

Brendan Donnelly, J. D. Miller and James Quick discuss mixogram curve characteristics obtained from the micro-mixograph (at left).

EDMORE NORTH DAKOTA'S FIRST STRONG GLUTEN DURUM

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"Edmore" (CI 17748) is a durum wheat cultivar (variety) developed by the North Dakota Agricultural Experiment Station, North Dakota State University, in cooperation with Agricultural Research, Science and Education Administration, U.S. Department of Agriculture. Edmore is the first strong gluten durum released by the Agricultural Experiment Station, NDSU, and it represents the first cultivar developed following a change in quality requirements. Gluten strength gives superior cooking quality to various pasta products made from semolina. The addition of strong gluten to a previously high quality standard required a continuous 16-year plant breeding research effort. Edmore also represents major improvements in root rot resistance and kernel size. The availability of Edmore should increase the demand for North Dakota durum, particularly in the export market.

The development of a strong gluten durum wheat cultivar with high grain yield, adequate disease resistance and improved spaghetti quality has been one of the goals of the North Dakota durum improvement program

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for about 16 years. Strong gluten gives various pasta products made from semolina greater cooked firmness and tolerance to overcooking (1, 2). These superior cooking characteristics are in demand in the European export market. In the past, potential U.S. exports have been lost to Canada or Argentina because of the higher gluten strength of their cultivars (3, 4).

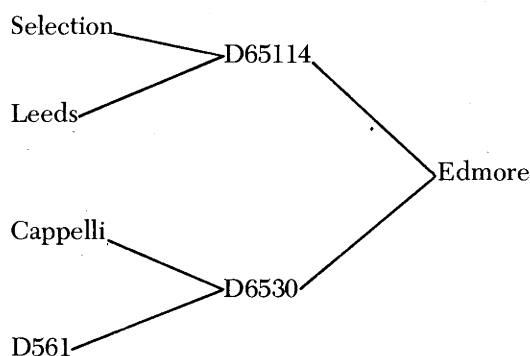
The name "Edmore" was taken from the city of Edmore, located in the prime durum production area of central Ramsey County, North Dakota.

Breeding History

Edmore was selected from the cross D6530/D65114 made in the greenhouse at Fargo in March 1968 (Figure 1). D6530 is a strong gluten North Dakota selection derived from a cross between Cappelli (an Italian cultivar with strong gluten) and North Dakota selection D561. D561 is a tall, stem rust resistant selection with good physical quality, high yield and lodging susceptibility. D65114 is a tall, high yielding, North Dakota selection from a cross between Leeds and a North Dakota semi-dwarf derivative involved in the parentage of Cando and Calvin. Leeds, Cando and Calvin are North Dakota-USDA cultivars released in 1966, 1975 and 1978, respectively.

The cross to produce Edmore was made to combine strong gluten with an adapted plant type having high grain yield, good physical quality, and disease resistance. Early selection through the F₅ generation was by the pedigree method and was done in four years by utilizing North Dakota and Mexico winter breeding nur-

Figure 1. Brief pedigree of Edmore durum wheat.



series. Edmore was bulked in the F₅ generation as an F₄-derived line at Casselton, ND, in 1971 and first entered in preliminary yield trials in North Dakota in 1972 as selection D7175.

Performance Trials

Edmore has been tested in North Dakota small plot trials since 1972, in regional trials in North Dakota, South Dakota, Montana, Minnesota, Manitoba and Saskatchewan since 1974; and in larger drill strip field plots at North Dakota Agricultural Experiment Stations since 1975. It also has been evaluated in national and international disease evaluation tests.

The grain yield of Edmore has been about equal to Ward and less than that of Cando when averaged over sites in North Dakota, western Minnesota, northern South Dakota, eastern Montana and Southern Manitoba and Saskatchewan (Table 1). Edmore is about equal to Ward in test weight and is superior to Ward and Cando in kernel weight. Edmore has been about one day earlier in heading and is slightly taller than Ward. Its average lodging resistance has been equal to Ward, but under severe lodging conditions, Edmore has been weaker than Ward and Rugby and about equal to Crosby and Leeds. Edmore has been about equal to Ward in disease resistance; however, it has had superior resistance to root rot (5).

Grain yields at various North Dakota stations during 1974-77 are summarized in Table 2. Over all stations, Edmore and Ward were essentially equal and below Cando. Edmore was superior to Ward at Langdon, below Ward at Fargo and essentially equal at other stations.

