

2023–24 Report for the Winter North American Barley Scab Evaluation Nurseries

Frolence Paul Fidelis and Eric J. Stockinger

Horticulture and Crop Science Department
The Ohio State University
Wooster OH 44691

INTRODUCTION

The goal of the winter North American Barley Scab Evaluation Nursery (Winter NABSEN) is to increase resistance to head blight (scab) disease in varieties of winter barley cultivated across North America. More specifically, we seek to identify lines that possess genetic resistance in the form of inherently accumulating low levels of the fungal toxin deoxynivalenol (DON). A key objective of the winter NABSEN is to assess scab resistance of new lines being developed by North American breeding programs. To accomplish that objective, barley lines were planted into nurseries designed to impose high levels of disease pressure. These nurseries were planted at multiple locations, over multiple years. This report details the information and results obtained from the nurseries grown the 2023–24 season.

MATERIALS AND METHODS

Cooperators and Locations

The coordinator of the winter NABSEN is Eric Stockinger at Ohio State University. Seed of all entries were sent to the Stockinger lab late August. Seed was treated with NipsIt™ SUITE Cereals OF Seed Protectant (Valent, <https://www.valent.com/>) following the manufacturer's recommendation and allowed to dry. Seed was then packaged and shipped to the nursery participants. Eight cooperators participated in the 2023-24 Winter NABSEN. Cooperators, institutions, and nursery locations are provided in Table 1.

Check Lines

Eight lines were used as checks, which were selected and vetted by the eight nursery participants, based on previous observations (Brooks, 2020; Cowger, 2021; Cowger et al., 2019). This information is provided in Table 2. These included four 6-row types and four 2-row barley types (Table 2).

Experimental Entries

A total of 55 entries were evaluated in the 2023-24 nursery, which included lines from seven breeding programs, plus the check varieties. A subset of these lines were tested for up to three seasons (2021-22, 2022-23, and 2023-24) while others were tested only the 2023–24 season. This information is provided in Table 3.

Disease Nursery Format and Inoculum

Each line was planted in two or three reps, typically using a headrow format. Participants at the Blacksburg VA, Ithaca NY, and Lincoln NE locations utilized corn cob "spawn" inoculation, spore inoculation, and overhead mist irrigation. Participants at the College Park MD, Raleigh NC, and Wooster OH locations utilized corn cob spawn inoculation, and overhead mist irrigation. Participants scored for disease using one or more of the following: disease index (IND), disease incidence (INC), diseased-head severity (DHS), Fusarium damaged kernels (FDK) defined by Paul et al. (2005), or FHB index as defined by Sneller et al. (2010). At maturity, the reps were hand-harvested. Reps were threshed, either as individual reps or a composite of the reps. Threshed material was ground to a fine powder and shipped to a lab equipped to assess DON levels. The target quantity of sample used for DON analysis was 100 g.

Data, Data Analysis and Interpretation

Data recorded by six of the eight NABSEN participants were provided to the coordinator and are shown in Tables 4-9.

Due to the single-year nature of the dataset and variable disease pressure among locations, statistical comparisons across locations were not conducted. Instead, results emphasize descriptive summaries and rankings within locations.

Relative DON (ReIDON) values were calculated by dividing each line's DON value by the DON value of VA15H-73 (AKA Greg) at each respective location. VA15H-73 has consistently ranked as the lowest or one of the lowest DON accumulators. This normalization allows comparison of line performance relative to a standard resistant check across sites with different overall disease pressure levels. A ReIDON value < 1.0 indicates better performance than the resistant check, $= 1.0$ indicates equivalent performance, and > 1.0 indicates poorer performance.

To evaluate the consistency of line performance across years and locations, correlation analysis was conducted on 17 lines that were evaluated in Ohio and Virginia during 2021-22 and 2022-23 and again in New York during 2023-24. The objective was to assess whether lines that exhibited lower DON in previous environments maintained relatively lower DON in New York.

RESULTS AND DISCUSSION

Disease Pressure Across Locations

Disease pressure varied considerably among locations during the 2023-24 season. Two locations, Ithaca, NY, and Blacksburg, VA, exhibited measurable DON accumulation with wide ranges of values, while the remaining locations (North Carolina, Nebraska, Ohio, and Maryland) had low to very low DON levels (Tables 4-9, Figure 2).

Ithaca, New York, showed a wide range of DON values (3.5–85.3 ppm), with VA15H-73 having the lowest and 13ARS526-8 the highest. Blacksburg, VA also had substantial DON variations ranging from 1.28 to 27.16 ppm, with MTWF6(F4)_84-127 being the lowest and DH170472 being the highest.

DON levels at Raleigh, NC, and Lincoln, NE, ranged from 0.1 to 13.1 ppm and 0.1 to 1.7 ppm, respectively. Ohio DON values ranged from 0.6 to 10.6 ppm, while Maryland DON values ranged from 1 to 19 ppm, with overall low DON levels.

At locations with apparently low disease pressure, DON values were low across most lines. Although some lines had ReIDON values greater than 1, the absolute DON values remained low.

DON Accumulation and Line Performance by Location

At locations that showed substantial variation (NY and VA), several lines had DON levels lower than or comparable to those of the resistant check VA15H-73, whereas other lines accumulated higher DON levels. Line rankings by DON and ReIDON for each location are provided in Tables 4-9.

Cross-Year and Cross-Location Comparison of DON Performance

To assess whether relative line performance was consistent across years and locations, correlation analysis was conducted on 17 lines evaluated in Ohio and Virginia during 2021-22 and 2022-23 and again in New York during 2023-24 (Table 10).

Correlation analysis showed that DON performance in NY 2023-24 was significantly associated with DON in VA 2021-22 ($r = 0.734$, $p = 0.0008$, $R^2 = 0.539$), suggesting moderate consistency of line ranking between these two environments (Table 11, Figure 1). However, correlations between NY 2023-24 and OH 2021-22 ($r = 0.367$, $p = 0.148$), OH 2022-23 ($r = 0.385$, $p = 0.127$), and VA 2022-23 ($r = 0.237$, $p = 0.360$) were not significant.

These results indicate that line performance was not uniformly stable across all environments and that environmental conditions likely influenced the expression of resistance.

Line Rankings Across Significant Environments

Ranking analysis of lines based on VA 2021-22 DON (lowest DON = best) and NY 2023-24 DON showed that several lines maintained good performance across both environments (Table 12). Lines 2MW18_4462-011, VA15H-73, and RIL02FL-029 had the best average rankings, indicating relatively consistent low DON accumulation. In contrast, lines such as Thunder, 13ARS537-19, HirondeLLa, and DH02FL-028 showed poor performance in both environments, with average rankings above 14.

