoint. Crosby, Botno and Rugby outyielded Leeds, the most popular North Dakota variety during the past six years, by 10 to 14 per cent in North Dakota in 1970-73, but only Crosby exceeded Ward for yield.

Milling and spaghetti processing characteristics of Crosby, Botno and Rugby are excellent. The overall quality of the three new durums is equal to that of Leeds and Ward and superior to that of Rolette, Hercules and Wells. Botno is considered a replacement for Rolette, and Crosby and Rugby are supplements to Ward. These three new durum varieties join recently released Ward and Rolette durums to provide durum producers with an excellent selection of superior varieties for production, and to assure millers, pasta processors and consumers of high quality food products.

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