Separating the Wheat from the Wheat

Accurate infield weather at a world-class varietal development program's testing sites is critical to breeding seeds for a changing climate.

THE CUSTOMER

The wheat breeding program at University of Nebraska - Lincoln's Institute of Agriculture and Natural Resources, one of the world's premier research institutions.

THE DEPLOYMENT

3 devices | USA | 2018-2021

KEY TAKEAWAYS

- Wheat researchers at a leading agricultural university breed varietals that must meet growers' requirements and thrive in the challenges of future environmental conditions.
- Varietal performance depends on weather; recent climate volatility makes historical data less relevant, while gridded weather can miss significant pop-up storms.
- Arable data from three trial locations across the state's climate zones deliver granular insights to truly understand cause and effect on varietals.

UNL wheat research trials can take up to 12 years to produce a varietal considered viable enough to release to growers commercially.

The Customer

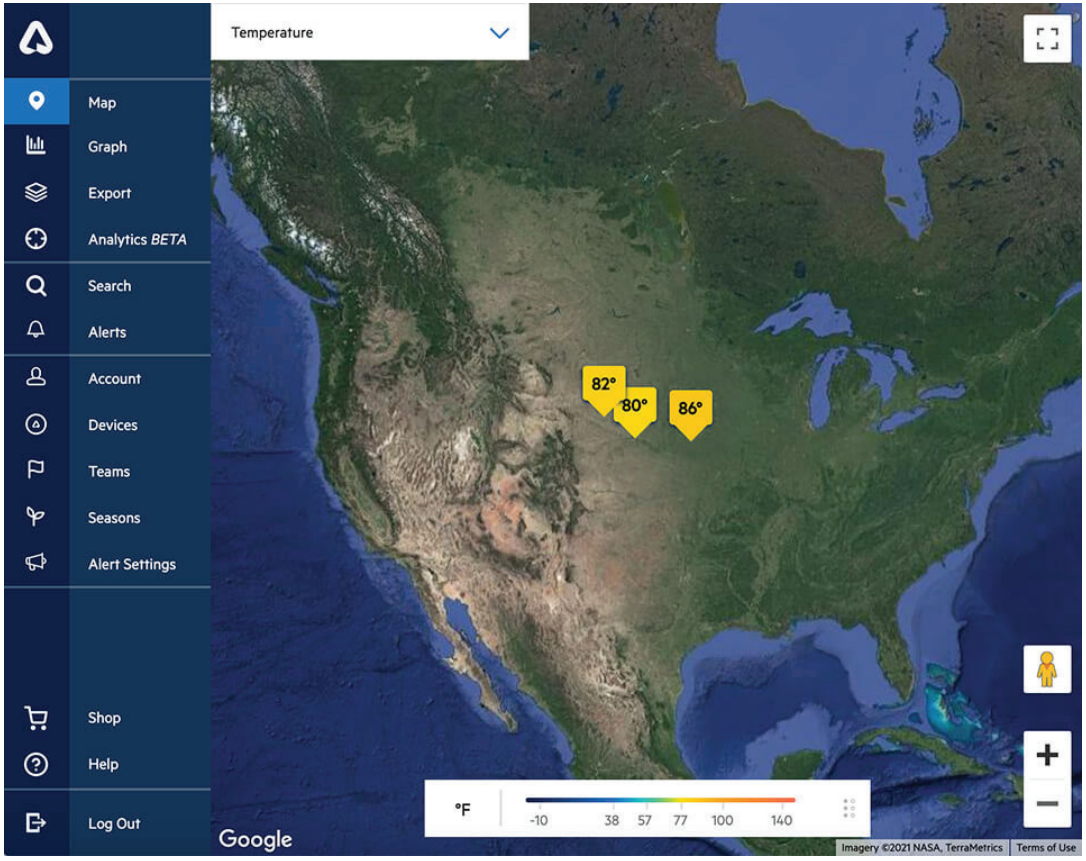
The University of Nebraska's Institute of Agriculture and Natural Resources, one of the world's premier research facilities, was established by the U.S. Congress 150 years ago as part of a national land-grant university system. A hallmark of land-grant universities is the cooperative extension program, an initiative that, in the words of the U.S. government, "emphasizes taking knowledge gained through research and education and bringing it directly to the people to create positive changes."

The University of Nebraska-Lincoln (UNL) Extension provides robust services for a state in the heart of America's breadbasket, and prides itself on rigorous and unbiased research and recommendations on crop production and pest management. The university's variety testing program, established in 1943, develops new seeds each year, including winter wheat, the state's third largest crop grown after corn and soybean. Dr. Stephen Baenziger ran the program until he handed the baton to the project's current lead, small grains breeder Dr. Katherine Frels, in March 2021.

