

CANDO . . .

North Dakota's First Semidwarf Durum

J.S. Quick, J.D. Miller, B.J. Donnelly

'Cando' is a durum wheat variety (CI 17438) developed by the North Dakota Agricultural Experiment Station, North Dakota State University, in cooperation with the Agricultural Research Service, United States Department of Agriculture. This variety is the first semidwarf durum released by the Agricultural Experiment Station, NDSU, and it represents a continuous 20-year research effort. Cando is the first semidwarf durum variety to possess acceptable quality, disease resistance and agronomic performance for North Dakota. Its availability should allow durum production over a wider area, thereby providing a more stable supply of raw material for pasta production.

The development of a short-stawed (semidwarf) durum wheat variety with high grain yield, adequate disease resistance and acceptable spaghetti quality has been one of the goals of the North Dakota durum improvement program for about 20 years. It is estimated that perhaps 10 to 25 per cent of the North Dakota durum acreage could be planted to a semidwarf height type (1). Areas having high moisture and fertility similar to those utilized to grow semidwarf bread wheats would be suitable. The transfer of the short straw character from a North Dakota bread wheat selection to durum required several cycles of crossing, selection and testing. This hybridization program began in 1956 (2).

The name "Cando" is taken from the city of Cando, county seat of Towner county, the most intensive durum growing area in North Dakota. Soil and climatic characteristics of the Cando area may be typical of areas where a short stawed durum would be adapted.

Drs. Quick and Donnelly are associate professors, Department of Agronomy and Department of Cereal Chemistry and Technology, respectively, and Dr. Miller is plant pathologist, ARS-USDA, Fargo, ND.



Dr. James Quick inspects Cando durum growing in field plots at Fargo.

Breeding History

Cando was selected from the cross D65152/D6148 made in the greenhouse at Fargo in November, 1966. D65152 is D61130/Leeds, a durum semidwarf with low spaghetti color, leaf disease susceptibility and unstable grain yield. The pedigree of D61130 is Lakota/5/Willet sib// Norin 10/Brevor/3/Langdon/4/Langdon. Willet sib//Norin 10/Brevor is a hard red spring wheat semidwarf breeding line from the North Dakota Program. D6148 is Br180/Wells, a normal height, high yielding ND-USDA durum breeding line. Langdon, Lakota, Wells and Leeds are North Dakota-USDA varieties released in 1955, 1960, 1960 and 1966, respectively.

The cross to produce Cando was made to combine short straw with high grain yield, good quality and leaf 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 nurseries. Cando was bulked in the F₅ generation as an F₄ derived line in Mexico in 1970-71 winter, and first entered in preliminary yield trials in North Dakota in 1971 as selection D7057.

Performance Trials

Cando has been tested in North Dakota small plot trials since 1971, in regional trials in North

Dakota, South Dakota, Montana, Minnesota and Manitoba since 1972, and in larger drill strip field plots at North Dakota Agricultural Experiment Stations from 1973 to 1975. It also has been evaluated in national and worldwide disease evaluation tests.

The yield of Cando has been about equal to Ward and ranked higher than Rolette and Wells (Table 1) when grown at locations in the Red River Valley and northcentral North Dakota. Cando is a tall semi-dwarf (28 inches) with excellent lodging resistance. Disease reactions were similar to those of Rolette. Cando headed 1½ days later than Ward. The kernel weight of Cando has been intermediate between Wells and Ward, and its test weight has averaged about one pound per bushel less than Ward.

Grain yield, test weight, kernel weight and height are compared over different growing areas from the Red River Valley to western North Dakota in Table 2. Although precise statistical comparisons are not possible, there appears to be no major change in rankings for grain yield, test weight, kernel weight or height for the areas studied. Grain yields decreased for all varieties when grown in western North Dakota. Test weights were little affected by growing area.

Kernel weight and height of the varieties decreased when they were grown in western North Dakota. If the swathing method of harvesting is used, the height of Cando may be inadequate for growing in western North Dakota or under lower moisture conditions such as second or third crop in a 4-year rotation. Shorter height also would allow

greater weed competition. Grower experience will ultimately determine the area where Cando will be grown.

Disease Resistance

Cando has been resistant to numerous stem rust races in North America. In seedling tests it has shown resistance to subraces of race 151, race group 11-32-113 and a composite of races 15B, 29, 38, 56 and 87 (Table 3). Its moderately susceptible-resistant mixed reaction to orange mutant race 9 is similar to that of Leeds. Cando has good resistance to mutant race 15. Adult plants have shown a high level of resistance to all races listed in Table 3.

Adult plants of Cando inoculated artificially in the field were highly resistant to races 15B and 151 in the North Dakota Rust Nursery, and to races 113 and 139 in the Puerto Rico nurseries. When exposed to naturally occurring rust in the 1972-75 Uniform Regional Durum Nurseries, Cando was resistant at locations in North Dakota, South Dakota, Minnesota, Montana and Manitoba. Furthermore, when grown in the 1973 International Spring Wheat Rust Nursery in 21 countries, Cando was immune or moderately resistant to stem rust in all countries except Ethiopia, Kenya, Mexico and Turkey.