TABLE 1. Performance of Edmore and check cultivars grown in North Dakota, Minnesota, South Dakota, Montana and Canada, 1974-77.

Trait	Station years	Ward	Cando	Edmore
Agronomic				
Yield, bu/a	50	40.8	42.3	40.7
Test wt., lb/bu	48	60.8	60.2	60.6
Kernel wt., mg	22	41.3	39.0	45.2
Days to head	40	59.4	59.2	58.4
Height, cm	42	86.1	67.6	89.6
Lodging, 0-9	33	1.0	0.2	1.1
Disease*				
Stem rust, seedling		R	R	R
Stem rust, adult		R	R	R
Leaf rust, seedling		MR	S	MR
Leaf rust, adult		MR	MR	MR
Leaf spots, 0-9	29	1.7	2.0	2.0
Blackpoint		MR	MR	MR
Root rot		MS	MS	R

*R — resistant, MR — moderately resistant, MS — Moderately susceptible and S — susceptible.

TABLE 2. Grain yield of Edmore and check cultivars grown at North Dakota locations in 1974-77.

Location	Station years	Ward	Cando	Edmore
Langdon	7	49.6	54.7	52.7
Minot	7	48.2	54.2	48.7
Carrington irrigated	3	48.0	48.8	47.0
Carrington dryland	2	35.9	36.2	34.7
Williston	4	25.5	27.6	24.6
Dickinson	5	36.0	35.0	36.1
Fargo	2	43.8	43.8	41.0
All locations	30	42.3	45.1	42.7

TABLE 3. Range in reaction of five durum wheats to the stem rust fungus, *Puccinia graminis* f. sp. *tritici*, in North Dakota nurseries during 1974-78.

Cultivar	Location and range in cultivaral reaction*					Avg**
	Carrington	Minot	Langdon	Oakes	Fargo***	C.I.
Edmore	0	0	0	0	0	0.0
Rolette	0-R	0	0	0	0	0.1
Cando	0	0	0	0	0	0.0
Ward	0	0	0	0	0	0.0
Mindum	S	S	S	S	S	14.9

*0 = immune (no visible infection), R = resistant, S = susceptible. Dash equals range, first reaction predominate.

**Average coefficient of infection — average of the per cent of rust multiplied by reaction.

***Additional inoculum of races 15B and 151 applied at Fargo.

Disease Resistance

Edmore is resistant to numerous stem rust races in North America. It has shown resistance in seedling tests to race group 11-32-113, subraces of 151 and a composite of these races plus races 15B; 29, 38, 56 and 87. Edmore has excellent resistance to mutant race 15WL which is virulent on cultivars Lakota and Wells. Adult plants of Edmore have been immune or very resistant to all of the above races in greenhouse tests.

When exposed to naturally occurring stem rust races and additional inoculum of races 15B and 151 in the 1974-78 North Dakota Rust Nursery, adult plants of Edmore showed no infection and its response was similar to those of Rolette, Cando and Ward (Table 3). Its immune response did not change at Oakes under overhead irrigation or with flood irrigation at Carrington. Its resistance to 15B and 151 was confirmed in field nurseries in Puerto Rico. When grown in the 1975 International Spring Wheat Rust Nursery at 24 sites in 18 countries, Edmore was immune or very resistant to stem rust at 19 locations and susceptible at one location each in Chile, Pakistan, Iran, Kenya and Ethiopia. Its reactions at all locations were similar to those of Rolette and Ward except for Ward's immune reaction in Chile and Rolette's resistant reaction in Pakistan.

Edmore has been similar to Ward in leaf rust resistance in the seedling and adult stages and more resistant

than Cando in the seedling stage (Table 1). The reaction intensity to leaf spotting diseases has been low and Edmore ranks similar to Cando and intermediate among presently grown durum cultivars. Edmore has shown the highest level of resistance to root rot (primarily *Helminthosporium sativum*) organisms among currently used durum cultivars (5). The level of resistance is apparently equal to the best resistance among the currently grown hard red spring wheat cultivars. Reactions of Edmore to blackpoint (*Helminthosporium sativum*) and scab (*Fusarium culmorum*) have not been specifically evaluated; however, its reactions have appeared similar to those of presently grown cultivars.

Milling and Spaghetti Quality

Quality data for Edmore and three check cultivars (Ward, Cando and Rolette) were averaged over 15 field trials grown during the crop years 1975, 1976 and 1977 (Table 4). Edmore was slightly lower in test weight than Ward, Cando and Rolette. Wheat grade and vitreous kernel content were similar to those of the three checks.