The Deployment

Wheat is largely a dryland (non-irrigated) crop in Nebraska, which makes weather conditions especially decisive in outcomes. Although the state has a reputation for being wide and flat, the climate of the Great Plains is anything but simple. Weather in the east tends to be relatively wet, with about 27” (690mm) historical annual rainfall at about 1,000 feet (300m) above sea level. In the panhandle region, over 400 miles west, it’s a different story. The high altitude desert receives about 12” (300mm) of rain a year and rises to about 4,300 feet (1,300m). The center of the state is a transitional zone that sees just about everything in between.

Even though three-quarters of wheat is grown in the western part of the state, UNL must do field research in each of the climate zones to understand how crops will fare in each location. With a focus on ground-truth weather, Baenziger deployed one Mark 2 device at each of three research sites, Eastern, Panhandle, and West Central, in 2019, 2020, and 2021. The Eastern nursery near Lincoln covers about 20 acres (8 hectares), and the others about 2 acres (just under a hectare) each.



Three UNL wheat breeding program Arable Mark 2 locations as seen in Arable Web Map view, in June, 2021.

The Challenge

Winter wheat is a rainfed crop with a long season. Depending on climate, it is generally planted August-October and harvested the next June-July, followed by a fallow year or no-till rotational crop to recharge the water in the soil for the next season. The crop spends much of its life in a fragile state of dormancy whose bookends are triggered by uncontrollable infield weather conditions. As a result, wheat growers have a lot riding on their crop outcomes. They can't afford to make uninformed choices about what varieties to grow because their livelihoods are at stake.

Each year, the experts at UNL develop a suite of wheat lines, but only release one, a product of about 12 years of testing. For Frels, the central question is, "How can we make a better decision on that one so that it works better for farmers?" Criteria for release include demonstrated suitability for certain growing conditions, yield, and resilience characteristics, all of which hinge on the weather. Part of the reason trials take so long is that researchers want to observe varietal performance across a sample set of weather conditions, and it just takes time for the clouds to roll in and out.

In addition to the climate variability across Nebraska, and increasing weather volatility in general, highly localized pop-up storms can arise out of nowhere, shifting weather patterns in a matter of minutes. The UNL researchers have a deep understanding of weather patterns and the environment they test in, but as it becomes more erratic and intense, reliance on historical patterns—even 150 years of them—is difficult for prediction.

Remote access to reliable data from different geographies is also an issue. The Nebraska mesonet weather station closest to UNL's panhandle site sits on airport turf 20 miles away from the trials. In addition, the university's research facilities in the east are well-staffed with better data than those in the west, but they are located hundreds of miles from the center of the state's wheat production. "We need to have better ways to interpret whatever data we can get out of our trials," explains Frels. "We have to somehow predict the future when we make our selections in our breeding programs. Adding in tools like Arable will give us the chance to do that."

A pop-up storm like this one in Nebraska can complicate gridded weather forecasts, highlighting the need for infield weather measurements.

“Better data at trial sites gives us the context we need to interpret how the varieties performed.”

DR. STEPHEN BAENZIGER
UNL WHEAT RESEARCHER

The Goal

Success for the UNL wheat research team is developing a variety that meets growers' needs, meets the challenges of future environments, and does well every year.

By his own recollection, during a career at UNL spanning nearly four decades, Baenziger has released around 42 wheat varieties. He speaks of them like they are his children; Pronghorn was his 4th. He developed it for western growers, and it continues to sell out in that region. They love it because it germinates quickly. Even though it showed problems with sprouting when there was a lot of moisture at harvest, that was what actually made it well suited for drier places like the panhandle.

The team wants to replicate wins like this, using highly specialized performance conditions to their advantage to create the breed with the best fit. "My dream scenario is figuring out how to integrate weather data to make decisions on which variety is good for which region, so that the trials we plant out in the west can work harder for us," says Baenziger. "Better data at trial sites gives us the context we need to interpret how the varieties performed."

An Arable Mark 2 in late-season wheat. Arable's contribution to the UNL wheat team's work is centered around accurate, reliable infield weather data—especially temperature, rainfall, solar radiation, and humidity—to help them make better recommendations based on past results.

The Strategy

A colleague of Dr. Baenziger's, Dr. Trenton Franz, first turned him onto Arable's technology through his work in geospatial research relative to understanding field variability in seed trials. Creating feedback loops through the ability to easily share data across teams (and generations within the same team) is an important component of continuous data quality.

