

Evaluation of Corn Varieties for the Michigan Craft Distilling Industry 2023-2024 Final Technical Report

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Abstract

In 2023-24, our team received support from the Michigan Craft Beverage Council to continue investigating alternative corn varieties for the Michigan Craft Distilling Industry, with the goal of identifying open pollinated varieties of corn suited to Michigan with unique flavor qualities inherent in the spirit they produce. Varieties evaluated vary widely in agronomic feasibility for different climatic regions of Michigan, with variability in yield, moisture, color and basic grain quality. Spirit yield (predicted and actual hearts yield) varied between varieties. Next steps in this project involve continuing field and lab trials and finishing sensory & flavor compound analysis.

Introduction

Corn is the most widely used cereal grain in whiskey products as most grain bills (recipes) are at least 50% corn, with some being as much as 100% corn. Corn can vary like any other crop in the color, composition, and flavor among other attributes. There are many varieties of corn that are grown throughout Michigan and the United States. Most varieties (hybrid vs. open pollinated) are chosen based on yield and extract content, among agronomic variables that lead a farmer to choose to grow and sell a specific variety at their farm. This selection process has resulted in nearly all the corn produced from hybrid #2 yellow dent varieties, for which a surprisingly low amount of variation exists between varieties.

More broadly, corn varieties exhibit a wide range of characteristics, particularly those varieties that are open pollinated instead of hybridized. As we explore the wider range of corn genotypes, we hypothesize that these unique varieties have different flavor profiles and aging potential. Thus, distillers are interested in finding unique flavors in corn as well as marketing potential that comes with utilizing varieties that are heirloom and have other unique properties. As the spirits industry becomes more competitive, the desire to have a unique product increases. The unique flavor of whiskey comes from a variety of sources: the grain and mash bill, the mashing process, the water minerals and pH, the yeast, and the distilling and aging process. Inherent in the grains used are some key flavor compounds that are retained in the end product, or they eventually are involved in reactions during the aging process. Holding all processing variables consistent, varieties can be compared on a semi-micro scale to determine subtle differences in the distillate made from 100% corn mashes.

In 2023-24, our team received support from the Michigan Craft Beverage Council to continue investigating alternative corn varieties for the Michigan Craft Distilling Industry. This project is part of a multi-year effort started in 2022 and continuing at least through 2025. The goal of this research is to identify open pollinated varieties of corn suited to Michigan with unique flavor qualities inherent in the spirit they produce. To complete this goal, 20 varieties of corn were selected. The varieties were grown on MSU research farms throughout the state of Michigan in summer 2023. After harvest in Fall 2023, corn samples were transferred to three laboratories for analysis, including the Grain Quality Lab at UPREC, the Hartwick College Center for Craft Food and Beverage, and the fermented beverage lab at Michigan State to mash, ferment and distill into

un-aged 100% corn whiskey. The whiskey is currently being analyzed using GC and HPLC analytics as well as evaluated by a tasting panel consisting of experts in the industry.

Objectives

The main objective of this research is to identify unique corn varieties that have desired qualities for distillers and compare varieties against each other as well as the location in which they are grown. This must be done by holding all other variables on whiskey production consistent. The following were specific hypothesis for the project.

1. Corn variety has an impact on productivity, agronomic feasibility, and the un-aged whiskey distillate it produces
2. Unique corn varieties differ in where they are best suited to be grown across Michigan
3. Precursor compounds involved in aging reactions vary in concentration within each variety
4. There is a sensory and analytical difference in corn variety which is apparent and concentrated in the un-aged whiskey

Methods

Twenty varieties of open pollinated corn were sourced from locations around the United States. Local and regional experts that have worked with open pollinated corn were asked to advise on what varieties may be best suited for Michigan's climate and the distilling process. We also leveraged information from the first year (2022) of this study to refine the variety list. The varieties selected ranged from identity preserved heritage varieties to landraces to more recently developed varieties. A commercial hybrid #2 yellow dent variety was used as a check.

