

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE

in cooperation with

STATE AGRICULTURAL EXPERIMENT STATIONS

Results from the

UNIFORM OATS WINTER HARDINESS NURSERY

2011-2012

Compiled by

D. P. Livingston
T. D. Tuong
J. H. Lyerly

This is a joint progress report of an investigation underway in the State Agricultural Experiment Stations and the Agricultural Research Service of the U. S. Department of Agriculture. It contains preliminary data which have not been sufficiently confirmed to justify general release; interpretations may be modified with additional experimentation. Confirmed results will be published through established channels. The report is primarily a tool for cooperators, their staff and those with special interest in agricultural research program development.

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USDA-ARS
South Atlantic Area
Department of Crop Science
North Carolina State University
Raleigh, NC 27695

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COOPERATING AGRICULTURAL EXPERIMENT STATIONS AND PERSONNEL

Country	State	AES Location	Personnel
USA	AR	Fayetteville	E. Mason
USA	IL	Lawrenceville	L. Phillippe
USA	NC	Laurel Springs/Waynesville	D. Marshall/M. Fountain
USA	TN	Knoxville	D. West
USA	LA	Baton Rouge	S. Harrison
Poland	Blonie	Plant Breeding and Acclimatization Ins.	B. Lapinski
Czech Republic	Kromeriz	Agricultural Research Institute	M. Kadlíková
Hungary	Martonvasar	Agric. Res. Inst. of Hungary Academy	O. Veisz
Austria	Edelhof	Saatzucht Edelhof	S. Berger & H. Hofbauer
Germany	Bad Vibel	Dottenfelderhof 1	B. Schmehe
UK	Wales	IBERS Aberystwyth University	S. Cowan

DIGEST

NUMBER OF TESTS:	11 tests (5 US States, 6 foreign countries)	
NUMBER OF ENTRIES:	13	
EXPERIMENTAL DESIGN:	Single-row, 5-foot plot Two replications Randomized complete block	
DATA RECORDED:	Percent winter survival	
DATA NOT USED IN ANALYSIS:	Knoxville, TN	100% Survival
	Baton Rouge, LA	100% Survival
	Lawrenceville, IL	100% Survival
	Kromeriz, Czech Republic	0% Survival
	Bad Vibel, Germany	0% Survival
	Fayetteville, AR	No Data
	Martonvasar, Hungary	No Data

COMMENTS:

- Analysis of markers associated with winter hardiness was implemented beginning with the 2008-2009 nursery.
- All new oat lines will be evaluated with Simple sequence repeats (SSRs) associated with winter hardiness traits and continue to be added to the report.

US STATE/COUNTRY	LOCATION	COOPERATORS' COMMENTS
IL, US	Lawrenceville	Mild winter and everything was 100% survival.
Czech Republic	Kromeriz	Due to the extreme weather (below -20C) and no snow cover in February, the nursery did not survive.
Austria	Edelhof	Very low precipitation in November, December, February, and March. Temperature went down to -20C in February with thin snowlayer. Overall, no heavy damages in our region.
UK	Wales	Plot 1 suffered some waterlogging

Table 1. Entries in the 2011-2012 Uniform Oat Winter Hardiness Nursery.

Entry No.	Entry name	Pedigree	Yrs in Nursery	Contributors	
1	Fulgum (ck)	CI 708	74		
2	Norline (ck)	CI 6903	51		
3	Winter Turf (ck)	CI 3296	71		
4	Wintok (ck)	CI 3424	71		
5	NC08-2517v	NC97-8349 / Horizon // SC961246	1	Murphy	NC
6	NC10-5051y	SC961246 / AR0258-7	1	Murphy	NC
7	NC10-5055y	SC961246 / AR0258-7	1	Murphy	NC
8	NC10-5069y	SC961246 / Rodgers	1	Murphy	NC
9	PR-5Q5	F1(Ebmeyer992212 x Avena macrostachya B6) x free pollination Q5	2	Lapinski	Poland
10	PR-5T8	F1(Ebmeyer992212 x Avena macrostachya B6) x free pollination T8	1	Lapinski	Poland
11	Win/Nor-1	Wintok x Norline	9	Livingston, Murphy	NC
12	Win/Nor-10	Wintok x Norline	10	Livingston, Murphy	NC
13	Win/Nor-10b	Selection from Win/Nor-10	8	Livingston, Murphy	NC