Arable made that easy. In addition to simple team management, from layered permissions to actionable weather, device, and crop growth stage alerts, Arable's Graph function allows real-time and historical comparisons of multiple measurements to make new connections between weather conditions and crop response. Since Arable data is anchored to a location, Dr. Frels could sift through past seasons at a site to gain insight into how conditions affected outcomes before she even joined the team.

Shown here in Arable Web at the panhandle location, 48 hours of canopy evapotranspiration overlaid with solar radiation. Also shown at the bottom are the previous 30 days of data at a glance. Visualizing data like this helps researchers make new connections in how crop varietals respond to weather conditions.

Convenience and replicability are also important for a research methodology that involves rotating cohorts of graduate students with varying degrees of experience setting up agtech hardware. During the four seasons Baenziger has used Arable, he has not had a problem. "Basically, we take them down at the end of the season, put them in a shed, take them out the next season, put them up, let the battery charge, punch go, and it's on."

Arable's contribution to the UNL wheat team's work is centered around accurate, reliable infield weather data—especially temperature, rainfall, solar radiation, and humidity—to help them make better recommendations based on past results, even the painful ones.

One promising variety, Rawhide, was shown to be very responsive to the kind of stressful growing conditions found in the west, with a yield 12 bushels higher than any other in the trial. For twelve years, it came out looking beautiful each time. But the first year after it was released and planted in actual growers' fields, there was a record high in the 70s F (low 20s C) for January, and the non-photoperiod-sensitive line broke dormancy. Over the course of three days, temperatures steadily dropped to around -10F (-23C), and about 70% of the line winterkilled.

"We can't predict the weather, but we can tell our growers, here's what you have to watch out for, here are the risks that you may be taking, you make the decision," says Baenziger. Frels chimes in, "Having better data at the trials might have helped us avoid that." It's possible that at one location they may have observed that breaking-dormancy behavior, but not known exactly why, and chalked it up to a bad year, a bad trial. "But when we have better data about what happened to that trial, it gives us context to interpret the results from that trial."

The Results

The pressing need for location-based weather initially took the researchers by surprise, since they had gotten by without it for decades. But after the Rawhide incident incurred real loss, and with each passing year showing more and more concentrated extreme weather events—heat, cold, storm, drought, or some unusual combination of all of them—weather soon became obvious as the limiting factor in getting high quality data to produce location-specific varieties.

Even with soil variability atop the Ogallala aquifer (usually the soil doesn't vary that greatly), they know that weather variability is what influences outcomes most. According to Baenziger, "Maybe someone got a timely rain, someone else didn't. Or, it got really hot and this variety was at an earlier stage than the other, so it missed the heat stress, whereas the other one got the heat. That's the type of thing we're seeing."

In one particular trial on herbicide resistance during the 2020-2021 season, they sprayed right before a cold snap, and the herbicide showed terrible results. Armed with infield weather data, the researchers knew the product had reacted badly to the cold, and can take that into consideration when evaluating future results. "Although it may still turn out to be a bum product with more testing," Baenziger laughed, "without knowing the precise weather conditions, I might have thought it was a worthless trait, and abandoned it right then. I couldn't put my reputation behind it and give it to a grower."

The Outcome

Ultimately, for UNL researchers with a decades-long reputation as trustworthy, unbiased straight shooters, having the right tools to make good recommendations that withstand scrutiny and years of use is important. “We’re their team,” says Baenziger, of the growers who use their seed. “Arable is a tool like any other in a toolkit we use to do our jobs well—combine, planter, weather station. It is like an adjective that can enrich the understanding of the environment we are all working in.”

While a public research institution is not completely oriented around the bottom line, using taxpayer dollars to fund their work means these tools must withstand budget scrutiny and serve many functions. “Arable is inexpensive, durable, and the price is right for us.”

As Frels takes the reins from Baenziger, she must think today about what wheat growers will be planting more than a decade from now. At this critical stage in climate projections, that future is even more unknowable than today’s conditions were a decade ago. She is working with Arable’s customer success team to incorporate more of the crop growth and analytics features into her analysis, to find more ways to measure which wheat characteristics respond to which weather conditions, and how those interactions lead to outcomes.

Achieving a variety that growers are happy with, fares well in Nebraska’s future climates, and proves itself year after year without getting flattened by an extreme weather event is more than a goal, it’s an imperative. “It’s about building and maintaining trust,” Baenziger says. “Nobody can predict the future, but we can lay out our findings, tell the growers what we’ve seen and say, ‘You evaluate the risk’.”

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