Cando has been similar to Rolette in reaction to leaf rust when evaluated in seedling and adult tests (Table 1). Its field resistance to leaf rust has been adequate for North Dakota and the northcentral U.S. The reaction intensity to leaf-spotting diseases has been low and ranks intermediate among presently grown durum varieties. The reactions of Cando to root-crown rot organisms, blackpoint

Table 1. Performance of Cando, Wells, Rolette and Ward grown at several locations in northcentral and northeastern North Dakota, Winnipeg and Crookston in 1972-75.

	Station years	Cando	Wells	Rolette	Ward
Agronomic					
Yield, bu/a	32	46.6	44.8	44.5	47.1
Test wt., lb/bu	32	59.6	61.0	61.7	60.7
Kernel wt., g/1000	17	37.8	34.4	43.2	40.4
Days to head	30	58.9	57.7	54.9	57.5
Height, in.	30	27.6	36.7	34.5	36.0
Lodging, 0-9	26	0.1	2.1	1.1	0.8
Disease*					
Stem rust, seedling		R	R	R	R
Stem rust, adult		R	R	R	R
Leaf rust, seedling		S	MS	S	MR
Leaf rust, adult		MR	MR	MR	MR
Leaf spots, 0-9	18	2.2	2.0	2.5	1.8
Blackpoint		MR	MR	MR	MR

*R-resistant, MR-mod. resistant, MS-mod. susceptible and S-susceptible.

Table 2. Performance by geographical area of Cando, Wells, Rolette and Ward grown at several locations in northeastern, north central and western North Dakota in 1972-75.

	Station years	Cando	Wells	Rolette	Ward
Yield, bu/a					
Red River Valley* and N. East ND	13	47.4	45.3	45.6	47.6
N. Central ND**	19	46.1	44.4	43.7	46.8
Western ND***	11	33.0	33.1	32.2	33.0
All	43	43.1	41.8	41.3	43.5
Test wt., lb/bu					
Red River Valley and N. East ND	13	60.0	61.2	62.3	60.9
N. Central ND	19	59.3	60.9	61.3	60.6
Western ND	11	60.2	60.3	61.4	60.3
All	43	59.7	60.8	61.6	60.6
Kernel wt., g/1000					
Red River Valley and N. East ND	5	37.4	34.5	43.3	40.3
N. Central ND	15	38.2	34.0	42.5	40.3
Western ND	8	31.3	30.6	37.8	36.4
All	28	36.1	33.1	41.3	39.2
Height, inches					
Red River Valley and N. East ND	11	28.1	37.0	34.7	36.7
N. Central ND	19	27.4	36.5	34.4	35.6
Western ND	9	24.1	32.2	31.4	31.6
All	39	27.6	36.7	34.5	36.0

*Includes tests at Fargo, Grand Forks, Garske, Cavalier, Park River, Crookston and Winnipeg.

**Includes tests at Langdon, Minot, Carrington irrigated, and Carrington dryland.

***Includes tests at Williston and Dickinson.

Table 3. Seedling reactions of four durum wheat varieties to the stem rust fungus, *Puccinia graminis* f. sp. *tritici*.

Variety	9**	Race and varietal reaction*			Composite***
		11-32-113	15**	151	
Cando	MSR	R	R	R	R
Ward	R	R	R	R	R
Leeds	RMS	R	R	R	R
Wells	MR	R	MS	R	R

*R-resistant, MR-mod. resistant, MS-mod. susceptible.

**The mutant cultures of orange race 9, moderately virulent on Cando and Leeds, and race 15, virulent on Wells, have not been found in the physiologic race survey in the United States.

***A composite of races 15B, 29, 38, 56 and 87.

(*Helminthosporium sativum*) and scab (*Fusarium culmorum*) have not been specifically evaluated; however, its reactions have appeared similar to presently grown durum varieties.

Milling and Spaghetti Quality

Quality data for Cando and three check varieties, Ward, Wells and Rolette, are averages of 16 field trials grown during the crop years 1973, 1974 and 1975 (Table 4). The test weight of Cando was similar to Ward and Wells but was lower than Rolette. The wheat grade of Cando was similar to the three check varieties.

Table 4. Average grade, milling and spaghetti quality data for Cando, Ward, Wells, and Rolette in 16 tests during 1973-1975.

Quality factor	Cando	Ward	Wells	Rolette
Test weight, lb/bu	60.6	60.7	60.9	61.6
Grade, U.S.	1 HAD 1	HAD 1	HAD 1	HAD 1
Vitreous kernels, %	91	90	88	89
Kernel distribution,				
Large	25	36	22	40
Medium	66	60	69	56
Small	9	4	9	4
1,000 kernel weight, g	35.6	38.3	32.9	40.4
Wheat protein, %*	14.5	15.1	15.0	15.7
Semolina protein, %*	13.4	14.1	13.9	14.6
Semolina yield, %	53.1	53.8	51.4	52.9
Semolina specks/10 in ²	21	17	17	19
Spaghetti color**	9.1	9.2	9.0	8.9
Spaghetti firmness, g cm***	5.0	4.9	5.0	4.7

*Expressed on a 14% moisture basis.