Top Ten Ranked Survival Entries

Top 10 ranked survival entries for 2011-2012

Rank	Ent No.	Entry	Pedigree	% Survival (across locations)
1	9	PR-5Q5	F1(Ebmeyer992212 x Avena macrostachya B6) x free pollination Q5	82
2	13	Win/Nor-10b	Selection from Win/Nor-10	74
3	3	Winter Turf (ck)	CI 3296	71
4	4	Wintok (ck)	CI 3424	67
5	6	NC10-5051y	SC961246 / AR0258-7	67
6	10	PR-5T8	F1(Ebmeyer992212 x Avena macrostachya B6) x free pollination T8	67
7	2	Norline (ck)	CI 6903	66
8	12	Win/Nor-10	Wintok x Norline	64
9	8	NC10-5069y	SC961246 / Rodgers	63
10	7	NC10-5055y	SC961246 / AR0258-7	63
LSD (0.05)				25

Table 2a. Winter Oat Survival (%) at Various Stations (sorted by entry number)

Ent. No.	Entry Name	Ranked Means	Means across loc	Radzikow Poland	Wales UK	Edelhof Austria	Laurel Spring NC
1	Fulgum (ck)	13	47	22	43	42	80
2	Norline (ck)	7	66	30	78	58	98
3	Winter Turf (ck)	3	71	35	54	100	97
4	Wintok (ck)	4	67	51	65	55	98
5	NC08-2517v	12	57	15	80	41	92
6	NC10-5051y	5	67	44	82	41	100
7	NC10-5055y	10	63	11	85	57	100
8	NC10-5069y	9	63	27	80	46	100
9	PR-5Q5	1	82	73	93	67	97
10	PR-5T8	6	67	66	80	23	98
11	Win/Nor-1	11	60	32	71	37	100
12	Win/Nor-10	8	64	37	76	43	99
13	Win/Nor-10b	2	74	71	85	40	99
Average			65	40	75	50	97
LSD (0.05)			25	60	22	80	50
CV(%)			18	69	14	74	25

Table 2b. Winter Oat Survival (%) at Various Stations (sorted by rank)

Ent. No.	Entry Name	Ranked Means	Means across loc	Radzikow Poland	Wales UK	Edelhof Austria	Laurel Spring NC
9	PR-5Q5	1	82	73	93	67	97
13	Win/Nor-10b	2	74	71	85	40	99
3	Winter Turf (ck)	3	71	35	54	100	97
4	Wintok (ck)	4	67	51	65	55	98
6	NC10-5051y	5	67	44	82	41	100
10	PR-5T8	6	67	66	80	23	98
2	Norline (ck)	7	66	30	78	58	98
12	Win/Nor-10	8	64	37	76	43	99
8	NC10-5069y	9	63	27	80	46	100
7	NC10-5055y	10	63	11	85	57	100
11	Win/Nor-1	11	60	32	71	37	100
5	NC08-2517v	12	57	15	80	41	92
1	Fulgum (ck)	13	47	22	43	42	80
Average			65	40	75	50	97
LSD (0.05)			25	60	22	80	50
CV(%)			18	69	14	74	25

**Table 3. Uniform Oats Winter Hardiness Nursery
Under Controlled Environment Freeze Test**

Entry #	Entry Name	Survival Rating ¹	% Survival ²
1	Fulgum (ck)	0.4	13
2	Norline (ck)	2.4	78
3	Winter Turf (ck)	1.1	48
4	Wintok (ck)	2.3	63
5	NC08-2517v	1.9	78
6	NC10-5051y	2.2	70
7	NC10-5055y	1.9	85
8	NC10-5069y	1.5	70
9	PR-5Q5	2.8	95
10	PR-5T8	2.0	80
11	Win/Nor-1	2.3	83
12	Win/Nor-10	1.8	75
13	Win/Nor-10b	2.0	88
Average		1.9	71
LSD (5%)		0.5	12
CV		13	7.8

Parameters:

- 2 reps/10 plants per rep planted in cone-tainers (Livingston et al. 2005, Crop Science, 45:1545-1558)
- 5 weeks at 13°C; 12 hours light/dark period; 400µmole light intensity
- 3 weeks at 3°C; 12 hours light/dark period; 350µmole light intensity
- 3 days @ -3°C in the dark (subzero acclimation)
- Whole plants were frozen @ 1°C/hour to -12°C for 3 hours
- Thawed @ 2°C/hour to 3°C
- Plants were watered once with 0.001% (v/v) Vitavax fungicide solution
- Plants were allowed to recover for 3 weeks in the greenhouse
- Whole Plants were rated for regrowth after 21 days by visually assessing leaves and roots.