FIGURES

Figure 1. Relationship between DON in New York (2023-24) and DON from previous trials in Ohio and Virginia (2021-22 and 2022-23).

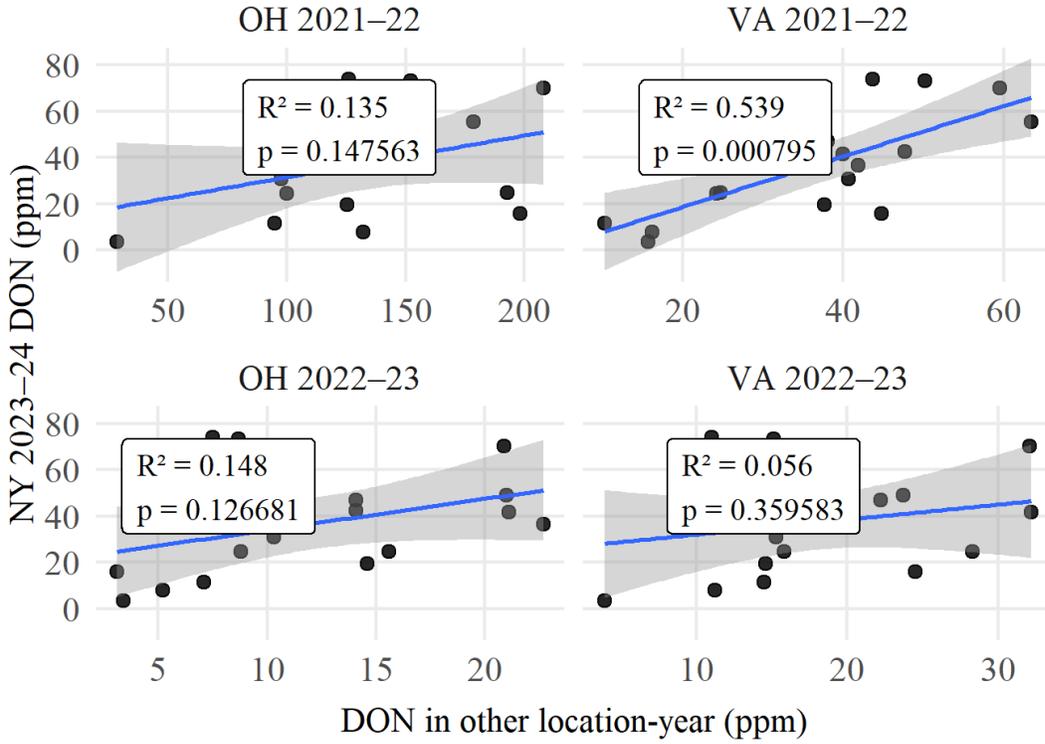
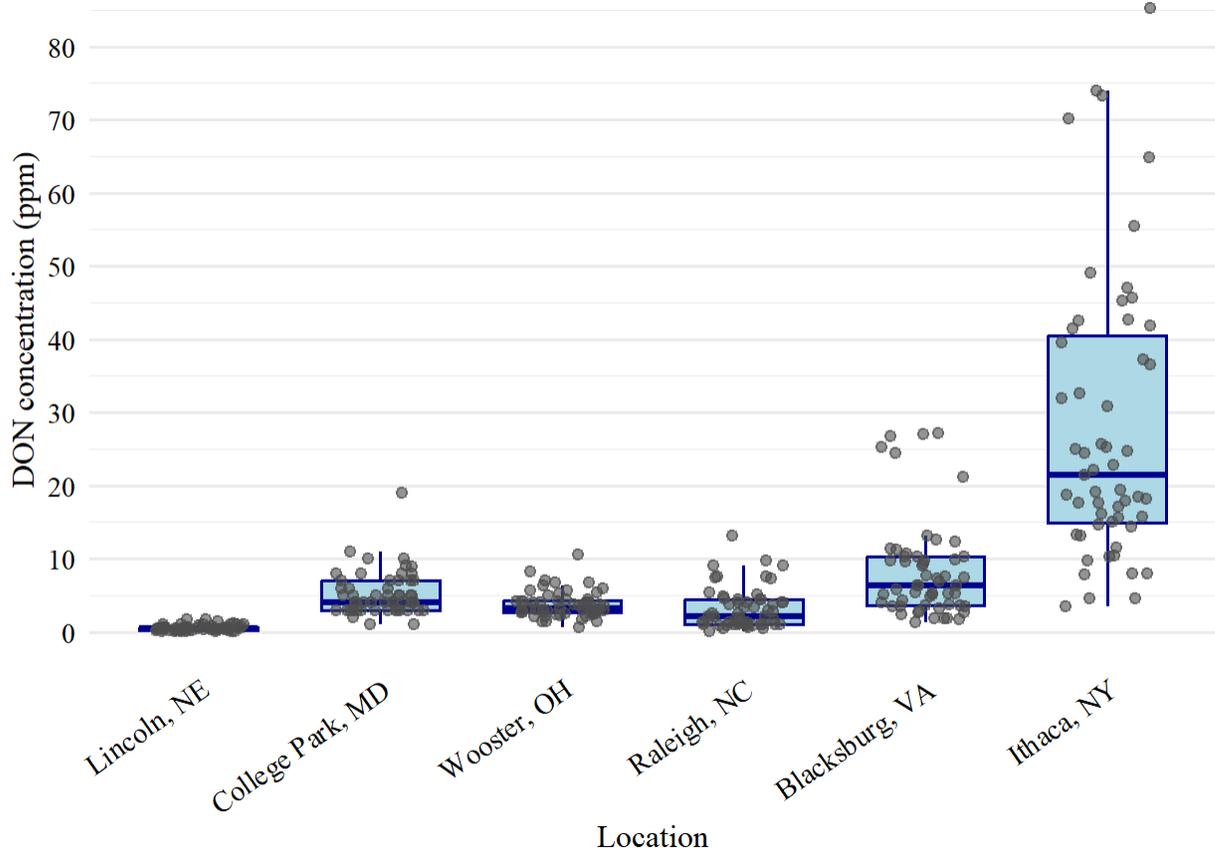


Figure 2. DON accumulation (ppm) across locations in the 2023–24 NABSEN trial. Data from Tables 4–9.



TABLES

Table 1. Cooperator, institution, and nursery location.

Cooperator	Institution	Location
Christina Cowger	North Carolina State University	Raleigh, NC
Katherine Frels	University of Nebraska	Lincoln, NE
Juliet Marshall	University of Idaho	Idaho Falls, ID
Nidhi Rawat	University of Maryland	College Park, MD
Nicholas Santantonio	Virginia State University	Blacksburg, VA
Jamie Sherman	Montana State University	Bozeman, MT
Mark E. Sorrells	Cornell University	Ithaca, NY
Eric J. Stockinger	The Ohio State University	Wooster, OH

Table 2. Lines selected as checks (controls).

