



Technology Licensing Opportunity: Advanced durum lines

Durum is a type of wheat that is very high in protein, low in gluten, and dense. It is often considered to be one of the most nutritionally significant forms of wheat. Durum in Latin means "hard", and the species is the hardest of all wheat. Its high protein content, as well as its strength, make durum good for special uses, the most well-known being pasta. Pasta made from durum is firm with consistent cooking quality. Also unique to durum is its yellow endosperm, which gives pasta its golden hue. Durum thrives in a climate characterized by cool summer nights, long warm days, adequate but not excessive rainfalls and a dry harvest. Durum is planted between mid-April and the end of May, and harvested in August or September. The domestic market accounts for two-thirds of demand for U.S. durum supplies, while the export market accounts for one-third. About 20 countries purchase U.S. durum and Europe is the single largest importer of U.S. durum, followed by African and Middle East markets, and Latin and South America.

Offering: With the pending retirement of Dr. Joyce Eckhoff, Montana State University is seeking a company to license lines of durum wheat in her research and development program. In this brief, we provide an overview of the emphasized traits, a list of all the lines available with agronomic data and pedigree. Please note that while most of the lines have data including protein and sedimentation rate, none have yield data. These lines have been grown only under irrigated conditions at the Eastern Ag Research Center (EARC) in Sidney, MT. Many of the crosses are from North Dakota, Canadian and private varieties. Yield and trait data for those varieties, by district, can be viewed at <http://plantsciences.montana.edu/documents/crops/2013data/2013SpringWheatVarieties.pdf> beginning on page 15.

Synopsis of lines available for license:

No. of lines	Description	Advanced to
75	Ug99 resistant x low-cadmium	F ⁵
20	Solid-stem	F ⁸
12	Solid-stem	F ⁷
9	Solid-stem	F ⁶
202	Low cadmium lines	F ⁹

MSU has heads from each of these entries from which head rows can be grown. The University also has bulk seed of most lines ranging from 30-100 gm of seed of each.

Agreement Structure: Companies interested in securing rights to the lines included in this overview should fill out the attached Option Term Sheet. Under the Option Agreement, the option holder would have a period of time to further develop the lines and determine the most appropriate for licensing. The option will be offered exclusively to one party. If there are questions that MSU can address please contact Gary Bloomer, MSU Technology Transfer Office, 406-994-7483 or gary.bloomer@montana.edu.

Emphasized Traits:

1. Low cadmium: Cadmium has been classified as a carcinogen to humans. Even moderate environmental exposure to cadmium through diet is linked to cancer through a higher risk

of endometrial, breast and prostate cancer and well as osteoporosis. Food is the second biggest source of exposure to cadmium behind cigarettes. High quantities of cadmium can be found for example in crustaceans, mollusks, organ meats, and algal products. However, due to the higher consumption the most significant contributors to dietary cadmium exposure are grains, vegetables, and starchy roots and tubers. The use of fertilizers as well as environmental conditions increase the uptake of cadmium in wheat.

2. Ug99 Resistance: While Ug99 (African Stem Rust) is not in the US at this time, its quick spread throughout Africa and the Middle East has put US authorities on alert. USDA ARS is advocating the development of Ug99 resistant varieties and the elimination of susceptible varieties. Development of resistant varieties is further enhanced by a call for increased varietal diversification.
3. Stem Solidness: These lines should be more resistant to lodging either from high inputs of water and nitrogen as well as from pest pressure including sawflies. Solid stemmed varieties are filled with pith, especially in the lower parts of the plant. This inhibits larval development and slows the movement of the larvae within the stem, resulting in increased larval mortality. One research study indicated that larval mortality was about 28% in hollow stems and about 67% in solid stems. Although past reports suggested durum wheat varieties were rarely attacked, some durum varieties appear to be as susceptible as some spring wheat varieties.

Parentage descriptions:

Alzada - Developed from the cross 'Mohawk/Kofa' and released in 2004 by WestBred, LLC. Alzada was tested extensively by WestBred, LLC trials in Arizona and in irrigated and dryland Pacific Northwest locations prior to testing in the MSU statewide trials. Alzada is an early, non-daylength sensitive durum that produces yields combined with very high quality grain when grown in northern durum areas. Alzada is a semi dwarf variety with excellent straw strength, good tolerance to sawfly and a good foliar disease package. Alzada has medium protein levels and with strong gluten characteristics, it produces a bright yellow semolina from which high quality durum products can be made. <http://www.sarc.montana.edu/MWBC/documents/mwbc/2013/StatewideDurum.pdf>

Commander - This variety is adapted to the durum production area of the Canadian prairies. It combines high yield, high grain pigment concentration, and very strong gluten properties. Commander is a semi dwarf with strong straw, and has similar maturity and disease resistance to other registered durum cultivars. <http://pubs.aic.ca/doi/pdf/10.4141/P04-189>

Lloyd - Lloyd is an awned, daylength sensitive, spring durum wheat cultivar, with the following botanical characteristics:

- Stem: semi dwarf, about 70 cm tall; strong straw, usually white, with slightly recurved peduncles.
- Spike: awned, oblong, dense, and erect.
- Glumes: glabrous, white, midlong to long, mid wide, shoulders narrow and elevated; beaks wide, acuminate and 3 to 4 mm long.
- Awns: white, 6 to 16 cm long.

