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How Will the GPS Outage on May 10 Affect US Farm Profitability?

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May 31, 2024

***farmdoc daily* (14): 103**

Recommended citation format: Griffin, T. "How Will the GPS Outage on May 10 Affect US Farm Profitability?" *farmdoc daily* (14): 103, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, May 31, 2024.

Permalink: https://farmdocdaily.illinois.edu/2024/05/how-will-the-gps-outage-on-may-10-affect-us-farm-profitability.html

Since May 10th, a new question has been getting economists thinking: How will the GPS outage associated with the geomagnetic solar storm affect US farm profitability during the 2024 cropping season? The answer, as usual, is that it depends, especially on who, what, where, and when.

The GPS outage occurred during planting season (when) for many crops across the heartland (where). In 2024, farm operations have become more reliant upon GPS technology (what) than at any other time in history. Some farm operations were more vulnerable to the GPS outage than others (who).

Farmers' Use of GPS

Global navigation satellite systems (GNSS) such as the Global Positioning System (GPS) have become an integral part of agricultural technology since the 1990s (McFadden et al., 2023). Farm operations not relying upon GPS during the outage on May 10, 2024, are likely to experience negligible yield and revenue differences. However, for farms relying upon GPS (i.e., navigation, automated row shutoffs, or variable rate input applications), whole-farm losses may be nontrivial. As automated guidance became more common, planters became wider due to GPS negating the necessity of physical row markers. Without row markers, planters could be much wider; however, this exposes farmers to downtime risk due to GPS outage vulnerability.

Understanding Downtime Costs on Farms

Intuitively, downtime during crucial planting windows is associated with yield penalties and reduced revenue. If all cropping acreage were unable to be planted with available equipment within the expected time, some acreage would be transferred to less desirable times to be planted later. Some planting dates may have lower potential harvestable yield; therefore, revenue losses can be calculated based on yield differences. Although many downtime models assume that the event in question occurs during a suitable day for fieldwork, Irwin (2024) noted wet years tend to displace planting later into the season thereby causing overall yield loss; and that late planting was the third leading cause of yield variability in their modeling (Irwin, 2023). Nafziger (2020) reported long-term yield response to corn planting dates; suggesting that mid-April had nearly 100% of the maximum yield while mid-June planted corn may have 80% of the maximum yield.

Assuming a 200-bushel expected harvested yield for one acre planted in mid-April, the June-planted corn was expected to have a 40-bushel penalty at 160 bushels harvested. Acreage that experienced delayed planting had $180 lower revenue per acre than if it had been planted in mid-April assuming a $4.50 per bushel corn price (Paulson and Schnitkey, 2024). Applying the same logic to the maximum yield percentage charts from Nafziger (2020) indicates about 95% potential harvestable yield on about May 10; a penalty of $90 per acre for Illinois farmers who planted that one acre at the end of May.

May 10 maximum yield percentage = 95%

May 31 maximum yield percentage = 85%

95% maximum yield - 85% maximum yield = 10% yield percentage difference

200 bu * 10% maximum yield difference * $4.50 per bu = $90 per acre

Although the single-acre example is useful for discussion, it is not applicable across all farm acreage. Evaluating a 3000-acre farm requires additional knowledge of machinery capacity. For instance, effective field capacity, measured as acres per hour, differs by planter size. An 8-row planter covers 13.4 acres per hour while a 12-row can plant 20 acres per hour. Using these examples, a 12-row planter covers 80 acres over 4 hours; alternatively, 80 acres would be transferred later in the season to be planted if using the 12-row planter during a downtime event. The greater the effective field capacity, the greater the yield penalty when planted later. Some displaced acres may have been transferred to different planting dates, each with a different maximum yield percentage.

Calculating whole-farm losses builds upon the above example but necessitates specialized software. The Purdue University linear programming software, e.g., PC-LP Farm Plan, (Doster et al. 2010) has been applied to a range of downtime scenarios. One classic downtime example is the $1000 lunch, which conveys the whole-farm penalty of shutting down the farm operation during peak planting times to take an extended lunch in town. A relevant downtime formulation that can be extrapolated to the solar storm events of May 10 calculates the whole-farm costs of diverting field equipment away from production practices for one-half day so that an on-farm experiment could be implemented during peak planting time (Griffin et al., 2014) (see Doster et al., 2006 for crop yield response to plant and harvest dates used for their study).

