HIGHER PROTEIN MILLING OAT FOR SASKATCHEWAN

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INTRODUCTION

A major objective of the CDC oat breeding project is to develop genotypes with improved market end-use quality for the U.S. market. Historically, Canadian oat has excellent milling quality, but relatively lower groat protein concentration than American oat. A moderate (1.0 - 2.0%) increase in groat protein concentration without a loss of physical grain quality or yield potential is our goal. Based on reports at the 3rd International Oat Conference (1,2) and one subsequent report (3), it was decided to utilize protein donor materials derived from Avena sterilis and A. maroccana. Four A. maroccana derived A. sativa lines were obtained from the Welsh Plant Breeding Institute and twenty A. sterilis derived A. sativa lines were obtained from Iowa State University. These and other foreign introductions have been evaluated for protein concentration and other important quality and agronomic traits over four years (1989-1992) at Saskatoon.

MATERIALS AND METHODS

Materials were grown at Saskatoon and evaluated for groat protein concentration as follows:

1989. Unreplicated groups of four hill plots each of 20 A. sterilis derivatives and 4 A. maroccana derivates and unreplicated yield trial plots of 50 introductions from the USSR, Czechoslovakia, Sweden, Wales, U.S.A., Norway and Germany.

1990. Two replicate hill plot test, two locations, 32 genotypes: 10 local checks, 4 A. maroccana derivatives, 11 selected A. sterilis derivatives and 7 foreign cultivars. Unreplicated yield trial plots of 27 introductions.

1991. (a) Two replicate yield trial, two locations, 25 genotypes: 7 local chks, 2 A. maroccana derivatives, 11 A. sterilis derivatives, 3 U.S. and 2 Welsh varieties. (b) 39 F5 lines from A. maroccana derivative/local line hybrid in unreplicated yield trial plots. (c) 94 F5 lines from A. maroccana derivative/local line hybrid and 66 F5 lines from local line/Otee hybrid in hill plot trials.

1992. (a) The 1991 two site replicated trial was expanded to 36 entries including: 7 local checks, 2 A. maroccana derivatives, 11 A.sterilis derivatives, 4 U.S., 2 Welsh, and 2 Norwegian genotypes and 8 CDC breeding program selections. (b) 19 F6 lines from A. maroccana derivative/local line hybrid, 40 F6 lines from OT334/Otee(USA) hybrid, 29 lines from SO87151/A85012(Nor) hybrid and 34 lines from OT327/Diadem(Czech) hybrid in unreplicated yield trial plots. (c) 2,117 F5 and F6 lines from various crosses with high groat protein parents in hill plot trials.

RESULTS AND DISCUSSION

1989. Initial evaluation of the A. sterilis derivatives were encouraging and, based on protein concentration and agronomic features, 11 genotypes were selected for further evaluation. While A. maroccana derivatives were not as high in protein, other interesting features of these materials encouraged continued evaluation. Eight of 50 introductions demonstrated higher protein combined with acceptable agronomic features and were selected for 1990 trials.

1990. Detailed evaluation confirmed the higher protein concentration of all A. *sterilis* derivatives, 1/4 A. *maroccana* derivatives and several introduced genotypes as compared to the dominant Canadian varieties Calibre and Cascade (Table 1). In addition, 10/11 *sterilis* lines and the U.S. varieties Otee and SN404 demonstrated significantly higher protein concentration than the local "high" protein check, Riel. The higher protein of five foreign introductions was confirmed (Table 2).

Table 1. Groat Protein Concentration of Selected Oat Genotypes as Grown at Two Locations, 1990

Name	% Prot.	Name	% Prot.	Name	% Prot.	Name	% Prot.
Calibre	16.3	David	16.9	J762.1	20.6**	J740-3	20.4**
Cascade	16.2	Av2402/2	16.7	J773.3	20.6**	J794-4	20.9**
Riel	17.9*	Av2402/4	16.9	J758-3	21.8**	J829-3	19.1*
Otee	20.6**	Av2027/3/1/27	18.4*	J756-3	21.1**	L966-3	20.1**
Maldwyn	18.8*	Av2027/3/1/32	17.4	J775-1	20.2**	Std error	0.42
Elen	19.0*	J756-1	21.4**	J706-1	20.6**		

* Significantly greater than $\bar{X}$ of Calibre and Cascade by LSD at P = 0.05. LSD = 0.82.
** Significantly greater than Riel by LSD at P = 0.05.