Line	Row Type
Thoroughbred	6-row
Hirondella	6-row
Atlantic	6-row
Secretariat	6-row
Endeavor	2-row
VA15H-73	2-row
Calypso	2-row
Wintmalt	2-row

Table 3. Entries for 2023-24 NABSEN

Entry	Line	Breeding program
NABSEN-2023-24-001	12ARS777-1 [†]	USDA Aberdeen Idaho
NABSEN-2023-24-002	12ARS777-2	USDA Aberdeen Idaho
NABSEN-2023-24-003	1316ARS627-037	USDA Aberdeen Idaho
NABSEN-2023-24-004	13ARS514-6 [†]	USDA Aberdeen Idaho
NABSEN-2023-24-005	13ARS526-8	USDA Aberdeen Idaho
NABSEN-2023-24-006	13ARS537-19*	USDA Aberdeen Idaho
NABSEN-2023-24-007	2MW18 3373-001 [†]	University of Minnesota
NABSEN-2023-24-008	2MW18 4462-011*	University of Minnesota
NABSEN-2023-24-009	2MW19 3013-004	University of Minnesota
NABSEN-2023-24-010	2MW19 3346-014	University of Minnesota
NABSEN-2023-24-011	TM17.125-008	University of Minnesota
NABSEN-2023-24-012	W2M001 (2MW19 3009-004)	University of Minnesota
NABSEN-2023-24-013	W2M002 (2MW19 3023-022)	University of Minnesota
NABSEN-2023-24-014	MTWF6(F2) 50-1 [†]	Montana State University
NABSEN-2023-24-015	MTWF6(F2) 50-7 [†]	Montana State University
NABSEN-2023-24-016	MTWF6(F3) 24	Montana State University
NABSEN-2023-24-017	MTWF6(F4) 84-127	Montana State University
NABSEN-2023-24-018	MTWF7 4-2	Montana State University
NABSEN-2023-24-019	MTWF7 4-3	Montana State University
NABSEN-2023-24-020	MTWF7 6-7	Montana State University
NABSEN-2023-24-021	NB17411	University of Nebraska
NABSEN-2023-24-022	NB17431*	University of Nebraska
NABSEN-2023-24-023	NB19406	University of Nebraska
NABSEN-2023-24-024	NB19420*	University of Nebraska
NABSEN-2023-24-025	NB22216	University of Nebraska
NABSEN-2023-24-026	NB22229	University of Nebraska
NABSEN-2023-24-027	2011-725-02*	Ohio State University
NABSEN-2023-24-028	DH0214-007*	Ohio State University
NABSEN-2023-24-029	DH02FL-028*	Ohio State University
NABSEN-2023-24-030	GHRIL0201-103 [†]	Ohio State University
NABSEN-2023-24-031	RIL0201-088 [†]	Ohio State University
NABSEN-2023-24-032	RIL0257-01-011 [†]	Ohio State University
NABSEN-2023-24-033	RIL02FL-029	Ohio State University
NABSEN-2023-24-034	MOB2549-NT074-012	Ohio State University
NABSEN-2023-24-035	DH141917 [†]	Oregon State University
NABSEN-2023-24-036	DH162310 [†]	Oregon State University
NABSEN-2023-24-037	DH150683 [†]	Oregon State University
NABSEN-2023-24-038	DH170472 [†]	Oregon State University
NABSEN-2023-24-039	DH180676 [†]	Oregon State University
NABSEN-2023-24-040	Lightning*	Oregon State University
NABSEN-2023-24-041	Thunder*	Oregon State University
NABSEN-2023-24-042	VA20MFHB-18DH515	Virginia State University
NABSEN-2023-24-043	VA21BFHB-19DH0143	Virginia State University
NABSEN-2023-24-044	VA21BFHB-19DH0184	Virginia State University
NABSEN-2023-24-045	VA22M-205	Virginia State University
NABSEN-2023-24-046	VA22M-20DH1299	Virginia State University

NABSEN-2023-24-047	VA22M-20DH1427	Virginia State University
NABSEN-2023-24-048	Thoroughbred*	Check #5
NABSEN-2023-24-049	Hirondella*	Check #6
NABSEN-2023-24-050	Atlantic*	Check #7
NABSEN-2023-24-051	Secretariat*	Check #8
NABSEN-2023-24-052	Endeavor*	Check #1
NABSEN-2023-24-053	VA15H-73*	Check #2
NABSEN-2023-24-054	Calypso*	Check #3
NABSEN-2023-24-055	Wintmalt*	Check #4

An asterisk () indicates lines evaluated in the 2021-22, 2022-23, and 2023-24 seasons*

A dagger (†) indicates lines evaluated in two of these seasons

Symbols and definitions used in Tables 4-9:

‡ = value is an average of three replications

† = value is an average of two replications

Relative DON (RelDON) was calculated as:

DON of a line ÷ DON of VA15H-73 (resistant check)

RelDON < 1.0 = better than VA15H-73

RelDON = 1.0 = same as VA15H-73

RelDON > 1.0 = worse than VA15H-73

Table 4. DON concentration (ppm), relative DON (RelDON), and associated disease traits of winter barley lines evaluated at the Ithaca NY location the 2023-24 Winter NABSEN season.

