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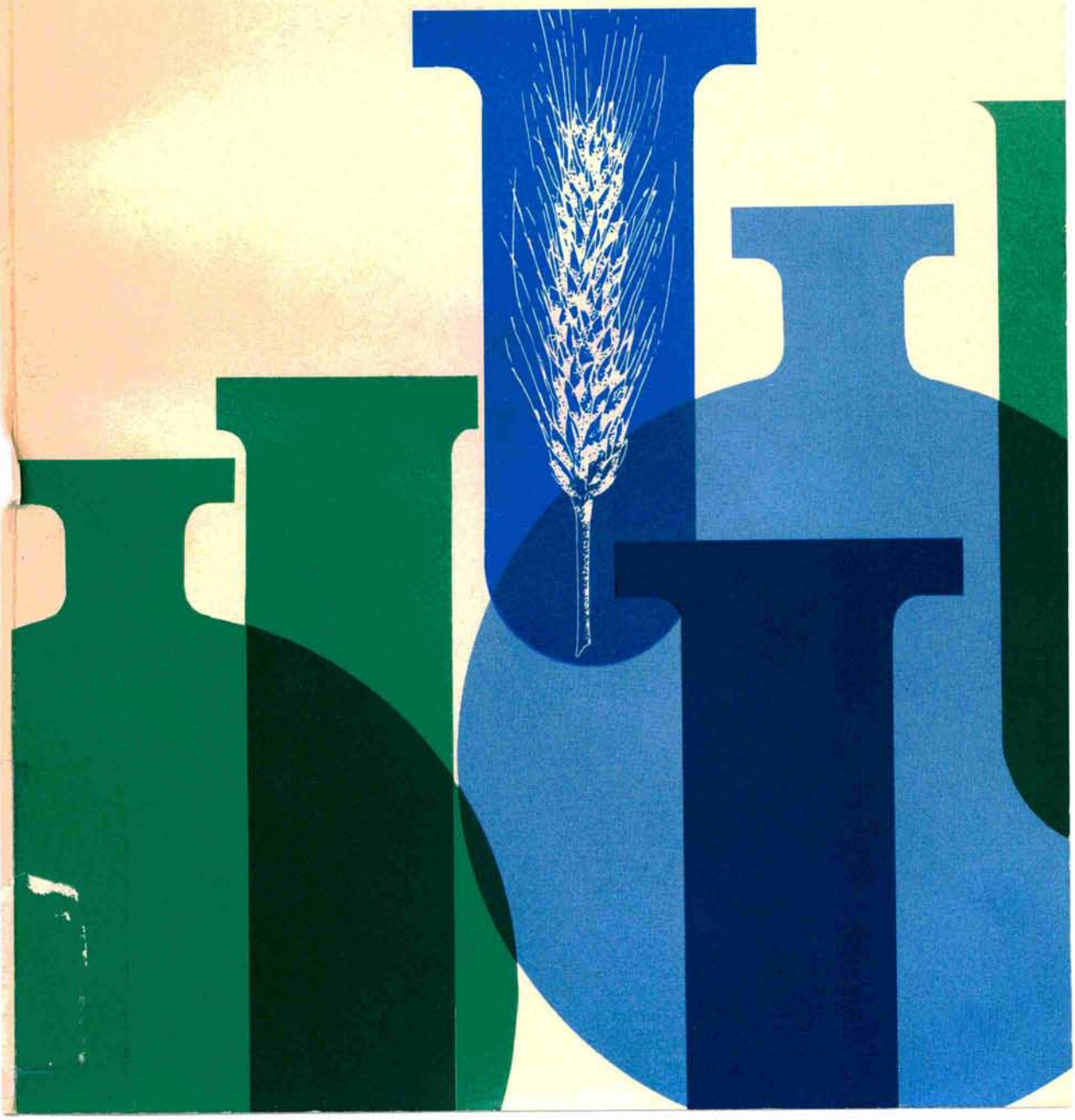
Editors: Reginald MacIntyre/Marilyn Campbell



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Editors: REGINALD MACINTYRE/MARILYN CAMPBELL

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Triticale: Its Potential as a Cereal Crop in the United States of America[1]

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Abstract Modern triticale varieties have been tested in the United States since 1967. With a few exceptions, the best-adapted wheat varieties have yielded more grain per acre than the best available triticale lines. This superiority was anticipated because very little effort has been devoted to the development of triticale varieties for use in the various climatic regions of the United States and particularly where the majority of the cereal grains planted are of the winter type.