Table 2. Groat Protein Concentration of Selected Foreign Oat Genotypes, Saskatoon, 1990

Name	Origin	% Protein	Name	Origin	% Protein
Calibre	CAN	18.2	Maldwyn	WAL	21.6
Cascade	CAN	18.7	Sv38529	SWE	20.1
Karhu	FIN	20.2	David	CZE	19.5
Leila	NOR	20.4			

1991. All A. *sterilis* derivatives and the A. *maroccana* derivative Av2027/3/1/27 continued to demonstrate significantly higher protein concentration compared with the cultivars Calibre and Cascade, as did all selected introductions (Table 3). As in 1990, the same genotypes, plus Av2027/3/1/27, were higher in % protein than the "high" protein check Riel.

Table 3. Combined Analysis, Oat Yield Trial, RCBD, 2 Reps at 2 Locations, 1991

Name	Gr. Yld. (kg/ha)	% Prot.	T.wt. (kg/hl)	Kernel wt. (mg)	% Plp.	Mat. Score†	Prot. Yld. (kg/ha)
Calibre	4815	16.0	56.5	37.5	70	4	770
Derby	5289	15.0	57.3	39.5	76	4	793
Cascade	5434	15.9	54.9	35.1	63	3	864
Riel	4728	17.7*	55.3	37.1	63	4	837
Otee	3161	21.5**	54.8	29.1	46	1	680
Maldwyn	4239	18.4*	54.3	25.7	29	2	780
Elen	5028	17.9*	51.9	27.4	30	4	900
Trucker	3862	18.1*	58.2	35.2	71	2	699
SN404	3802	20.5**	55.6	29.1	37	4	779

Av2027/3/1/27	3608	19.4**	52.6	31.2	60	4	700
Av2027/3/1/32	5229	16.8	52.0	30.9	47	4	878
J706-1	3751	21.0**	52.9	31.3	37	2	788
J740-3	3921	20.1**	52.9	34.8	49	3	788
J756-1	3886	21.6**	55.9	33.5	53	1	839
J756-3	3383	20.0**	54.9	30.2	49	1	677
J758-3	3568	22.1**	55.1	33.8	59	2	789
J762-1	3706	21.4**	54.3	34.8	56	2	793
J773-3	3728	22.1**	55.3	33.2	49	1	824
J775-1	4926	20.4**	53.6	31.0	35	3	1005
J794-4	3559	20.8**	55.7	31.3	53	2	740
J829-3	4540	18.4*	54.2	35.2	60	4	835
L966-3	3327	21.1**	47.5	29.2	18	3	702
Std. error	285	0.7	1.0	1.5	9.2	-	-

* Significantly greater $\bar{X}$ of Calibre and Cascade, P = 0.05
** Significantly greater than Riel, P = 0.05
† 1 = earliest

1992. (a) Replicated trial (Table 4). The results for the materials repeated from 1991 were consistent with J775-1 and J829-3 performing best among the *A. sterilis* derivates; Av2027/3/1/27, Otee and SN404 demonstrating higher protein than all checks including the high protein check Riel, and other introductions showing protein equal to Riel, i.e. greater than the other checks. The generally poor physical grain quality of these materials was unfortunately also corroborated. The first year entries 82Ab1142 (USA), A4013 and A85012 (Norway) and 5 of 8 CDC selections demonstrated improved protein, equal to Riel. The US genotype demonstrated the usual poor grain quality, however, the Norwegian lines, while having small less plump grain had good hull percentage and test weight. In addition the yield level of both was very encouraging considering their early maturity. Of the CDC lines S090175 and SO91051 performed well enough to be advanced, although the hull percentage for SO90175 is a concern.