Entry	Line	‡INC (%)	‡SEV (%)	‡INX (%)	‡Heading Date	†FDK (%)	†DON (ppm)	RelDON
NABSEN-2023-24-001	12ARS777-1	48.3	11.3	5.4	155	15	4.6	1.3
NABSEN-2023-24-002	12ARS777-2	56.7	12	7.1	152	10	4.6	1.3
NABSEN-2023-24-003	1316ARS627-037	93.3	26	24.3	150	10	41.8	11.94
NABSEN-2023-24-004	13ARS514-6	56.7	12.3	7	155	5	9.7	2.76
NABSEN-2023-24-005	13ARS526-8	91.7	24.7	22.6	150	5	85.3	24.36
NABSEN-2023-24-006	13ARS537-19	93.3	30.7	28.4	150	5	73.3	20.94
NABSEN-2023-24-007	2MW18_3373-001	58.3	14.3	9.1	150	5	17.1	4.89
NABSEN-2023-24-008	2MW18_4462-011	78.3	14	10.9	152	5	11.5	3.27
NABSEN-2023-24-009	2MW19_3013-004	76.7	15	11.8	150	7.5	18.8	5.36
NABSEN-2023-24-010	2MW19_3346-014	86.7	26.7	23	150	15	45.6	13.03
NABSEN-2023-24-011	TM17.125-008	95	33.7	32.2	150	7.5	64.8	18.5
NABSEN-2023-24-012	W2M001 (2MW19_3009-004)	71.7	18.7	13.6	152	5	15.6	4.44
NABSEN-2023-24-013	W2M002 (2MW19_3023-022)	85	19.7	16.9	150	5	18.2	5.2
NABSEN-2023-24-014	MTWF6(F2)_50-1	96.7	30.7	29.6	150	7.5	22.8	6.51
NABSEN-2023-24-015	MTWF6(F2)_50-7	56.7	15.3	7.8	152	10	10.4	2.97
NABSEN-2023-24-016	MTWF6(F3)_24	53.3	19.3	10.2	150	5	17.6	5.03
NABSEN-2023-24-017	MTWF6(F4)_84-127	78.3	18.3	14.2	150	7.5	19.2	5.49
NABSEN-2023-24-018	MTWF7_4-2	75	15	11.3	150	5	15.1	4.31
NABSEN-2023-24-019	MTWF7_4-3	65	15.3	10.5	150	7.5	16.2	4.63
NABSEN-2023-24-020	MTWF7_6-7	53.3	15	9	152	7.5	14.7	4.19
NABSEN-2023-24-021	NB17411	78.3	15	11.9	150	5	13.2	3.76
NABSEN-2023-24-022	NB17431	60	24.3	14.5	150	5	15.8	4.51
NABSEN-2023-24-023	NB19406	91.7	29.7	27.2	150	5	37.3	10.64
NABSEN-2023-24-024	NB19420	91.7	28.7	26.3	152	7.5	24.7	7.06
NABSEN-2023-24-025	NB22216	73.3	24.7	19.1	155	7.5	45.2	12.9

NABSEN-2023-24-026	NB22229	85	26	22.1	155	5	31.9	9.1
NABSEN-2023-24-027	2011-725-02	71.7	23.3	16.5	152	7.5	19.4	5.54
NABSEN-2023-24-028	DH0214-007	78.3	25.3	19.4	150	5	21.4	6.11
NABSEN-2023-24-029	DH02FL-028	80	28.3	23.4	152	7.5	55.5	15.86
NABSEN-2023-24-030	GHRIL0201-103	75	26	19.6	152	7.5	18.4	5.24
NABSEN-2023-24-031	RIL0201-088	45	10.3	4.7	155	5	8	2.27
NABSEN-2023-24-032	RIL0257-01-011	76.7	20.3	16.2	152	7.5	22.1	6.3
NABSEN-2023-24-033	RIL02FL-029	56.7	12.7	7.1	155	5	7.8	2.23
NABSEN-2023-24-034	MOB2549-NT074-012	61.7	15.7	10.1	150	5	8	2.27
NABSEN-2023-24-035	DH141917	85	32.7	28	155	5	32.6	9.3
NABSEN-2023-24-036	DH162310	90	19.3	17.4	150	7.5	39.6	11.3
NABSEN-2023-24-037	DH150683	78.3	20	15.8	150	12.5	25	7.13
NABSEN-2023-24-038	DH170472	80	14.7	11.6	152	7.5	14.4	4.11
NABSEN-2023-24-039	DH180676	81.7	19.7	16.1	152	10	25.2	7.19
NABSEN-2023-24-040	Lightning	80	22	18.4	152	5	36.6	10.46
NABSEN-2023-24-041	Thunder	86.7	40.3	34.4	150	10	74	21.13
NABSEN-2023-24-042	VA20MFHB-18DH515	88.3	28	25.3	152	10	42.7	12.2
NABSEN-2023-24-043	VA21BFHB-19DH0143	75	13	9.8	152	5	13.3	3.8
NABSEN-2023-24-044	VA21BFHB-19DH0184	73.3	18	13.6	152	7.5	17.7	5.06
NABSEN-2023-24-045	VA22M-205	78.3	22	19	152	7.5	25.7	7.34
NABSEN-2023-24-046	VA22M-20DH1299	75	21.3	16.2	152	10	17.9	5.1
NABSEN-2023-24-047	VA22M-20DH1427	50	20.7	10.3	155	5	10.3	2.94
NABSEN-2023-24-048	Thoroughbred	90	28.3	25.7	150	10	47	13.41
NABSEN-2023-24-049	Hirondella	88.3	34.3	30.6	152	10	70.1	20.01
NABSEN-2023-24-050	Atlantic	88.3	34.3	30.2	150	7.5	41.5	11.84
NABSEN-2023-24-051	Secretariat	95	36.7	34.3	150	10	49.1	14.01
NABSEN-2023-24-052	Endeavor	78.3	23.3	18.4	152	7.5	30.8	8.79
NABSEN-2023-24-053	VA15H-73	36.7	7	2.6	150	10	3.5	1
NABSEN-2023-24-054	Calypso	86.7	19	16.6	152	5	24.5	6.99

NABSEN-2023-24-055	Wintmalt	91.7	28	25.7	150	5	42.5	12.13
---------------------------	----------	------	----	------	-----	---	------	-------

Table 5. DON concentration (ppm), relative DON (RelDON), and disease response traits of winter barley lines evaluated at the Blacksburg VA location the 2023-24 Winter NABSEN season.

Entry	Line	†Scald (0-9)	†FHBPlantResponse (0-9)	†FDK (%)	†DON (ppm)	RelDON
NABSEN-2023-24-001	12ARS777-1	0.52	5	7.5	9.3	1.47
NABSEN-2023-24-002	12ARS777-2	0.52	3	10	4.34	0.69
NABSEN-2023-24-003	1316ARS627-037	0.52	2	5	3.98	0.63
NABSEN-2023-24-004	13ARS514-6	0.52	3	12.5	6.34	1
NABSEN-2023-24-005	13ARS526-8	0.52	4	7.5	7.76	1.23
NABSEN-2023-24-006	13ARS537-19	0.52	3	12.5	1.84	0.29
NABSEN-2023-24-007	2MW18_3373-001	0.52	3.5	10	7.5	1.19
NABSEN-2023-24-008	2MW18_4462-011	0.52	3	10	4.82	0.76
NABSEN-2023-24-009	2MW19_3013-004	0.52	4	17.5	9.06	1.43
NABSEN-2023-24-010	2MW19_3346-014	0.52	2.5	20	6.36	1.01
NABSEN-2023-24-011	TM17.125-008	0.52	1.5	17.5	1.8	0.28
NABSEN-2023-24-012	W2M001 (2MW19_3009-004)	0.52	2	7.5	5.18	0.82
NABSEN-2023-24-013	W2M002 (2MW19_3023-022)	0.52	5	17.5	10.32	1.63
NABSEN-2023-24-014	MTWF6(F2)_50-1	0.52	1.5	10	2.46	0.39
NABSEN-2023-24-015	MTWF6(F2)_50-7	0.52	5	12.5	12.28	1.94
NABSEN-2023-24-016	MTWF6(F3)_24	0.52	4	22.5	5.82	0.92
NABSEN-2023-24-017	MTWF6(F4)_84-127	0.52	1.5	15	1.28	0.2
NABSEN-2023-24-018	MTWF7_4-2	0.52	3	10	2.72	0.43
NABSEN-2023-24-019	MTWF7_4-3	0.52	6	17.5	10.7	1.69
NABSEN-2023-24-020	MTWF7_6-7	0.52	3.5	17.5	3.46	0.55
NABSEN-2023-24-021	NB17411	0.52	3	10	9.56	1.51
NABSEN-2023-24-022	NB17431	0.52	4	12.5	5.24	0.83
NABSEN-2023-24-023	NB19406	0.52	6	15	21.22	3.36
NABSEN-2023-24-024	NB19420	0.52	4.5	5	9.94	1.57
NABSEN-2023-24-025	NB22216	0.52	3	7.5	5.42	0.86