Breeders have identified many characters in triticale that need improving. Among them are kernel conformation, floret fertility, tillering ability, standability, winter hardiness, disease resistance, and response to fertilizers. Triticale lines are available that are superior to present varieties in one or more of these characters; however, they are also deficient for certain of these characteristics as well. Therefore, if triticale is to be competitive with other cereal grains, plant breeders must concentrate on assembling in a variety the characters needed to ensure satisfactory production of varieties in a given locality.

Résumé Les variétés modernes de triticale font depuis 1967 l'objet d'essais aux Etats-Unis. A quelques exceptions près, les variétés de blé les mieux adaptées ont donné des rendements supérieurs à ceux des meilleures lignées de triticale disponibles. On prévoyait cette supériorité du fait des initiatives minimes qui ont été consacrées à la création de variétés de triticale utilisables dans les diverses régions climatiques des Etats-Unis, en particulier là où la majorité des céréales-grain utilisées sont du type des céréales d'automne.

Les obtenteurs ont répertorié chez les triticales un grand nombre de caractères nécessitant des améliorations, dont la conformation du grain, la fertilité des fleurs, les capacités de tallage, la densité de peuplement, la résistance au froid et aux maladies, la réponse à la fumure. Il existe des lignées de triticale supérieures par un ou plusieurs de ces caractères aux variétés actuellement utilisées, mais également déficientes relativement à certains de ces caractères. S'ils veulent que le triticale devienne concurrentiel par rapport aux autres céréales-grain, les phytosélectionneurs devront s'appliquer à réunir au sein d'une même variété les caractères permettant d'assurer en un lieu donné une production satisfaisante de variétés.

[1]Contribution of the Agricultural Research Service, U.S. Department of Agriculture, and the Agronomic Crop Science Department, Oregon Agricultural Experiment Station, Corvallis, Oreg. 97331.

IN the last decade triticale has been evaluated on an experimental basis at many experiment stations in the United States. Briggle (1968) summarized the data available in 1969 and concluded triticale had to be improved before it could compete successfully with wheat. All varieties and experimental lines available in 1969 had serious deficiencies including insufficient cold hardiness for fall planting, excessive lodging, low tillering capacity, reduced seed-set, shrivelled seeds, and poor disease resistance. Since 1969, plant breeders have retested many of the older selections and varieties. A few breeders have been devoting some effort to the development of new experimental lines. A portion of the information collected within the last 2 years by State Agricultural Experiment Stations and the Agricultural Research Service, U.S. Department of Agriculture, was utilized in preparing this report.

Summarization Procedure

The highest yielding triticale was compared with the highest yielding wheat, barley, oat, and rye included as checks in the same trial. Triticale grain, forage, and percentage of protein are expressed in percent of the check varieties. Test weight is stated in kilograms per hectoliter. Information obtained from 13 states was utilized in the preparation of this report.

Grain Production

Triticale produced about 87% as much grain as wheat when yields were averaged over all trials harvested in 1972 and 1973 (Table 1). Triticale planted in the fall produced 18% less grain than wheat, but when seeded in the spring it yielded 18% more grain than wheat. Under irrigation the best triticale line in each trial averaged 27% more grain than wheat.

Advanced experimental lines, selected for adaptation in northern California, from CIMMYT material were grown at Tulelake. The best line produced 27% more grain than the highest yielding wheat check (Table 1). Another group of lines obtained from crosses of cytoplasmic male sterile wheat/rye//6x triticale selected for adaptation in northern Texas was grown at Bushland. The best triticale line produced 11% more grain than the wheat check (Table 1).

Triticale grain yields ranged from 995 kg/ha at one location in Colorado to 11,087 kg/ha at Tulelake, California. In the same trials wheat produced 2283 kg/ha and 10,537 kg/ha, respectively.