Table 4. Combined Analysis, Oat Yield Trial, RCBD, KCRF and Goodale, 1992

Name	Gr. Yld. (kg/ha)	% Prot.	T.wt. (kg/hl)	Kernel wt. (mg)	% Plp.	% Hull	Mat. Score†	Prot. Yld. (kg/ha)
Calibre	6875	15.6	52	38	53	23	5.5	826
Derby	6348	14.3	52	39	75	22	5.0	708
Cascade	6593	14.5	50	39	59	25	4.5	717
Dumont	6269	15.2	50	42	76	23	4.5	734
Waldern	6475	15.0	50	47	85	25	5.8	728
Riel	5698	17.1*	49	36	37	21	4.8	770
Jasper	5986	16.3	52	35	27	23	2.8	751

Otee	3897	20.3**	49	30	8	26	1.5	585
Maldwyn	5584	17.8*	49	29	3	24	4.3	755
Elen	5900	17.7*	47	31	6	26	6.0	773
Trucker	4892	17.5*	52	36	52	22	3.0	668
SN404	4402	21.3**	48	30	7	28	5.8	675
Av20-27	3708	18.6*	45	34	31	24	4.5	524
AV20-32	5717	16.9	50	33	30	24	3.3	734
J706-1	4926	21.7**	46	31	4	25	2.5	802
J740-3	5153	20.4**	47	35	16	24	3.3	799
J756-1	4699	22.9**	49	33	14	27	2.8	786
J756-3	4603	21.6**	49	33	8	27	2.5	726
J758-3	4716	21.8**	49	33	18	28	2.5	740
J762-1	4690	21.6**	46	35	19	26	3.3	750
J773-3	4645	21.4**	49	33	10	26	2.3	736
J775-1	5693	19.7**	46	32	10	26	5.0	839
J794-4	4942	20.9**	48	32	11	26	3.0	764
J829-3	5789	19.4**	49	34	22	26	4.8	831
L966-3	4028	19.6**	43	31	9	25	4.0	592
82Ab1142	4945	18.3*	48	32	6	25	4.3	679
S089061	5919	17.1	50	40	79	21	4.0	800
S090175	5532	18.2*	52	38	53	27	3.5	735
A85012	5559	18.3*	50	33	22	24	1.5	773
A4013	5943	18.1*	50	34	7	24	1.8	818
S091051	5797	17.6*	51	48	90	23	3.3	786
S091202	5247	18.2*	49	43	75	23	4.0	735
S091227	6450	16.8	50	45	66	28	5.5	780
S091236	6198	16.6	51	35	16	25	2.8	772
S091256	6539	16.3	51	33	10	24	3.5	810
S091301	5547	17.5*	50	37	47	23	4.0	747
Std. error	323	1.1	1	1	8	0.7	0.8	-

* Significantly greater $\bar{X}$ of Calibre and Cascade, P = 0.05
** Significantly greater than Riel, P = 0.05
† 1 = earliest

(b) Unreplicated yield plot evaluations. For the 16 *A. maroccana* derived sib-lines, protein ranged from 15.8 to 19.8%, with > 19.0% considered a significant improvement. None of the 4 of the 16 lines with this protein level performed well agronomically. 17 of the 40 OT334/Otee selections demonstrated % protein > 19.0%, with 4 lines in excess of 22.0% (approximately 30% > checks). Four lines combined reasonable performance and grain quality with this improved protein (Table 5). Three of the 29 selections evaluated from the SO87151/A85012(Nor) cross had % protein > 19.0% and, with the exception of plumpness, had reasonable performance (Table 6). Three of the 34 OT327/Diadem lines demonstrated % protein > 19.0% and of these SO92377 looks very promising as it demonstrated premium test weight and grain plumpness, good hull percentage and apparent high yield potential (Table 7).

