

Hail in the Midwest & Impacts to Agriculture

Key Takeaways



- ◆ Research indicates an **increase in the days favorable for hail** in the Midwest by **2-4 days** since the late 1970's.
- ◆ Future climate modeling suggests an **earlier start to the hail season**, with a **slight increase** in large hail (>1") frequency.
- ◆ Most states have their largest fraction of annual severe hail reports in **May, June, or July**. The monthly fraction of annual hail reports has not changed much since the 1960's.
- ◆ Hail insurance claims for corn and soybean crops over recent years have been most common during **June, July, & August** (time of **peak hail frequency & crop damage vulnerability**).
- ◆ Hail-damaged corn and soybeans **can recover** from less-severe hail damage, but in the case of total loss, **replanting or cover crops** can become viable options.
- ◆ **Protection structures** like wire caging, hail netting, or hoop houses are options for fruit & vegetable producers to **shield their crops from hail damage**.

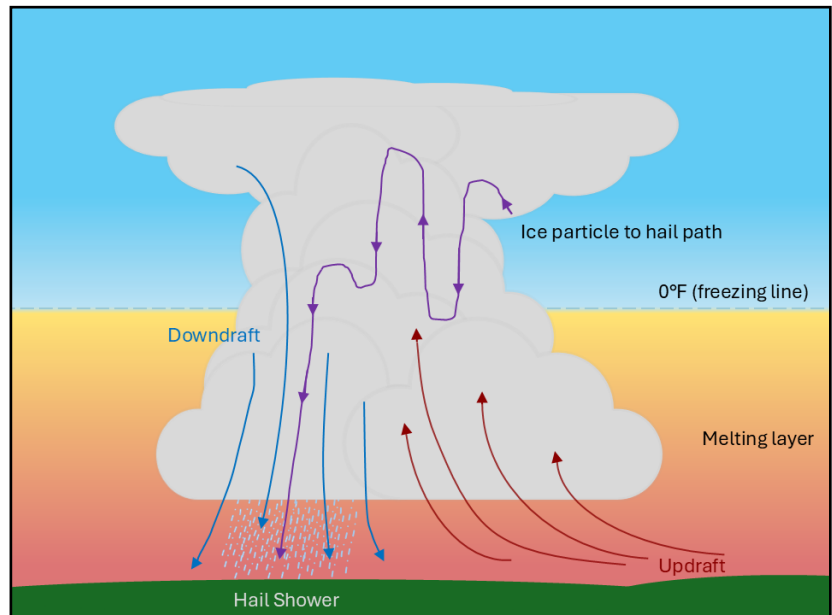


Research Synthesis

Hail is common in the Midwest and Great Plains region during the growing season, where crop losses amount to **~5% of crop value** annually¹. Hail ranges from 1/4" (pea-sized) to 2" (golf ball-sized), though larger hail can occur. The figure to the right shows hail formation in a cumulonimbus cloud. Hail stones form in convective clouds with strong updrafts and high moisture content. An ice particle can remain suspended by the updraft, allowing it to collide multiple times before falling to the surface when the stone either moves out of the updraft or is no longer supported.

Assessing the climatology of hail is difficult largely because the reporting of hail has been inconsistent. To avoid this, researchers analyze **atmospheric conditions that favor hail formation**. From 1979 to

2017, there has been an increase in favorable large hail environments by **2-4 days** in the Midwest². Hail climate change research commonly focuses on hail environments in the high-emission scenario (RCP 8.5). These studies find by the end of the century that, the hail season may **begin earlier in the year**, with a possible **decrease** in smaller hail (due to a larger melting layer) and a slight **increase** in the frequency of large hail (>1")^{3,4}.



Schematic of hail formation within a cumulonimbus cloud (Credit: Tayler Schillerberg).