NABSEN-2023-24-026	NB22229	0.52	3.5	25	1.92	0.3
NABSEN-2023-24-027	2011-725-02	0.52	4	17.5	3.22	0.51
NABSEN-2023-24-028	DH0214-007	0.52	3.5	10	5.28	0.84
NABSEN-2023-24-029	DH02FL-028	0.52	2.5	10	3.48	0.55
NABSEN-2023-24-030	GHRIL0201-103	0.52	3	7.5	1.76	0.28
NABSEN-2023-24-031	RIL0201-088	0.52	5	17.5	2.82	0.45
NABSEN-2023-24-032	RIL0257-01-011	0.52	5.5	17.5	9.78	1.55
NABSEN-2023-24-033	RIL02FL-029	0.52	6	15	24.38	3.86
NABSEN-2023-24-034	MOB2549-NT074-012	0.52	5.5	20	25.26	4
NABSEN-2023-24-035	DH141917	0.52	4	7.5	11.18	1.77
NABSEN-2023-24-036	DH162310	0.52	5.5	15	26.98	4.27
NABSEN-2023-24-037	DH150683	0.52	4.5	15	26.78	4.24
NABSEN-2023-24-038	DH170472	0.52	6	7.5	27.16	4.3
NABSEN-2023-24-039	DH180676	0.52	3.5	12.5	12.56	1.99
NABSEN-2023-24-040	Lightning	0.52	4.5	12.5	13.1	2.07
NABSEN-2023-24-041	Thunder	0.52	4.5	7.5	10.36	1.64
NABSEN-2023-24-042	VA20MFHB-18DH515	0.52	3	5	7.52	1.19
NABSEN-2023-24-043	VA21BFHB-19DH0143	0.52	3.5	10	9.76	1.54
NABSEN-2023-24-044	VA21BFHB-19DH0184	0.52	3.5	12.5	7.28	1.15
NABSEN-2023-24-045	VA22M-205	0.52	2.5	27.5	3.64	0.58
NABSEN-2023-24-046	VA22M-20DH1299	0.52	3	10	3.76	0.59
NABSEN-2023-24-047	VA22M-20DH1427	0.52	3.5	17.5	10.34	1.64
NABSEN-2023-24-048	Thoroughbred	0.52	3.5	22.5	3.64	0.58
NABSEN-2023-24-049	Hirondella	0.52	4	22.5	5.32	0.84
NABSEN-2023-24-050	Atlantic	0.52	5.5	15	6.96	1.1
NABSEN-2023-24-051	Secretariat	0.52	3	10	5.18	0.82
NABSEN-2023-24-052	Endeavor	0.52	4.5	7.5	3.5	0.55
NABSEN-2023-24-053	VA15H-73	0.52	3.5	7.5	6.32	1
NABSEN-2023-24-054	Calypso	0.52	2	25	2.68	0.42

NABSEN-2023-24-055	Wintmalt	0.52	7	17.5	11.32	1.79
---------------------------	----------	------	---	------	-------	------

Table 6. Mean DON concentration (ppm), mean heading date, mean disease index, and relative DON (RelDON) of winter barley lines evaluated at the Raleigh, NC location the 2023-24 Winter NABSEN season.

Entry	Line	‡Heading Julian	‡Index (DI*DS/100)	‡DON (ppm)	RelDON
NABSEN-2023-24-001	12ARS777-1	105	4	7.4	6.73
NABSEN-2023-24-002	12ARS777-2	99	1.3	1.9	1.73
NABSEN-2023-24-003	1316ARS627-037	95	1	2.1	1.91
NABSEN-2023-24-004	13ARS514-6	101	5	4.9	4.45
NABSEN-2023-24-005	13ARS526-8	95	0.8	4.4	4
NABSEN-2023-24-006	13ARS537-19	77	0.8	0.5	0.45
NABSEN-2023-24-007	2MW18_3373-001	99	12.1	13.1	11.91
NABSEN-2023-24-008	2MW18_4462-011	90	1.3	1	0.91
NABSEN-2023-24-009	2MW19_3013-004	96	1.3	5.1	4.64
NABSEN-2023-24-010	2MW19_3346-014	74	0	1	0.91
NABSEN-2023-24-011	TM17.125-008	92	2.7	0.9	0.82
NABSEN-2023-24-012	W2M001 (2MW19_3009-004)	95	0.3	4.1	3.73
NABSEN-2023-24-013	W2M002 (2MW19_3023-022)	87	2.4	0.5	0.45
NABSEN-2023-24-014	MTWF6(F2)_50-1	78	1	0.1	0.09
NABSEN-2023-24-015	MTWF6(F2)_50-7	87	0.4	2.1	1.91
NABSEN-2023-24-016	MTWF6(F3)_24	92	0.3	2.6	2.36
NABSEN-2023-24-017	MTWF6(F4)_84-127	76	0.6	1.1	1
NABSEN-2023-24-018	MTWF7_4-2	86	1.1	0.6	0.55
NABSEN-2023-24-019	MTWF7_4-3	87	0.2	1.1	1
NABSEN-2023-24-020	MTWF7_6-7	90	0.6	3.3	3
NABSEN-2023-24-021	NB17411	97	0.1	1.1	1
NABSEN-2023-24-022	NB17431	94	4.4	3.7	3.36
NABSEN-2023-24-023	NB19406	91	1.7	1.6	1.45
NABSEN-2023-24-024	NB19420	102	4	4.6	4.18
NABSEN-2023-24-025	NB22216	93	0.8	1.9	1.73