Kernel distribution for Edmore showed a higher proportion of large kernels than the three check cultivars, and in general, was more similar to Rolette in kernel size. Average kernel weight was higher than those of Ward, Cando and Rolette.

TABLE 4. Average grade, milling and spaghetti quality data for Edmore, Ward, Cando and Rolette in 15 tests during 1975-1977.

Quality factor	Edmore	Ward	Cando	Rolette
Test weight, lb/bu	60.8	61.1	61.1	62.0
Grade, U.S.	1 HAD	1 HAD	1 HAD	1 HAD
Vitreousness, %	90	90	90	91
Kernel distribution, %				
Large	48	42	29	44
Medium	50	56	67	54
Small	2	2	4	2
Kernel weight, mg	45.8	40.9	38.3	43.1
Wheat protein, %*	15.3	14.9	14.1	15.4
Semolina protein, %*	14.3	14.0	13.1	14.3
Semolina yield, %	52.4	53.0	52.7	52.7
Semolina specks/10 in ²	24	17	17	24
Spaghetti color**	9.3	9.2	9.3	8.8
Spaghetti firmness, g cm***	6.0	5.4	5.1	5.1

*Expressed on a 14% moisture basis.

**Higher score indicates more yellowness.

***Higher value indicates firmer cooked spaghetti.

Wheat protein averaged 15.3%, which was higher than both Ward and Cando and similar to Rolette. An outstanding feature of this cultivar is its protein quality characteristics. The cultivars currently being grown in North Dakota have weak gluten. A representative semolina dough mixing curve of these cultivars, as determined by the micro-mixograph using 48% absorption and a spring setting of 8, is shown in Figure 2a. A comparison of this curve with that obtained for Edmore (Figure 2b), using the same operating conditions, clearly indicates a stronger mixing curve for Edmore with good mixing tolerance.

Experimental milling performance (semolina yield) of Edmore compared favorably with those of Cando and

Fig. 2a. A typically weak mixogram representative of currently grown North Dakota durum cultivars.

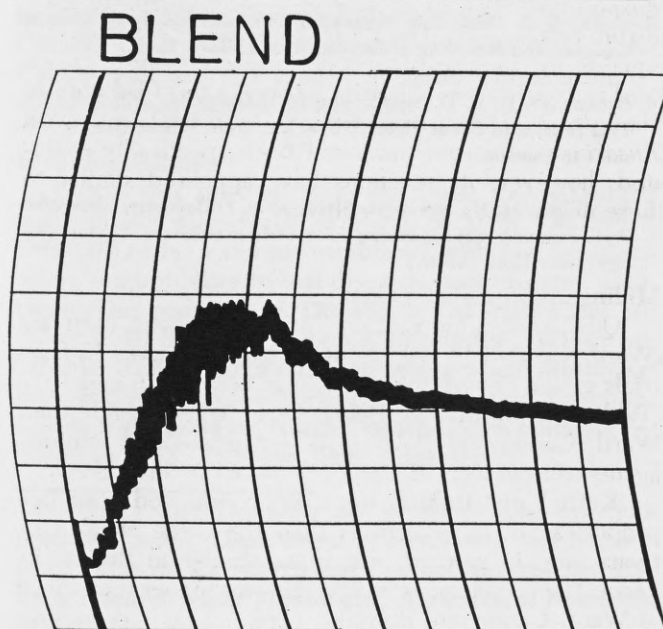
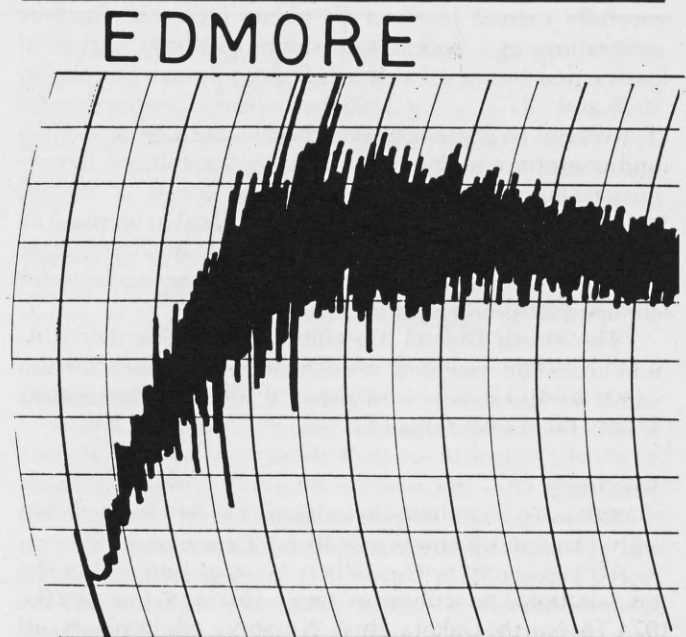


Fig. 2b. A typically strong mixogram representative of the Edmore durum cultivar.