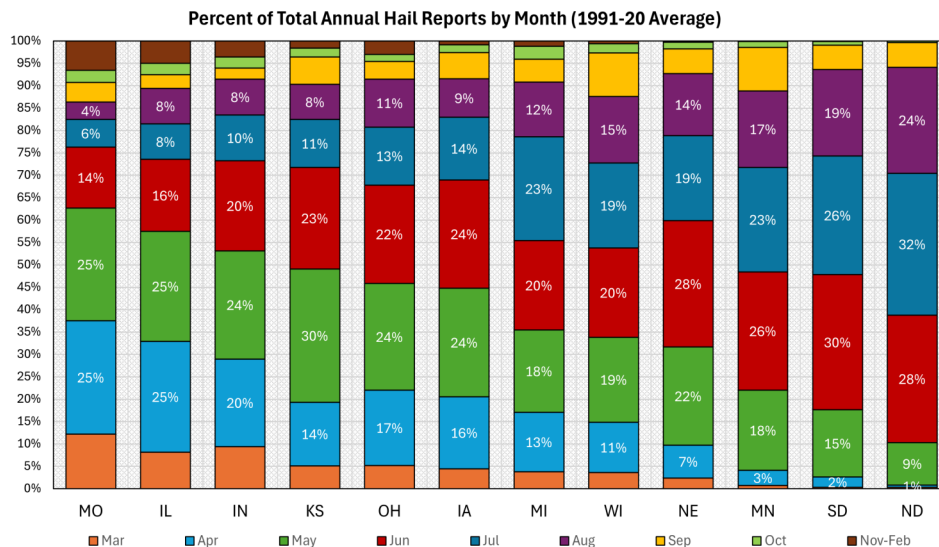




Trends in Hail Seasonality

In the Midwest & Great Plains, the occurrence of hail varies from season to season and by state to state. Using hail report data from the NCEI Storm Events Database, we can determine the average **“monthly hail fraction”**, or the percentage of annual hail reports that occur in a given month.

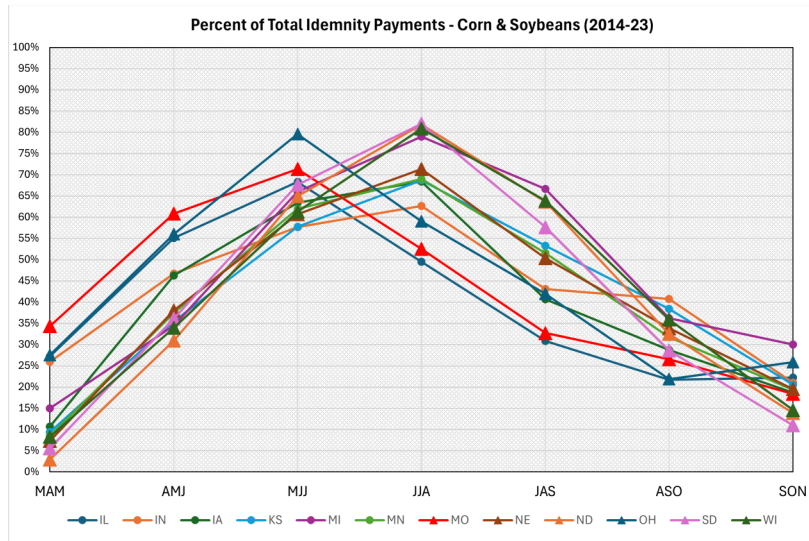
The results of this analysis (shown in the figure on the right) indicate that states in the south, such as Missouri and Illinois, see their highest monthly hail fractions during April and May. However, once we get into June, July, & August, northern states such as Wisconsin, Minnesota, & the Northern Plains have higher monthly hail fractions than their neighbors to the south. **The majority of the states have their highest monthly hail fraction in either May, June, or July.**



Data Source: [Storm Events Database](#), NOAA National Centers for Environmental Information

We compared the monthly average hail fraction between 1991-2020 and 1961-1990. When averaged across all states, monthly hail fraction has slightly increased during April and May, decreased in June and July, and increased from August through November. However, **these changes are minimal** (~2% or less) and are not statistically significant for most states.

A similar analysis of hail seasonality can be done using crop insurance data from the USDA Risk Management Agency. Crop insurance data in the Midwest and Northern Plains is limited for crops other than corn and soybeans, so we will stick with those two crops for this assessment. Similarly to the hail report data, here we are analyzing the 3-month fraction of the annual number of indemnity payments made for hail claims.



Data Source: [AgRisk Viewer](#), USDA Southwest Climate Hub

Over the past 10 years (2014-23), the fraction of annual crop insurance payments made to hail claims is the **highest during the months of June, July, and August (JJA)** for most states. As shown above, these are the peak months for hail occurrence. Plus, the corn and soybeans are actively growing during this time and are vulnerable to damage.