NABSEN-2023-24-026	NB22229	93	0.9	2.6	2.36
NABSEN-2023-24-027	2011-725-02	99	2.5	4.4	4
NABSEN-2023-24-028	DH0214-007	90	1.7	1	0.91
NABSEN-2023-24-029	DH02FL-028	99	2.9	4.4	4
NABSEN-2023-24-030	GHRIL0201-103	87	1.5	0.9	0.82
NABSEN-2023-24-031	RIL0201-088	108	11.5	9.1	8.27
NABSEN-2023-24-032	RIL0257-01-011	105	15.7	9.8	8.91
NABSEN-2023-24-033	RIL02FL-029	102	9.3	7.3	6.64
NABSEN-2023-24-034	MOB2549-NT074-012	98	4.2	1.6	1.45
NABSEN-2023-24-035	DH141917	100	7.5	7.6	6.91
NABSEN-2023-24-036	DH162310	94	3.3	1.3	1.18
NABSEN-2023-24-037	DH150683	93	0.4	1.4	1.27
NABSEN-2023-24-038	DH170472	99	2.4	2.8	2.55
NABSEN-2023-24-039	DH180676	85	1	1	0.91
NABSEN-2023-24-040	Lightning	102	2.9	7.6	6.91
NABSEN-2023-24-041	Thunder	91	0.4	1.3	1.18
NABSEN-2023-24-042	VA20MFHB-18DH515	96	2.3	4	3.64
NABSEN-2023-24-043	VA21BFHB-19DH0143	100	2.3	2.1	1.91
NABSEN-2023-24-044	VA21BFHB-19DH0184	102	1.9	5.4	4.91
NABSEN-2023-24-045	VA22M-205	93	0.9	3	2.73
NABSEN-2023-24-046	VA22M-20DH1299	106	13.3	4	3.64
NABSEN-2023-24-047	VA22M-20DH1427	105	10.7	4.1	3.73
NABSEN-2023-24-048	Thoroughbred	101	5.5	0.9	0.82
NABSEN-2023-24-049	Hirondella	97	5.8	3.7	3.36
NABSEN-2023-24-050	Atlantic	85	12.1	1.2	1.09
NABSEN-2023-24-051	Secretariat	85	9.7	0.9	0.82
NABSEN-2023-24-052	Endeavor	87	0.2	1.3	1.18
NABSEN-2023-24-053	VA15H-73	96	0.2	1.1	1
NABSEN-2023-24-054	Calypso	103	13	9.1	8.27

NABSEN-2023-24-055	Wintmalt	92	5.1	3.4	3.09
---------------------------	----------	----	-----	-----	------

Table 7. Mean DON concentration (ppm), relative DON (RelDON), mean severity, mean incidence, and mean FDK of winter barley lines evaluated at the Lincoln NE location the 2023-24 Winter NABSEN season.

Entry	Line	‡SEV (%)	‡INC (%)	‡INDEX (%)	‡FDK (%)	‡DON (ppm)	RelDON
NABSEN-2023-24-001	12ARS777-1	5	43	4	2	1	10
NABSEN-2023-24-002	12ARS777-2	6	43	4	14	0.8	8
NABSEN-2023-24-003	1316ARS627-037	13	43	8	4	1	10
NABSEN-2023-24-004	13ARS514-6	9	30	4	1	0.5	5
NABSEN-2023-24-005	13ARS526-8	7	30	3	3	1	10
NABSEN-2023-24-006	13ARS537-19	15	57	13	2	1	10
NABSEN-2023-24-007	2MW18_3373-001	9	30	3	2	0.5	5
NABSEN-2023-24-008	2MW18_4462-011	39	50	19	5	0.1	1
NABSEN-2023-24-009	2MW19_3013-004	25	43	14	0	0.5	5
NABSEN-2023-24-010	2MW19_3346-014	26	50	14	3	0.3	3
NABSEN-2023-24-011	TM17.125-008	20	63	11	0	0.8	8
NABSEN-2023-24-012	W2M001 (2MW19_3009-004)	12	33	4	1	0.6	6
NABSEN-2023-24-013	W2M002 (2MW19_3023-022)	22	50	12	5	0.6	6
NABSEN-2023-24-014	MTWF6(F2)_50-1	32	53	19	3	0.5	5
NABSEN-2023-24-015	MTWF6(F2)_50-7	16	70	12	2	0.6	6
NABSEN-2023-24-016	MTWF6(F3)_24	24	67	17	3	1.2	12
NABSEN-2023-24-017	MTWF6(F4)_84-127	15	43	7	3	1.7	17
NABSEN-2023-24-018	MTWF7_4-2	16	50	9	0	0.4	4
NABSEN-2023-24-019	MTWF7_4-3	17	33	8	3	0.3	3
NABSEN-2023-24-020	MTWF7_6-7	26	53	15	7	0.7	7
NABSEN-2023-24-021	NB17411	24	63	14	1	0.3	3
NABSEN-2023-24-022	NB17431	39	47	15	6	0.2	2
NABSEN-2023-24-023	NB19406	13	47	7	5	0.5	5
NABSEN-2023-24-024	NB19420	14	67	9	4	0.5	5
NABSEN-2023-24-025	NB22216	10	30	6	3	1	10

NABSEN-2023-24-026	NB22229	10	57	6	2	0.6	6
NABSEN-2023-24-027	2011-725-02	11	70	9	5	0.1	1
NABSEN-2023-24-028	DH0214-007	12	70	9	6	0.4	4
NABSEN-2023-24-029	DH02FL-028	15	40	7	8	1	10
NABSEN-2023-24-030	GHRIL0201-103	13	37	4	1	1.4	14
NABSEN-2023-24-031	RIL0201-088	5	13	1	4	1.7	17
NABSEN-2023-24-032	RIL0257-01-011	11	50	5	2	0.9	9
NABSEN-2023-24-033	RIL02FL-029	5	33	3	1	0.4	4
NABSEN-2023-24-034	MOB2549-NT074-012	10	40	4	4	0.2	2
NABSEN-2023-24-035	DH141917	18	70	13	0	0.2	2
NABSEN-2023-24-036	DH162310	24	50	11	5	0.1	1
NABSEN-2023-24-037	DH150683	15	30	6	1	0.2	2
NABSEN-2023-24-038	DH170472	14	37	5	3	0.2	2
NABSEN-2023-24-039	DH180676	12	37	4	2	0.5	5
NABSEN-2023-24-040	Lightning	9	53	5	2	0.3	3
NABSEN-2023-24-041	Thunder	10	57	5	1	0.1	1
NABSEN-2023-24-042	VA20MFHB-18DH515	40	37	11	2	0.5	5
NABSEN-2023-24-043	VA21BFHB-19DH0143	19	73	14	1	0.2	2
NABSEN-2023-24-044	VA21BFHB-19DH0184	48	77	38	3	0.2	2
NABSEN-2023-24-045	VA22M-205	15	67	10	1	0.4	4
NABSEN-2023-24-046	VA22M-20DH1299	26	67	18	10	0.1	1
NABSEN-2023-24-047	VA22M-20DH1427	18	73	12	0	0.1	1
NABSEN-2023-24-048	Thoroughbred	19	60	11	1	0.3	3
NABSEN-2023-24-049	Hirondella	14	57	8	2	0.5	5
NABSEN-2023-24-050	Atlantic	24	80	20	0	0.5	5
NABSEN-2023-24-051	Secretariat	21	87	19	2	0.7	7
NABSEN-2023-24-052	Endeavor	16	47	7	1	0.4	4
NABSEN-2023-24-053	VA15H-73	37	87	33	6	0.1	1
NABSEN-2023-24-054	Calypso	12	63	7	1	0.2	2