Table 5. Grain Yield, % Groat Protein and Agronomic Data for Checks and OT334/Otee Selections, KCRF, POYT #2 and POYT #10, 1992

Name	Gr. Yld. (kg/ha)	% Prot.	T.wt. (kg/hl)	Kernel wt. (mg)	% Plp.	% Hull	Mat. Score
POYT #2							
Derby	4925	15.3	50	40	61	20	5
Jasper	4744	16.9	49	36	24	22	3
S092005	4564	19.3	49	34	12	25	3
S092008	4705	20.7	50	34	11	26	6
POYT #10							
Derby	4523	16.0	48	41	69	19	5
Jasper	4426	19.4	48	35	18	24	3
S092254	4957	22.2	49	40	20	29	5
S092259	4327	19.6	45	40	75	25	6

Table 6. Grain Yield, % Groat Protein and Agronomic Data for Checks and S087151/A85012 Selections, KCRF, 1992

Name	Gr. Yld. (kg/ha)	% Prot.	T.wt. (kg/hl)	Kernel wt. (mg)	% Plp.	% Hull	Mat. Score
Derby	4725	16.4	49	39	61	22	5
Jasper	4696	19.3	48	38	20	22	3
S092221	4780	19.7	52	37	31	25	3
S092222	5028	19.7	50	42	50	25	4
S092226	5223	19.2	50	40	46	24	4

Table 7. Grain Yield, % Groat Protein and Agronomic Data for Checks and OT327/Diadem Selections, KCRF, 1992

Name	Gr. Yld. (kg/ha)	% Prot.	T.wt. (kg/hl)	Kernel wt. (mg)	% Plp.	% Hull	Mat. Score
Derby	4531	17.5	49	42	69	20	6
Waldern	5229	15.8	48	46	75	25	7
S092361	4400	19.1	47	38	43	25	5
S092377	5369	19.5	53	43	72	23	4
S092379	4682	20.3	49	38	28	26	6

(c) F5 and F6 hill plot tests. Of the 2,117 genotypes evaluated in the field from 17 different hybrid combinations, 1,043 were harvested and are being evaluated for % groat protein. Approximately 1/3 of these will be yield plot tested in 1993.

Clearly the majority of the wild species derivative and introduced lines are not agronomically equal to the checks, being generally lower yielding, earlier maturing and less desirable in terms of physical grain quality. However, in the group with significantly higher protein than the checks, A4013, A85012, Maldwyn, Elen and J829-3 offer good potential, demonstrating acceptable yield levels and, for J829-3,and the Norwegian lines, reasonable kernel quality. The A. maroccana derivative Av2027/3/1/27, while low in yield potential, combines high protein with fair grain quality.

Of the remaining A. sterilis derivatives, J775-1 offers the best potential demonstrating comparable yield and maturity with Riel with fair kernel quality. Lines J756-1 and J758-3 combine consistently high % protein with fair kernel quality. The U.S. variety Otee is of interest based on very high protein with good test weight and reasonable grain size.

Results indicate that the increased protein concentration of several of these parental genotypes can be transferred to locally adapted materials. The best lines appear to have a 1.0 - 2.0%+ protein improvement combined with acceptable agronomic performance and grain quality. Further testing of these materials and advanced lines from crosses with A. sterilis derivatives is planned for 1993. While at least one more breeding cycle will obviously be required to attain better adaptation the goal appears achievable.

SUMMARY

A. sativa genotypes derived from an A. sterilis background and selected for high groat protein concentration at Iowa State consistently demonstrated high groat protein in trials at Saskatoon during 1989-1991 and are being used as donors of increased protein in the U. of Sask. breeding program.

Genotypes derived from an A. maroccana background at the Welsh Plant Breeding Institute did not demonstrate as high a protein concentration as expected, although Av2027/1/3/27 appears to have some potential as high protein donor parent. Advanced lines with acceptable performance and a 1.0 - 2.0% protein increase are being evaluated.

Several foreign cultivars consistently demonstrated increased groat protein compared with local checks, including: Elen and Maldwyn from Wales; Otee, Trucker and SN404 from the USA; Karhu from Finland and Leila and A85012 from Norway. Materials derived from crosses with some of these lines and the Czechoslovakian variety Diadem have demonstrated the feasibility of combining higher groat protein concentration with acceptable field performance under Saskatchewan conditions.

REFERENCES

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