Based on parameters associated with the 2011 production season for the eastern corn belt, whole-farm losses of $2,684 were calculated when the one-half day of suitable fieldwork days were removed during late April, but acreage planted at the end of the season (Griffin et al., 2014). These loss estimates may be extrapolated to the May 10 GPS outage by adjusting for inflation and differences in potential harvested yield percentages for weeks between the outage and planting for specific regions.

Downtime Costs from GPS Outage

Understanding the characteristics of individual farms is very important when parameterizing whole-farm models. Results are sensitive to the timeliness of the farm, e.g., equipment inventory capacity relative to cropping acreage. If planting all acreage could be completed on the same day with or without the downtime event, then results would suggest no tangible penalty for delayed planting.

For farms not employing any GPS-enabled navigation technologies, geomagnetic storms likely had a negligible impact; but for farms reliant upon automated guidance for planting (i.e., larger planters without physical row markers) unexpected downtime may occur during times when seeding operations were planned. Although a substantial portion of US farms are not reliant upon GPS, 70% of planted US acreage uses some sort of GPS (McFadden et al., 2023). Precision farmers that operate these 70% of planted acres are deemed vulnerable to GPS outages.

Farmers' Vulnerability to GPS Outages

In addition to evaluating the downtime costs due to a GPS outage, it is important to understand the value that GPS guidance adds to existing farms. Rather than downtime or uptime scenarios, Griffin et al. (2005) evaluated the benefits of adding GPS-enabled automated guidance to existing farm acreage. They modified the effective field capacity of machinery such that overlaps were reduced from 10% of equipment width to the advertised accuracy of various guidance technologies. Acreage was planted in a timelier manner resulting in $3 per acre net benefits, and when additional acreage could be farmed with existing equipment sets $12 per acre net benefits were realized. Their results provided a foundation for assessing the cost of a regional GPS outage by reversing the adoption of guidance and summing up to nearly $500M for adoption levels at that time (Griffin, 2010). Cost estimates from the regional GPS outage rolled into a much larger project on space weather impacts on agricultural technology (Bishop et al., 2022); and research is underway to assess valuation for the current and forthcoming solar cycle that is expected to arrive in the year 2035. Outages associated with geomagnetic storms are more likely to last a few hours rather than become season-long events.

Relevant portions of the Purdue PC-LP model were developed into an interactive dashboard specific to autonomous cotton harvest systems. A portion of the online tool is devoted to space weather such that the user selects the week of year and duration of the outage. The autonomous cotton harvest downtime model assumes field operations cease during the outage because of reliance on GPS for navigation; however, the next generation of autonomy is being developed to use machine vision, artificial intelligence, and expert systems for guidance to avoid vulnerability to GPS outages. The current autonomous cotton harvest tool is assessable on the development site at: https://shiny.agmanager.info/cottonBotsDev/

Long-Term Costs Beyond the 2024 Season

Loss of farm data benefits are more difficult to estimate than revenue losses from delayed planning; however, forthcoming issues with farm data will be associated with the May 10 GPS outage. A lack of as-applied planting data may adversely impact farm operations that were able to continue planting without guidance. The event on May 10th may not be the only geomagnetic storm impacting farmers' use of GPS in 2024 or 2025; similar events may occur during mid-season spray applications or the harvest of crops. If a radio blackout occurs during harvest, combine harvesters will remain operational without guidance but yield monitor data will not be georeferenced for further analysis or mapping. Lack of GPS for logging georeferenced farm data prevents farm operations from mapping yields, analyzing on-farm experiments, negotiating farmland leases with landowners, or participating in third-party data services.

Summary

Additional downtime analyses may be developed for other crops and regions of the USA. Results presented here can be updated for current price ratios, regions beyond the eastern corn belt such as the Great Plains and Mid-South, and potential harvestable yield by plant and harvest timing for crops in addition to corn and soybean. Region-specific analyses are important because crop yield response to planting dates may be more sensitive or less sensitive than in the eastern corn belt.

When future GPS outages occur during peak field operations, farm operators should be certain if the problem is a local hardware issue or geomagnetic event; knowledge of the possible repercussions of solar activity is important.

Acknowledgements: Terry Griffin is Professor and Extension Cropping Systems Economist specializing in agricultural technology. He appreciates Extension Disaster Education Network (EDEN) supporting exploratory work that he and Kathryn Draeger are conducting on space weather impacts on agriculture. Collaborations with Aerospace Corporation and Rebecca Bishop have been invaluable; especially for Rebecca reaching out to include economics of GPS outage on farms and for bringing awareness to space weather in agriculture.

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