NABSEN-2023-24-055	Wintmalt	26	67	20	2	0.2	2
---------------------------	----------	----	----	----	---	-----	---

Table 8. Mean DON concentration (ppm), standard deviations, and relative DON (RelDON) of winter barley lines evaluated at the College Park MD location the 2023-24 Winter NABSEN season.

Entry	Line	‡DON (ppm)	Std deviation	RelDON
NABSEN-2023-24-001	12ARS777-1	5	3	2.2
NABSEN-2023-24-002	12ARS777-2	3	1	1.2
NABSEN-2023-24-003	1316ARS627-037	4	2	1.4
NABSEN-2023-24-004	13ARS514-6	3	2	1.1
NABSEN-2023-24-005	13ARS526-8	4	2	1.6
NABSEN-2023-24-006	13ARS537-19	4	2	1.6
NABSEN-2023-24-007	2MW18_3373-001	5	3	2.1
NABSEN-2023-24-008	2MW18_4462-011	3	1	1.1
NABSEN-2023-24-009	2MW19_3013-004	5	6	2.2
NABSEN-2023-24-010	2MW19_3346-014	3	2	1.2
NABSEN-2023-24-011	TM17.125-008	1	1	0.5
NABSEN-2023-24-012	W2M001 (2MW19_3009-004)	3	1	1.3
NABSEN-2023-24-013	W2M002 (2MW19_3023-022)	1	0	0.5
NABSEN-2023-24-014	MTWF6(F2)_50-1	9	13	3.5
NABSEN-2023-24-015	MTWF6(F2)_50-7	6	4	2.6
NABSEN-2023-24-016	MTWF6(F3)_24	8	5	3
NABSEN-2023-24-017	MTWF6(F4)_84-127	10	13	3.8
NABSEN-2023-24-018	MTWF7_4-2	3	0	1.1
NABSEN-2023-24-019	MTWF7_4-3	7	6	2.9
NABSEN-2023-24-020	MTWF7_6-7	3	1	1.2
NABSEN-2023-24-021	NB17411	19	2	7.5
NABSEN-2023-24-022	NB17431	6	5	2.5
NABSEN-2023-24-023	NB19406	7	4	2.9
NABSEN-2023-24-024	NB19420	5	6	1.9
NABSEN-2023-24-025	NB22216	11	8	4.3
NABSEN-2023-24-026	NB22229	9	10	3.8
NABSEN-2023-24-027	2011-725-02	4	3	1.5
NABSEN-2023-24-028	DH0214-007	3	3	1.4
NABSEN-2023-24-029	DH02FL-028	8	8	3.1
NABSEN-2023-24-030	GHRIL0201-103	4	2	1.7
NABSEN-2023-24-031	RIL0201-088	7	6	2.9
NABSEN-2023-24-032	RIL0257-01-011	8	6	3.1
NABSEN-2023-24-033	RIL02FL-029	8	2	3.2
NABSEN-2023-24-034	MOB2549-NT074-012	3	3	1.2
NABSEN-2023-24-035	DH141917	4	2	1.7
NABSEN-2023-24-036	DH162310	5	3	1.9

NABSEN-2023-24-037	DH150683	7	4	2.7
NABSEN-2023-24-038	DH170472	5	3	2.2
NABSEN-2023-24-039	DH180676	4	2	1.5
NABSEN-2023-24-040	Lightning	5	6	2
NABSEN-2023-24-041	Thunder	3	3	1.1
NABSEN-2023-24-042	VA20MFHB-18DH515	3	3	1.4
NABSEN-2023-24-043	VA21BFHB-19DH0143	3	1	1.1
NABSEN-2023-24-044	VA21BFHB-19DH0184	2	1	0.9
NABSEN-2023-24-045	VA22M-205	3	1	1.1
NABSEN-2023-24-046	VA22M-20DH1299	3	2	1.1
NABSEN-2023-24-047	VA22M-20DH1427	7	5	2.7
NABSEN-2023-24-048	Thoroughbred	4	2	1.5
NABSEN-2023-24-049	Hirondella	4	3	1.5
NABSEN-2023-24-050	Atlantic	10	10	4.1
NABSEN-2023-24-051	Secretariat	6	7	2.3
NABSEN-2023-24-052	Endeavor	4	1	1.5
NABSEN-2023-24-053	VA15H-73	3	1	1
NABSEN-2023-24-054	Calypso	5	5	2.2
NABSEN-2023-24-055	Wintmalt	4	1	1.8

Table 9. Mean DON concentration (ppm) and relative DON (RelDON) of winter barley lines evaluated at Wooster OH location the 2023-24 Winter NABSEN season.