Triticale was more competitive when compared with barley. In trials planted in the fall it produced more grain per hectare than barley (Table 1). The relationship was reversed in spring-seeded trials. When compared to barley checks, triticale grain yields ranged from 2186 kg/ha at Comfort, Texas, to 4810 kg/ha in an irrigation trial at Garden City, Kansas. Barley in the same trials produced 1173 kg/ha and 4581 kg/ha, respectively.

Triticale consistently produced more grain than rye (Table 1). It produced less grain than oats in spring-seeded nurseries, but more than oats in the one winter trial included in this summary (Table 1).

Grain Protein and Test Weight

Investigators in Kansas and Texas determined the percent grain protein of triticale lines and cereal checks harvested in 1973 (Table 2). In both states at least one triticale line produced more protein per hectare than the wheat, barley, and rye checks. Because kilograms of protein produced per hectare is the product of grain yield × percent grain protein, the triticale line chosen for comparison with the cereal checks was not necessarily the highest yielding nor the one containing the highest percentage of grain protein.

Triticale seeds are usually shrivelled and test weight is low in comparison with wheat and rye (Table 3). Through hybridization and selection breeders have gradually improved test weight. Simultaneously, grain protein has been reduced in many of the high test weight lines.

At Tulelake, California, one of the new selections produced 9890 kg/ha, which

TABLE 1. Grain yield of the highest yielding triticale included in each trial expressed in percent of wheat, barley, oats, and rye checks in trials conducted in 11 states.

Source	Crop year	No. trials	Wheat	Barley	Oats	Rye
			Fall-seeded			
Arkansas	1972	7	74			
Kansas	1972	10	89	168(1)[a]		130(5)
Kansas, irrigated	1972	2	121	105(1)		130(2)
Ohio	1972	1	76	71		
Oklahoma	1972	1	142	108	134	139
Arkansas	1973	2	67			
California	1973	4	83			
Colorado	1973	19	64			
Kansas	1973	1	75			332
Kansas, irrigated	1973	1	100			208
Louisiana	1973	1	70			
Oklahoma	1973	5	113			171
Texas	1973	4	80	172(1)		
Texas, Bushland	1973	2	111	86		
Average (%)			82	113	134	163
			Spring-seeded			
North Dakota	1972	2	89	74	97	
Ohio	1972	4			67	97(2)
Wyoming	1972	3	109			
Wyoming, irrigated	1972	2	146			
California, Tulelake	1973	1	121			
Indiana	1973	1	140	89	73	
Average (%)			118	79	76	97

[a]Numbers in parentheses are number of trials in which barley and rye were included as checks.

TABLE 2. Grain protein content of triticale, wheat, and rye grown in Kansas and Texas in 1973.

	Triticale	Wheat	%	Rye	%
		Kansas, irrigated			
Grain yield, *kg/ha*	2706	2712	100	1301	208
% grain protein	16.9	14.4	117	16.7	101
Protein yield, *kg/ha*	457	391	117	217	211
Test weight, *kg/hl*	58.7	77.6		68.5	
		Texas, advanced lines			
Grain yield, *kg/ha*	4143	3740	111	4797	86
% protein	17.0	15.7	108	13.4	127
Protein yield, *kg/ha*	704	587	120	643	109
Test weight, *kg/hl*	63.3	72.8		65.3	

weighed 68 kg/hl. Grain protein was not reported. At Bushland, Texas, Porter and Tuleen (1974) have increased test weight of some of their new hybrids without markedly reducing grain protein (Table 4). In Michigan, new winter-hardy triticales have been

TABLE 3. Average test weights of highest yielding triticale line and checks grown in yield trials.[a]

Source	Year	No. trials	Test weights (*kg/hl*) Triticale	Wheat	Barley	Oats	Rye
			Fall-seeded				
Kansas	1972	12	62	76	56(2)[b]		53(7)[b]
Arkansas	1973	1	59	79	58		
Colorado	1973	14	60	80			
Georgia	1973	2	59	70			65
Kansas	1973	6	64	74	57		52
Louisiana	1973	1	58	70			
Texas	1973	6	61	77			
Texas, Bushland	1973	1	63	73	65		
			Spring-seeded				
North Dakota	1972	1	66	77		39	
California, Tulelake	1973	1	70	79			
Indiana	1973	1	58	74	57	46	