The 20 varieties were grown (~May planting) in 2023 at three locations where randomized complete block designs were utilized to plant four replications of each variety. The three locations were at MSU research farms in Kalamazoo, Ingham and Alger counties. These locations were chosen to provide a latitudinal gradient that will result in a wide range of weather conditions across the state of Michigan. Each plot was approximately ten feet wide and 20 feet long, with some buffer space in between each plot. The corn was managed using best management practices for conventional corn, including tillage, fertilizers, and pesticides to achieve the highest yield and protect grain from disease or degradation. Harvest occurred in the fall (November) using a plot combine or hand harvested. After collecting yield data on individual plots, grain samples were taken from each plot, and a larger composite grain sample was collected from each variety at each location for grain quality analyses. Grain quality analysis was conducted at the MSU UPREC Grain Quality Lab including grain moisture, test weight, and protein, starch, and oil using NIR. Hartwick College Center for Craft Food and Beverage completed analysis on protein, starch and oil using wet chemistry as well as Predicted Spirit Yield based on fermentable extracts for each variety. The site with the best grain quality for each variety was selected for further distillation and analyses in the fermented beverage analysis lab at MSU. In 2023, 18 varieties were selected from Kalamazoo County and two from Alger County.

At the Fermented Beverage Analysis Lab, the corn was milled, mashed, fermented, and distilled into an unaged whiskey distillate. The unaged whiskey made from each variety will go through multiple analysis after the completion of this funding cycle, including HPLC, GC and sensory analysis to help differentiate the varieties.

Results

The 2023 growing season was challenging across Michigan, with drought conditions persisting from early May until early July in southern and mid-Michigan, and cooler than average conditions across the entire state. The dry spring weather led to challenges with crop establishment at the Ingham County site where dry soil resulted in poor and uneven crop stands. Dry soils and cool conditions led to delayed crop progression at all three sites, resulting in some varieties not reaching maturity at the Ingham and Alger county locations, and wet grain moisture at harvest at all sites. An August storm caused substantial lodging at the Ingham county site. The varieties that reached physiological maturity exhibited ears of corn that were a remarkable range of colors, shapes, and sizes (Figure 1).

The Kalamazoo County site was the overall best performing location with good crop stands and harvestable grain for most varieties, except for two that were destroyed by raccoons (Atomic Orange and Montana Morado) and one with poor emergence (Otto File). A subset of the varieties including Bloody Butcher, Boone County White, Hickory King White, Jimmy Red, Reid's Yellow Dent, and Trucker's Favorite, grew substantially taller than the other varieties, including the Dekalb Hybrid DKC 5615 control. Lodging was minimal, with some varieties exhibiting some leaning but none that were un-harvestable. Of the 18 varieties harvested, yields ranged from 220 bu/A (Dekalb Hybrid Control) to 49 bu/A (Nothstine Dent), with an overall plot average of 104 bu/A. The highest yielding open pollinated variety was Ohio Blue at 129 bu/A, which was over 90 bu/A less than the control hybrid. Moistures at harvest ranged from 20.2% (Nothstine Dent) to 36.8% (Boone County White). Test weights averaged 57.6 lb/bu and ranged from 60.9 lb/bu (Experimental Hybrid 4) to 53.3 lb/bu (Boone County White).

Thirteen varieties were harvested at the Alger County location, but only five varieties (Atomic Orange, Montana Morado, MN 13, Otto File, & Wapsie Valley) were mature enough by the first killing frost to have grain test weights of 50 lb/bu or greater. The remaining eight varieties harvested were immature when killed by frost, but still harvested to evaluate possible end use. Yields in Alger County of varieties harvested averaged 47 bu/A, ranging from 17.2 bu/A (Otto File) to 81 bu/A (Experimental Hybrid 4). Grain test weights averaged 49.1 lb/bu, and ranged from 45.3 (Experimental Hybrid 4) to 54.2 (MN 13). The Dekalb Hybrid Control was not harvestable at this location.