¹Rating:

- 0 = Completely dead
- 1 = 1 survived (green) shoot or 1 primary root
- 2 = 1 or 2 survived (green) shoots or 1 survived shoot and 1 or 2 primary roots
- 3 = 1 or 2 survived shoots with developed roots (primary and secondary roots)
- 4 = 95% survived shoots with well developed roots
- 5 = 100% survived with very little or no sign of freeze damage; same as unfrozen plants

²Survival (%):

- 50% of plants with rating of 1 plus all plants rated >2 divided by total number of plants frozen multiplied by 100

Marker-Assisted Selection (MAS)

Winter hardiness is related to multiple quantitative traits, including winter field survival, crown freezing tolerance, vernalization response, and photoperiod. Crown freezing tolerance (CFT) is measured in controlled freeze tests and is an important component to winter hardiness. Photoperiod (PPD) and vernalization response (VRN) are frequently correlated with winter field survival and freezing tolerance because these traits contribute to delaying new growth until after the danger of freezing temperatures has passed. This avoidance response, affected by the combination of certain photoperiod and vernalization traits, can be useful for increasing winter field survival. The 7C-17 translocation is thought to contain a cluster of genes for increased tolerance to freezing temperatures and has been significantly correlated with winter field survival and crown freezing tolerance.

Genetic markers are fragments of DNA that are linked with known genes or traits. Associating markers with winter hardiness component traits (above) provides a valuable tool for oat research programs. Simple sequence repeats, known as SSRs or microsatellites, are a popular marker choice due to their relative low cost and ease of use. Oat SSR markers were previously evaluated for their association with winter hardiness component traits in a 'Fulghum' x 'Norline' population and in an oat association mapping population consisting of 25 spring sown, 36 fall sown, and two facultative oat lines. The markers associated with selected traits were chosen for testing with lines from the Uniform Oats Winter Hardiness Nursery, and the data are presented in Table 4.

If the DNA fragment associated with the phenotype of interest is present, this suggests that the line may have the winter hardiness trait. For example, the SSR marker HVM20 is associated with crown freeze tolerance and the 7C-17 translocation. The presence of the HVM20-142bp allele could translate to increased crown freeze tolerance and would be desirable in a marker-assisted selection program.

In the case of winter hardiness, a combination of traits is necessary, and marker selection at this stage is preliminary. Even though entries in the nursery may be winter hardy, they may not necessarily possess all the winter hardiness component markers. Further research will clarify which combination of traits, and therefore which SSR markers, are most informative for the development of a marker-assisted selection program.

Table 4. Markers Associated with Winter Hardiness Traits

	Primer	AM2	AM102	AM270S-1	HVM20	JAO4042	JAO4234a	JAO4234b	JAO4636	VRN1	Xncs15-3	AME23 MAT, LPPD, SPPD, VRN, NO- VRN, MAT- VLD, RS, LS, CFT	AME178	AME184a	AME184b	
	Traits	RS, LS, CFT	RS, LS, CFT	FT, TR, LS, CFT	LS, RS, CFT, TR	TR	VRN, RS, LS, CFT	CFT	CFT	VRN	CFT, TR		RS	CFT	WFS, MAT, LPPD, SPPD, VRN, NO- VRN, MAT- VLD	Number of Significant Alleles
	Allele Size (bp)	164	220	206	142	262	260	283	286	390	232	263	182	190	193	
Entry No.	Entry name															
1	Norline (ck)	no	yes	yes	yes	yes	no	yes	yes	yes	yes	-	no	no	yes	9
2	Winter Turf (ck)	yes	yes	no	no	yes	no	no	no	no	no	yes	no	no	yes	5
3	Wintok (ck)	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	no	no	no	yes	10
4	NC08-2517v	yes	yes	yes	yes	yes	no	no	yes	no	yes	no	no	no	no	7
5	NC10-5051y	no	yes	yes	yes	yes	no	no	no	no	yes	no	yes	no	yes	7
6	NC10-5055y	no	yes	yes	yes	yes	no	no	no	no	yes	yes	no	no	no	6
7	NC10-5069y	yes	yes	yes	yes	yes	no	no	yes	no	yes	yes	no	no	no	8
8	PR-5Q5	no	no	no	no	yes	no	no	no	no	yes	no	no	no	yes	3
9	PR-5T8	no	yes	no	no	yes	no	no	no	no	yes	no	yes	no	no	4
10	Win/Nor-1	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	no*	no	yes	11
11	Win/Nor-10	yes	yes	yes	-	yes	no	yes	yes	-	yes	yes	no	no	yes	9
12	Win/Nor-10b	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	no	no	no	10

WFS = Winter Field Survival
 FT = Freeze Tolerance
 TR = Translocation 7C-17
 MAT = Maturity

LPPD = Long Photoperiod
 SPPD = Short Photoperiod
 MAT-VLD = Maturity in vernalized long day treatment
 HD = Heading date

RS = Root score
 LS = Leaf Score
 CFT = Crown Freeze Tolerance
 VRN = Vernalization

NO-VRN = No Vernalization

* Results differ from previous testing and may represent variation within these lines using these markers. Fulgum was not included due to low germination rate.