[a]*Official test weights*
Wheat 77.4 kg/hl (60 lbs/bu)
Rye 72.2 kg/hl (56 lbs/bu)
Barley 61.9 kg/hl (48 lbs/bu)
Oats 41.3 kg/hl (32 lbs/bu)

Test weight, unofficial
Triticale 67.1 kg/hl (52 lbs/bu)

[b]Numbers in parentheses are number of trials in which barley and rye were included as checks.

developed (Table 4). They have plump seeds and acceptable test weights, but grain protein is low in comparison with the Texas lines. This difference may be in part related to climatic conditions. Daily average temperatures during the grain maturation period are usually lower in the north-central states in comparison with those observed in northern Texas. The genetic potential for grain protein production of the Michigan lines may have been influenced adversely by the relatively low temperatures.

TABLE 4. Relationship between test weight and percent grain protein in winter triticale lines grown in Texas and Michigan in 1973.

Variety or selection	Yield *kg/ha*	Test weight	% grain protein
	Bushland, Texas		
27042-45 Triticale	4143	63.3	17.0
27053-53 Triticale	3195	57.1	16.7
Centurk Wheat	3740	72.8	15.7
	Lansing, Michigan		
MSU #4 Triticale	4378	68.6	12.4
MSU #2 Triticale	4123	65.2	12.2
6TA610 Triticale	4075	59.7	13.6

Forage Production

Triticale produced slightly more forage per hectare than wheat, barley, oats, and rye in 1972 (Table 5). It was less competitive in the trials conducted in 1973. Unfortunately total dry matter production is less important than is the distribution of production throughout the growing season, rate of regrowth, cold hardiness, and seed production. Specific varieties of wheat, barley, rye, and oats possess more desirable combinations of these characteristics than do the best available triticale lines. Both public and private breeders are devoting considerable effort to the development of forage types that possess the necessary attributes.

TABLE 5. Forage yield of the highest yielding triticale included in each trial expressed in percent of wheat, barley, oats, and rye checks in trials conducted in five states.

Source	No. trials	Wheat	Barley	Oats	Rye
		1972 crop year			
Arkansas	3	115		108	87
Kansas	1	119	142		86
Oklahoma	1	98	97	86	82
Texas	10	105	170(7)[a]	126(9)	112(8)
Texas, irrigated	2	116	95(1)	106(1)	93(3)
Average		108	152	120	102
		1973 crop year			
Arkansas	3	119	70	94	85
Georgia	1	75	95	67	62
Oklahoma	4	94	101(10)	116	82
Texas	11	103	98	103	102
Average		102	98	102	93

[a]Numbers in parentheses are numbers of trials in which barley, oats, and rye were included as checks.

Future for Triticale

Research conducted by the International Maize and Wheat Improvement Center (CIMMYT), Mexico, in Canada, Europe, and the United States indicates the germ plasm for producing high-yielding adapted triticale varieties is available. In the United States most of the plant breeders have been testing lines developed outside the United States or by the Jenkins Foundation for Research, Salinas, California. Public breeders in California, Oregon, and Texas have been devoting some effort to the development of new types. Through hybridization and selection within their new crosses and in CIMMYT material, they have improved self-fertility, grain yield, and test weight. Yet the lines available today are merely building blocks that will be used to produce crosses for another cycle of selection.

During the last few years California breeders have produced new wheat × rye crosses that will be utilized in their breeding program. Porter and Tuleen (1974) are growing male sterile wheats in blocks surrounded by ryes. The best of their new triticale lines were obtained from some of the resulting cytoplasmic male sterile wheat/rye//6x triticale crosses. Some of these lines are self-fertile. They have shown that rye carries gene(s) for restoration of fertility of male sterile wheat/rye hybrids that carry *T. timopheevi* cytoplasm.

If the potential triticale may have as a feed and food is to be realized in the foreseeable future in the United States, far more effort must be devoted to its improvement. Plant breeders throughout the world must be encouraged to follow the CIMMYT policy of making their germ plasm available to other breeders. Through such changes breeders will be able to obtain the genetic variability needed to develop suitable varieties.

Acknowledgments

Data summarized in this report were obtained from State and Federal plant scientists in 13 states: Arkansas, California, Colorado, Georgia, Indiana, Kansas, Louisiana, Michigan, North Dakota, Ohio, Oklahoma, Texas, and Wyoming.

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