Entry	Line	‡DON (ppm)	RelDON
NABSEN-2023-24-001	12ARS777-1	4.4	3
NABSEN-2023-24-002	12ARS777-2	2.1	1.4
NABSEN-2023-24-003	1316ARS627-037	2.2	1.5
NABSEN-2023-24-004	13ARS514-6	3	2
NABSEN-2023-24-005	13ARS526-8	5	3.4
NABSEN-2023-24-006	13ARS537-19	2.4	1.6
NABSEN-2023-24-007	2MW18_3373-001	5.3	3.6
NABSEN-2023-24-008	2MW18_4462-011	3.1	2.1
NABSEN-2023-24-009	2MW19_3013-004	1.7	1.2
NABSEN-2023-24-010	2MW19_3346-014	6.4	4.4
NABSEN-2023-24-011	TM17.125-008	5.7	3.9
NABSEN-2023-24-012	W2M001 (2MW19_3009-004)	4.2	2.9
NABSEN-2023-24-013	W2M002 (2MW19_3023-022)	2.9	2
NABSEN-2023-24-014	MTWF6(F2)_50-1	2.7	1.8
NABSEN-2023-24-015	MTWF6(F2)_50-7	5.6	3.8
NABSEN-2023-24-016	MTWF6(F3)_24	4.2	2.9
NABSEN-2023-24-017	MTWF6(F4)_84-127	4.2	2.9
NABSEN-2023-24-018	MTWF7_4-2	2.2	1.5
NABSEN-2023-24-019	MTWF7_4-3	2.3	1.6
NABSEN-2023-24-020	MTWF7_6-7	3	2
NABSEN-2023-24-021	NB17411	4.5	3.1
NABSEN-2023-24-022	NB17431	10.6	7.2
NABSEN-2023-24-023	NB19406	6.8	4.6
NABSEN-2023-24-024	NB19420	6.8	4.6
NABSEN-2023-24-025	NB22216	6	4.1
NABSEN-2023-24-026	NB22229	8.3	5.6
NABSEN-2023-24-027	2011-725-02	2.6	1.8
NABSEN-2023-24-028	DH0214-007	1.4	1
NABSEN-2023-24-029	DH02FL-028	4.1	2.8
NABSEN-2023-24-030	GHRIL0201-103	3.7	2.5
NABSEN-2023-24-031	RIL0201-088	3	2
NABSEN-2023-24-032	RIL0257-01-011	3.2	2.2
NABSEN-2023-24-033	RIL02FL-029	5.4	3.7
NABSEN-2023-24-034	MOB2549-NT074-012	0.6	0.4
NABSEN-2023-24-035	DH141917	2.7	1.8
NABSEN-2023-24-036	DH162310	1.5	1
NABSEN-2023-24-037	DH150683	3.7	2.5

NABSEN-2023-24-038	DH170472	2.7	1.8
NABSEN-2023-24-039	DH180676	2.4	1.6
NABSEN-2023-24-040	Lightning	4.2	2.9
NABSEN-2023-24-041	Thunder	2.9	2
NABSEN-2023-24-042	VA20MFHB-18DH515	3.1	2.1
NABSEN-2023-24-043	VA21BFHB-19DH0143	2.6	1.8
NABSEN-2023-24-044	VA21BFHB-19DH0184	3.7	2.5
NABSEN-2023-24-045	VA22M-205	3.1	2.1
NABSEN-2023-24-046	VA22M-20DH1299	2.6	1.7
NABSEN-2023-24-047	VA22M-20DH1427	3.2	2.2
NABSEN-2023-24-048	Thoroughbred	4.1	2.8
NABSEN-2023-24-049	Hirondella	7	4.8
NABSEN-2023-24-050	Atlantic	3.8	2.6
NABSEN-2023-24-051	Secretariat	4.1	2.8
NABSEN-2023-24-052	Endeavor	2.9	2
NABSEN-2023-24-053	VA15H-73	1.5	1
NABSEN-2023-24-054	Calypso	3.7	2.5
NABSEN-2023-24-055	Wintmalt	4.1	2.8

Table 10. DON levels in NY 2023-24, OH 2021-22 and 2022-23, and VA 2021-22 and 2022-23, which were used to test the Multi-Year Model shown in Figure 1.

Entry	Line	OH_2021-22	VA_2021-22	OH_2022-23	VA_2022-23	NY_2023-24
NABSEN-2023-24-006	13ARS537-19	152.1	50.2	8.7	15.1	73.3
NABSEN-2023-24-008	2MW18_4462-011	94.9	10.3	7.1	14.5	11.5
NABSEN-2023-24-022	NB17431	198.1	44.8	3.1	24.5	15.8
NABSEN-2023-24-024	NB19420	192.9	24.7	8.8	28.3	24.7
NABSEN-2023-24-027	2011-725-02	125.3	37.7	14.6	14.6	19.4
NABSEN-2023-24-029	DH02FL-028	178.7	63.4	9.2	11.2	55.5
NABSEN-2023-24-033	RIL02FL-029	132.3	16.2	5.2	11.2	7.8
NABSEN-2023-24-040	Lightning	126.9	41.9	22.7	13.4	36.6
NABSEN-2023-24-041	Thunder	125.9	43.7	7.5	11	74
NABSEN-2023-24-048	Thoroughbred	103	38.1	14.1	22.2	47
NABSEN-2023-24-049	Hirondella	208	59.5	20.9	32.1	70.1
NABSEN-2023-24-050	Atlantic	108	40	21.1	32.2	41.5
NABSEN-2023-24-051	Secretariat	95.1	26	21	23.7	49.1
NABSEN-2023-24-052	Endeavor	97.5	40.7	10.3	15.3	30.8
NABSEN-2023-24-053	VA15H-73	28.5	15.7	3.4	3.9	3.5
NABSEN-2023-24-054	Calypso	100	24.2	15.6	15.8	24.5
NABSEN-2023-24-055	Wintmalt	141	47.7	14.1	9.1	42.5

Table 11. Correlation between NY 2023-24 DON and DON from each previous location-year.

Location - year	r	p	R²	Significance
OH_2021-22	0.367	0.148	0.135	Not significant
VA_2021-22	0.734	0.0008	0.539	Significant
OH_2022-23	0.385	0.127	0.148	Not significant
VA_2022-23	0.237	0.360	0.056	Not significant

Note: Significance is defined as $p < 0.05$.

Table 12. Ranking of lines based on DON levels (lowest DON = best) at the VA location 2021-22 and the NY location 2023-24.

Entry	Line	VA_2021-22	NY_2023-24	Rank_VA	Rank_NY	Avg_rank
NABSEN-2023-24-053	VA15H-73	15.7	3.5	2	1	1.5
NABSEN-2023-24-008	2MW18_4462-011	10.3	11.5	1	3	2
NABSEN-2023-24-033	RIL02FL-029	16.2	7.8	3	2	2.5
NABSEN-2023-24-054	Calypso	24.2	24.5	4	6	5
NABSEN-2023-24-024	NB19420	24.7	24.7	5	7	6
NABSEN-2023-24-027	2011-725-02	37.7	19.4	7	5	6
NABSEN-2023-24-022	NB17431	44.8	15.8	13	4	8.5
NABSEN-2023-24-052	Endeavor	40.7	30.8	10	8	9
NABSEN-2023-24-050	Atlantic	40	41.5	9	10	9.5
NABSEN-2023-24-051	Secretariat	26	49.1	6	13	9.5
NABSEN-2023-24-040	Lightning	41.9	36.6	11	9	10
NABSEN-2023-24-048	Thoroughbred	38.1	47	8	12	10
NABSEN-2023-24-055	Wintmalt	47.7	42.5	14	11	12.5
NABSEN-2023-24-041	Thunder	43.7	74	12	17	14.5
NABSEN-2023-24-006	13ARS537-19	50.2	73.3	15	16	15.5
NABSEN-2023-24-029	DH02FL-028	63.4	55.5	17	14	15.5
NABSEN-2023-24-049	Hirondella	59.5	70.1	16	15	15.5