We analyzed the average monthly indemnity payment fraction for other decades going back to 1989 and compared them to 2014-23. There were **no clear shifts in monthly fraction over time**, with the JJA fraction remaining the highest.





How to Assess, Manage, & Mitigate Hail Damage

DAMAGE ASSESSMENT

There are several Midwestern Extension resources that guide producers on how to **assess and cope with hail damage to crops**. See below for links, sorted by crop:

Corn & Soybeans: [Nebraska](#), [Minnesota](#) (Corn), [Minnesota](#) (Soybean), [Purdue](#), [Iowa State](#), [South Dakota State](#)

Alfalfa: [Wisconsin](#)

Fruit: [Michigan State](#), [Minnesota](#)

Vegetables: [South Dakota State](#), [Iowa State](#)

CORN & SOYBEANS

When making decisions on how to move forward after a hail event, make sure to first discuss your plans and options with your crop insurance agent.

Plants can recover from hail damage up to a point. Whether fields can recover from damages or are a total loss, there are **several options to consider**:

- **Replanting** is an option when fields are a total loss early in the season, but be sure to contact your seed suppliers as soon as possible to **confirm seed availability**.
- **Chopping** damaged crops as **livestock feed** could be a viable option, but account for reduced feed nutrient values and forage utilization intervals for applied pesticides.
- **Cover crops** seeded in areas of severe damage can be hayed/chopped, grazed, or simply left in the field to provide soil health gains.
- In damaged fields, focus on staying on top of **weed and insect issues** that hail-damaged plants are more susceptible to. Plants that survive but have damage are also more susceptible to **bacterial infection**, which fungicides will NOT help with.

FRUITS & VEGETABLES

For fruit trees and small-scale vegetable plots, there are options for **hail protection structures**:

- **Wire caging or hail netting** are viable options to keep smaller vegetable plots protected.
- **Permanent structures**, like hoop houses with metal framing.
- **Hail netting** draped over fruit trees or suspended overhead of the trees (see image to right).
- All such structures must be able to **withstand the high winds** that often come with hailstorms & **should NOT** restrict pollination.



Wounded fruit and vegetable crops are very susceptible to **bacterial infection**. For vegetables like tomatoes and peppers, it is better to **remove the damaged fruits** to allow non-damaged fruit to more-readily access nutrients. In fruit crops, **sprays** can be used to reduce the spread of disease or measures can be taken to **protect highly-susceptible varieties** from the disease spread from infected crops (ex., fire blight in apples). More intense hailstorms can cause **damage to the fruit tree** itself, which is very important to treat promptly.

References & Data Sources



- 1) McMurdie, W. L., & Houze, R. A. (2006). 8 - Weather Systems. In J. M. Wallace & P. V Hobbs (Eds.), Atmospheric Science (Second Edition) (pp. 313–373). Academic Press. <https://doi.org/10.1016/B978-0-12-732951-2.50013-2>
 - 2) Tang, B. H., Gensini, V. A., & Homeyer, C. R. (2019). Trends in United States large hail environments and observations. NPJ Climate and Atmospheric Science, 2(1), 45. <https://doi.org/10.1038/s41612-019-0103-7>
 - 3) Trapp, R. J., Hoogewind, K. A., & Lasher-Trapp, S. (2019). Future Changes in Hail Occurrence in the United States Determined through Convection-Permitting Dynamical Downscaling. Journal of Climate, 32(17), 5493–5509. <https://doi.org/10.1175/JCLI-D-18-0740.1>
 - 4) Brimelow, J. C., Burrows, W. R., & Hanesiak, J. M. (2017). The changing hail threat over North America in response to anthropogenic climate change. Nature Climate Change, 7(7), 516–522. <https://doi.org/10.1038/nclimate3321>
- Extension Articles: Iowa State, Michigan State, Minnesota, Nebraska, Purdue, South Dakota State, & Wisconsin → refer to links under “Damage Assessment” on page 3
- NOAA National Centers for Environmental Information (NCEI): Storm Events Database. <https://www.ncdc.noaa.gov/stormevents>
- USDA Southwest Climate Hub: AgRisk Viewer. <https://agrisk.jornada.nmsu.edu/rma/rma-data-viewer.html>



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