**Higher score indicates more yellowness.

***Higher value indicates firmer cooked spaghetti.

Cando had 91 per cent hard and vitreous kernels, which is acceptable for good milling properties and above the minimum requirement for "Hard Amber Durum". Cando had kernel sizes similar to Wells, with larger proportions in the small and medium category than Ward and Rolette. The average 1,000 kernel weight of the new variety was heavier than Wells but lighter than Ward and Rolette.

Wheat protein of Cando averaged 14.5 per cent and was lower than the three check varieties, but adequate for the production of good quality pasta.

The milling performance of Cando was good. In experimental milling studies, Cando produced a 53 per cent semolina yield, which was higher than Wells and Rolette, but lower than Ward. Speck count, which indicates the number of bran and dark particles in the semolina of Cando, was higher than

those of the check varieties but within the acceptable range.

Pasta processing performance of Cando was tested by extruding spaghetti made from the semolina obtained from 16 variety trials. During the three-year test period, no unusual processing characteristics were noted for either Cando or the check varieties. In addition, no cracks or checking were noted in the finished dried spaghetti. The color score for Cando averaged 9.1, indicating bright yellow spaghetti similar in appearance to spaghetti from Ward, and better than Rolette and Wells. Spaghetti cooking tests also showed that Cando had a cooked spaghetti texture similar to the three check varieties.

Botanical Description

Cando is an awned, spring durum wheat variety, *Triticum turgidum* L. var. *durum*, with the following botanical characteristics:

Stem: semidwarf, about 70 cm tall; strong straw, usually white, with slightly recurved peduncles.

Spike: awned, oblong, dense, erect.

Glumes: glabrous, yellow, midlong to long, midwide; shoulders narrow, elevated; beaks wide, acuminate, 3 to 4 mm long.

Awns: yellow, 6- to 16-cm long.

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

Seed Production

In 1972, 66 pounds of Cando breeder seed were produced from a carefully rogued block of F7 plants increased for two generations as a bulk from a single F4 plant. This seed was used for drill strip tests during 1973-75, and in 1975, 24 bushels of Cando breeder seed were produced at the Langdon Branch Station from a carefully rogued block of F8, F9 and F10 plants derived from the 1972 production and subsequent increases. Twenty-four bushels were seeded on 40 acres near Yuma, Arizona, in November, 1975. About 2,000 bushels of clean seed should be available from the Arizona increase for growing in 1976 by approved seed producers under contract to the North Dakota Agricultural Experiment Station. Other states also had access to limited supplies of the new variety, if they wished to increase it, in compliance with the policy of mutually sharing new variety seed stocks. Cando

durum will be available for commercial production in 1977.

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

Summary

Cando, a new durum wheat variety, has been developed and released by the Agricultural Experiment Station, North Dakota State University, in cooperation with the United States Department of Agriculture. Cando is the first semidwarf durum variety released by the Agricultural Experiment Station and represents a continuous research effort over a 20-year period. Cando has been about equal to Ward and ranked higher than Rolette and Wells in grain yield during the past four years over northeastern and north central North Dakota and the Red River Valley. Cando is a tall semidwarf with excellent lodging resistance and has been similar to Rolette in disease reactions. It is about 1½ days later in heading than Ward.

Milling and spaghetti processing characteristics of Cando were satisfactory when evaluated over a three-year period (1973-75) in North Dakota drill strips. The test weight and wheat and semolina protein of Cando were lower than Ward and Rolette; however, average semolina yield was higher than Wells and Rolette, but lower than Ward. Kernel distributions was similar to Wells. Spaghetti color was slightly higher than Wells and Rolette and slightly lower than Ward.

Acknowledgements

The authors are grateful to all cooperators who have contributed to the development of this variety. Several scientists, technicians and secretaries in the Departments of Agronomy, Cereal Chemistry and Technology, and Plant Pathology at NDSU, the Cooperative Rust Laboratory at St. Paul, Minnesota, the Agricultural Research Center, Beltsville, Maryland, the USDA Hard Red Spring and Durum Wheat Quality Laboratory at NDSU and the NDSU Branch Experiment Stations cooperated in the development of Cando. The winter increases of Cando at CIANO (Experiment Station), Ciudad Obregon, Sonora, Mexico, and near Yuma, AR, were accelerated through cooperation of the Crop Quality Council, Minneapolis, MN, the Mexican Ministry of Agriculture, CIMMYT and the Arizona Crop Improvement Association.

References

1. Quick, J.S. 1973. **Breeding for yield, quality, and disease resistance in durum wheat.** Proceedings of the Symposium on Genetics and Breeding of Durum Wheat, Bari, Italy. p 313-325.
2. Lebsock, K.L. 1963. **Transfer of Norin 10 genes for dwarfism to durum wheat.** Crop Sci. 3:450-451.