Rolette, and was lower than Ward. No specific problems were encountered when milling this stronger gluten wheat. Semolina protein averaged 14.3%, a value similar to that of Rolette and higher than Ward and Cando. Speck count, which indicates the number of bran and dark particles present in the semolina, was the same as Rolette, slightly higher than Ward and Cando and well within acceptable limits.

No unusual problems were observed in processing Edmore semolina into spaghetti during the 3-year test period. In addition, no checking or cracking was observed in the dried spaghetti. Spaghetti color score of 9.3 for Edmore was similar to the 15-station averages for Ward and Cando and higher than Rolette. Spaghetti

cooking quality showed that Edmore had higher cooked spaghetti firmness than the three-check cultivars. This higher cooked firmness is, in part, a reflection of the stronger gluten characteristics of Edmore and represents a desirable cooking quality feature.

Botanical Description

Edmore is an awned, daylength sensitive, spring durum wheat cultivar, *Triticum turgidum* L. var. *durum* with the following botanical characteristics:

Stem: strong straw, usually white and about 90 cm tall.

Spike: awned, oblong, dense and erect.

Glumes: glabrous, white, midlong to long, midwide; shoulders narrow and elevated; beaks wide, acuminate and 3 to 5 mm long.

Awns: white and 8 to 18 cm long.

Kernels: amber, hard, midlong and elliptical; the germ midsized; the crease midwide and shallow; cheeks angular to rounded; and the brush very short (essentially none).

Seed Production

In 1975, about six bushels of Edmore breeder seed were produced at the Langdon Branch Station from a carefully rogued block of F₉ plants increased for four generations as a bulk from a single F₄ plant. This seed was further increased at North Dakota Branch Stations in 1976 and 1977. About 1100 bushels of clean seed were distributed to approved seed producers to grow in 1978 under contract to the North Dakota Agricultural Experiment Station. Other states also had access to limited supplies of the new cultivar, if they wished to increase it, in compliance with the policy of mutually sharing new cultivar seedstocks. Edmore durum will be available for commercial production in 1979.

The North Dakota Agricultural Experiment Station will maintain purified seedstocks of Edmore durum wheat for foundation seed growers as long as the cultivar is in commercial demand.

Summary

Edmore, a new durum cultivar, has been developed and released by the Agricultural Experiment Station, North Dakota State University, in cooperation with the United States Department of Agriculture. Edmore is the first strong gluten durum released by the Agricultural Experiment Station and represents a continuous research effort over a 16-year period. Edmore has been about equal to Ward and lower than Cando in grain yield

during the past four years over North Dakota and the northern plains and parts of Canada. Edmore is a normal height cultivar and also represents major improvements in kernel weight and resistance to root rot.

The quality characteristics of Edmore showed improvement in several factors over Ward, Cando and Rolette. This cultivar had good test weight, high vitreous kernel content, larger kernel size, high kernel weight, high protein content and excellent spaghetti color. Milling and spaghetti processing characteristics were excellent. The inclusion of strong gluten as an additional quality factor provides a cultivar that produces spaghetti with superior cooking characteristics. Edmore will provide durum producers in North Dakota an excellent quality wheat to assure millers, pasta processors and consumers (domestic and foreign) of high quality products.

Acknowledgements

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References

1. Matsuo, R. R., and G. N. Irvine. 1970. **Effect of gluten on the cooking quality of spaghetti.** Cereal Chem. 47:173-180.
2. Donnelly, B. J. 1977. **Durum research at NDSU: A progress report.** Macaroni J. 59(2):21, 24, 26, 27, 30.
3. Quick, J. S. 1973. **Trip report for International Symposium on Genetics and Breeding of Durum Wheat, Bari, Italy.**
4. Banasik, O. J., L. D. Sibbitt, and B. J. Donnelly. 1978 and 1979. **Trip reports to Great Plains Wheat Inc. from Wheat Quality Missions to Europe.**
5. McMullen, M. V., and R. W. Stack, 1978. **Differential susceptibility to common root rot among durum wheat cultivars.** Phytopathology News 12:89 (Abstr.).