The Ingham County site suffered from poor and uneven plant stands due to dry soils at planting. A storm in August caused severe lodging in most plots and we were unable to harvest them with a combine. However, we were able to manually collect ears from 10 plants in each plot which allowed us to conduct grain quality analyses and some estimates of agronomic characteristics such as yield.

Overall field observations and agronomic data lead us to the following conclusions.

- Two varieties have short plants and are early maturing making them suited only for northern Michigan locations. Care must be taken to protect these varieties from racoon damage, especially if planted in small fields. (Atomic Orange, Montana Morado Maize)
- Six varieties evaluated originated in southern U.S. locations and require long growing seasons to reach maturity, which makes them only suitable for southern Michigan locations

in warm years. These varieties also tend to be very tall. (Bloody Butcher, Boone County White, Hickory King White, Jimmy Red, Reid’s Yellow Dent, and Trucker’s Favorite)

- Six varieties appear suitable to grow across the entire state of Michigan, although more years of evaluation may provide more information about ideal growing locations (Choices F1, Experimental Hybrid 4, MN 13, Northstine Dent, Otto File, Wapsie Valley)
- Six varieties appear to be most feasible in the southern half of Michigan (Dublin, Hopi Blue, Jerry Peterson Blue, Oaxacan Green, Ohio Blue, Strubbes Orange)

Table 1. Yield, test weight and grain moisture at harvest information for the Kalamazoo and Alger county locations.

	Yield (bu/A)		Test Weight (lb/bu)		Moisture at Harvest (%)
	Kalamazoo	Alger	Kalamazoo	Alger	Kalamazoo
Atomic Orange		17.9		53.1	
Bloody Butcher	111.3		56		28
Boone County White	95.6		53.3		36.8
Choices F1	137.3	67.4	60.6	47.7	21.6
Dekalb DKC 5615	220		57.1		22.6
Dublin	87.1	43.4	58.5	46.4	21.5
Exp HYB 4	119.3	81.3	60.9	45.3	21.8
Hickory King White	102.6		54.5		35.4
Hopi Blue	83.7	26.2	54.3	45.6	30.1
Jerry Peterson Blue	62.8	44	56.6	49.6	25.6
Jimmy Red	103.5		56.6		27.6
MN 13	123.1	68.7	59.6	54.2	20.7
Montana Morado		36.9		51.5	
Northstine Dent	49	43.4	57.4	49.6	20.2
Oaxacan Green	80.7	33.8	58.3	47.9	24.2
Ohio Blue	128.5		60.2		29.3
Otto File		17.2		51.1	
Reids Yellow Dent	114		58.7		27.9
Strubbes Orange	51.2	54.1	56.9	47.1	22.1
Truckers Favorite	89.8		57.5		32.4
Wapsie Valley	111.4	72.7	60.2	49.6	22.2
Average	103.9	46.7	57.6	49.1	26.1

Composite grain samples from all harvestable varieties at each site were sent to the Hartwick Center for Craft Food and Beverage for protein, starch, oil, and predicted spirit yield (Modified Cereals 5 with High Temp Alpha Method) analysis. Protein and starch content varied slightly between sites, but more between varieties within a site. For example, the Ingham County site ranged from 9.2% protein (Dekalb Hybrid Control) to 11.9% protein (Three Varieties). Predicted spirit yield was highest from the Ingham County site (347 LAA/Tonne) and lowest from the Alger County site (288 LAA/Tonne). The high spirit yield values from the Ingham County site could have resulted from selective hand harvesting of quality ears that resulted from poor plant stands. See data for each variety per site in Table 2 below.

Ten pounds of grain from each variety at the Kalamazoo County location were mashed and distilled in Dr. Nicole Shriner’s research laboratory to determine amount of distilled product that could be produced from a sample of each variety. Most of the varieties have been processed and analyzed at the time of this report, but several are still in process. Results for hearts yield (Proof Gallons per 1,000 lbs) are reported in Table 2 below.

Table 2. Selected grain quality data from each variety harvested at each site. LAA/Tonne = Liters of Absolute Alcohol per metric Ton. PG/1000 lbs = Proof Gallons (at 50% Alcohol by Volume) per 1,000 pounds.