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

Lloyd was developed and released by the Agricultural Experiment Station, NDSU, in cooperation with the USDA. It has demonstrated a yield advantage over Cando when grown in central and western North Dakota. The yield of Lloyd in eastern regions was less than Cando. Lloyd has white awns and glumes and a test weight and kernel weight superior to Cando. Disease resistance has been very good and resistance to root rot is superior to Cando and similar to Vic, The quality characteristics of Lloyd are very similar to the strong gluten, high quality cultivar Vic, Increased cooked spaghetti firmness is the most significant improvement in cooking quality over Cando. http://library.ndsu.edu/tools/dspace/load/?file=/repository/bitstream/handle/10365/5543/farm_41_02_02.pdf?sequence=1

Composite Cross 4 (CC4) is a male sterile facilitated recurrent selection population. It was developed from CC1 which is a population developed from a bulk of several populations of unknown parentage developed by Rex Thompson at the University of Arizona. The population was first grown at the EARC in 1987. This population has been maintained annually at the EARC since 1996 by crossing varieties adapted to the area onto male sterile plants, and by harvesting seed set on male sterile plants. Varieties used in these crosses are Kyle, Plenty, Renville, Crosby, Medora, Sceptre, Voss, Ben, Cortez, Mountrail, AC Avonlea, Munich, AC Navigator, Plaza, AC Morse, Lebsock, Maier, AC Pathfinder, Lloyd, Commander, Alkabo, Divide, Grenora, Alzada, and Strongfield. In 2005, 95 lines from the World Collection of durum were identified as having solid or semi-solid stems. These lines were crossed onto CC1 and the resulting population was labeled CC4. The table World Collection4 contains the lines that were used to develop CC4. The Montana lines MT06541 and MT06543 used in some crosses were selections from CC1 that had semi-solid stems.

CIMMYT Lines

Pedigree for CIMMYT lines:

CIMMYT#4: GLAS_5/LOTUS_4//SOMBRA_20

CIMMYT#5: KITTI_1/DUKEM_4//5*KITTI_1/3ADAMAR_15

CIMMYT#7: LOTAIL_6/BUSCA_3

CIMMYT#8: MUSK_3//TPAA/AUK/3/PLATA_18

CIMMYT#12: RCOL/PLATA_2

CIMMYT#14: BRAK_2/AJAIA_2//SOLGA_8

Durum Statewide Trial – 2009

<http://www.sarc.montana.edu/mwbc/documents/mwbc/2009/09StatewideDurum1.pdf>

Averages, across sites (Bozeman, Huntley, Moccasin, Havre, Conrad, Sidney irrigated, Sidney dryland, Williston, ND)

entry	Heading*	Height, cm	Test wt, lb/bu	Grain protein, %	Yield, bu/ac	semolina extract, %	semolina color	mixograph pattern
Mountrail	67.9	75.0	61.1	13.80	57.1	66.2	22.6	3.0
Divide	67.7	76.4	61.3	13.52	55.3	66.1	25.8	5.7
Alzada	64.2	65.0	61.3	13.67	48.3	67.7	25.9	7.3
Strongfield	67.6	74.9	61.4	14.00	58.4	65.8	26.2	6.1
Cimmyt#5	66.4	57.8	61.1	12.34	57.1	64.4	23.5	5.7
Cimmyt#8	67.4	61.9	62.5	11.64	61.7	65.9	23.0	4.7

Durum Statewide Trial – 2010

<http://www.sarc.montana.edu/MWBC/documents/mwbc/2010/10StatewideDurum.pdf>

Averages, across sites (Bozeman, Huntley, Moccasin, Havre, Conrad, Sidney irrigated, Sidney dryland, Williston, ND)

entry	Heading	Height, cm	Test wt, lb/bu	Grain protein, %	Yield, bu/ac	semolina extract, %	semolina color	mixograph pattern
Mountrail	68.5	91.7	60.0	12.49	59.3	64.4	24.2	2.6
Divide	68.3	93.0	60.5	12.32	60.4	64.3	27.2	4.9
Alzada	65.5	75.0	59.3	12.49	51.9	64.9	29.6	7.6
Strongfield	68.8	91.8	60.2	12.55	62.5	62.8	28.0	5.8
Cimmyt#5	67.6	68.8	58.7	12.18	58.2	62.3	25.4	4.9
Cimmyt#8	68.1	72.7	60.7	11.94	60.0	64.1	24.8	4.7

Syrian lines

Data from CIMMYT/ICARDA – 2000 – 2001 Durum Observation Nursery – Mediterranean Dryland

Line	Name or Cross/Pedigree	FAO Status	Seed Source
Syrian 7	Haurani (check), Turkey, ACNO & IVNO: 166459	D	DAT00N 107
Syrian 38	Ossl-1/4/MrbSH/3/Rabi//Gs/CR/5/Mbar ICD96-0746-C-3AP-0AP-3AP-0AP	U	DPT00N 913
Syrian 65	Artisan/3/Lahn//Gs/Stk/4/Brch ICD94-0422-T-3AP-0AP-3AP-0AP-1AP-0AP	U	DPT00N 1118

U=Undesignated, D=Designated

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Additional sources for this overview:

<http://www.efsa.europa.eu/en/efsajournal/pub/2551.htm>
<http://www.ndwheat.com/buyers/?ID=295>
http://www.sarc.montana.edu/mwbc/scripts/2000_mwbc.html
<http://www.wisegeek.org/what-is-durum-wheat.htm>
<http://www.sarc.montana.edu/MWBC/MWBC14V150208A.html>
<http://www.agriculture.gov.sk.ca/Default.aspx?DN=f9423245-0426-441b-b49b-4b2bf4c8f75c>