Variety	Protein %			Starch %			Predicted Spirit Yield (LAA/Tonne)			Hearts Yield (PG/1000 lbs)
	Kalamazoo	Ingham	Alger	Kalamazoo	Ingham	Alger	Kalamazoo	Ingham	Alger	Kalamazoo
Atomic Orange			11.8			69.5			256	
Bloody Butcher	10	11.9		70.1	69.2		345	332		46.5
Boone County White	10.5	11.9		69	69.4		332	321		
Choices F1	10.9	10.4	11.4	69	69.3	69.2	263	358	269	37.7
Dekalb Hybrid Control	9.4	9.2		69.6	70.2		274	377		43.0
Dublin	11.4	10.9	11.1	69.2	69.2	69.7	287	342	272	
Exp HYB 4	11.7		11.7	68.6		69.1	322		285	33.5
Hickory King White	10.6			69.2			323			46.6
Hopl Blue	10.4	10.7	12.6	69.5	69.8	68.5	346	345	297	33.9
Jerry Peterson Blue	11.7		11.7	69.2		68.9	293		327	39.1
Jimmy Red	10	11.9		69.9	69.3		337	321		39.0
MN 13	10.6	11	11	69.5	68.9	69.9	294	356	235	44.8
Montana Morado			11.4			69.2			339	44.5
Northstine Dent	11.8	11.6	11.5	67.8	68.6	68.6	335	356	301	32.2
Oaxacan Green	11.9	11.3	12.7	68	70.2	68.8	274	355	248	48.1
Ohio Blue	10.3			69			325			37.3
Otto File			11.6			69.5			336	27.5
Reids Yellow Dent	10.8	11.4		68.9	70.4		321	348		
Strubbes Orange		11	10.8		68.9	70.2		344	302	
Truckers Favorite	10.3	11.3		69.3	68.8		331	350		
Wapsie Valley	10.7	10.7	11.3	69.5	70	70.3	274	359	281	
Average	10.8	11.1	11.6	69.1	69.4	69.3	310.4	347.4	288.3	39.5

Additional tables or charts available on request from the principal investigator.

Communication Activities

Several groups of interested stakeholders were able to visit the research plots in the late summer and fall at the Kalamazoo and Alger County locations to see this variability first-hand. These included attendees at formal field days, and individual visits from interested distillers. Side conversations with multiple distillers and farmers around the state of Michigan resulted from these corn trials, and several distillers are already using open pollinated corn alternatives for spirit production. Wapsie Valley seems to be the variety most used currently by Michigan distillers, but interest is also high related to Bloody Butcher, Ohio Blue, Oaxacan Green, MN 13, Otto File, & Northstine Dent which we are following up with more intensively in subsequent trials. Our ultimate goal is to provide enough information, and possibly seedstock, that Michigan distillers can start working directly with farmers to grow varieties of interest at production scale.

Season long observations and preliminary results were shared with a breakout room audiences at multiple conferences including the Great Lakes Crop Summit in Mt. Pleasant on January 25, 2024 and the inaugural Michigan Craft Beverage Summit in Kalamazoo on March 4, 2024.



Figure 1. Nine of the varieties harvested from the Kalamazoo County site lined up to show the diversity of ear and kernel colors, shapes and sizes.

Budget Narrative

The project was conducted consistent with the budget proposed by the principal investigator and approved by the State of Michigan. The Corn Marketing Program of Michigan has been providing additional funding (\$10-20K per year starting in 2023) for agronomic trials with a subset of these varieties at two locations in southern Michigan. We've primarily been using these funds to evaluate optimal seeding rates for Wapsie Valley, Ohio Blue, Bloody Butcher and MN 13, learning which varieties can tolerate modern high seeding rates.

Several Michigan distillers have volunteered time to help with evaluation of the varieties post harvest, including some corn bread trials with a subset of varieties and also participating in our panel of tasters for distillate produced in Dr. Shriner's lab.