Leading Crop Weather Indicators

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Weather is not the only risk in crop production and marketing, but it is the major risk both at the farm and at national levels. Understanding the soil moisture reserves, the El Niño and the 19-year climate cycle (the leading crop weather indicators) is basic to the management of risk.

Uncertainty and Risk

Weather is the principal cause of variability in the production, management, and marketing of agricultural products. It is typical for an economic analyst to provide 3 scenarios when making an annual grain supply-demand outlook: high yield, trend-line yield, and low yield. The producer should plan and manage with the realization that the outcome may be any of the three. In economies where the producer also markets the yield, the producer must consider the impact of all three possibilities on the time value of the produced crop. In managed economies the national planner must make the decision for the society. In either case, risk and uncertainty are present.

Weather includes risk and uncertainty. To the extent possible, the planner should consider weather as a risk and respond accordingly. By physical definition risk can be managed and managed to the advantage of the planner. Uncertainty cannot be managed, as it is not quantifiable. Some risk (such as the chance of excessive water reducing U.S. corn yield) may by be ignored in some computations for simplicity, as it is only a remote possibility (only twice in 100 years has excessive water substantially reduced national yield). The risk of delayed planting for the individual farm cannot, in general, be ignored. Climatology has provided considerable risk information to the cultural community. Producers and consumers are subject to the impact of weather and must accept the possible impacts either as Risk (that they may manage to improve their economic sustainability) or as uncertainty. The general population seems to accept uncertainty but becomes very upset when the price of food and fiber increases beyond their budgeted means. In the latter case politicians are usually accused of poor risk management.

Evaluating Risk

Risk may be accepted as random or an effort may be made to evaluate the risk at a point in time. There were 17 widespread drought situations in North America during the past century. The risk of drought could be analyzed as 17%, or stated as one chance of a drought year in every six years. Likewise the "risk" or perhaps better stated, "chance" of a crop that yields at least 10% above the trend (expected "average" yield) may be one in four or five (23%). The overall one-in-six risk assessment is not sufficient for most planners; they wish to know if the risk for current
next year is higher or lower than the one-in-six. Most wish to know the weather outlook to one-in-one and then know exactly what crop yield will result. When they cannot know these factors they too often arbitrarily decide what it will be and proceed to manage for no other eventuality (in the year 2000, many decided there would be a drought to reduce grain yield to 50% of trend in the hemi-sphere and marketed accordingly, causing a loss to the farm economy of more than $3 billion US).

A scientific forecast of risk during a specific time period can be useful. The long-range forecast is generally presented in the form of a risk and as such may be implemented in an agricultural risk management system. Simply knowing the risk of warm or cool, dry or wet conditions is not sufficient. The weather risk must be related to the growth and development of a crop or some other factor that has direct economic impact. Often a farmer will state that if the weather forecasts were perfect, his troubles would be over. Occasionally, I ask a farmer what he will do if I guarantee a warm spring and a cool summer with slightly below average rain. I seldom get a definitive response. First you must know exactly what to do for each situation assuming a perfect forecast, and then apply the risk of that scenario being expressed. The application of risk management will provide the optimal hedging against the eventualities. [There is risk of tire failure so most carry a spare tire in their vehicle, thereby reducing the risk of serious disruption of their program when a tire fails. Most do not carry two spare tires, as the risk does not warrant this much hedging. A racecar driver typically, and appropriately, carries 8 spare tires.]

Sustainable production requires that risk be managed to the load carrying capacity of the producer or of the system as the case may be.

**Leading Long Range Indicators**

The leading long-range indicators of agricultural weather may be considered to be:
- Subsoil Moisture (pre-season)
- Climate cycle (both the annual cycle and any applicable longer term cycle(s))
- ENSO (the status of the El Nino/La Nina event)

Additional seasonal indicators include:
- Semi-permanent global pressure pattern
- Jet Stream activity and configuration
- Growing Degree Days

**Subsoil Moisture**

Routine monitoring/analysis of crop available subsoil moisture was initiated and made publicly available in the year 2000 although it was initiated in some localities earlier (Iowa, during the mid-1950s). Variability of subsoil moisture and the variability of growing season temperature are commonly the environmental factors that most directly impact the variability of crop yield in central North America. In some climates the intensity and duration of sunlight is a significant factor. Subsoil moisture in November is the earliest indication of the agronomic outlook for the coming year. The November outlook is meaningful in that all crop available moisture in the subsoil in November will remain in the soil until the roots of a living plant remove it. Over winter the moisture may increase slightly but only to the extent that water is available to the
topsoil when the soil is not in a frozen condition. Little if any water is able to infiltrate frozen soil. The moisture in the top 5 feet of soil typically increases by 2 inches between November and mid-April.

About 22 to 25 inches of moisture is required to produce a "full" crop. The better agricultural soils can retain about 10 inches of crop available moisture or about 40% of the water that will be needed for the growing season. If the soils are at capacity as the season begins there is a considerable buffer against adverse effects from dry spells during the season. If the initial soil moisture is very low the crop is extremely sensitive to periods of low precipitation or high temperature. In some localities seasonal precipitation is fairly reliable (mainly the eastern Corn belt) and the impact of initial soil moisture is not as significant as in areas where seasonal precipitation is highly variable (mainly the western portion of the Corn belt). If all cases it is true that below usual moisture at planting time increases the risk of drought to something greater than 17% and above usual moisture diminishes the risk unless conditions are so wet as to impede establishment of the crop.

**Benner Cycle**

The long-term observations establish the risk of Mid-west drought at one-in-six, however, when viewed over a series of years it is apparent that drought is not randomly distributed. Usually there are three drought years during an 18- or 19-year period. Often the drought years are grouped. Samuel Benner, a Mid-west farmer in the Ohio-Indiana region, noted that grain prices varied with crop yield in a 18-19-year cycle. He anticipated that the cycle would continue and extrapolated his observations from 1885 to the year 2000. His predictions of likely drought around 1936, 1955, 1974, etc. were accurate. Although the cause of this cycle is not as obvious as the cause of the 12 month seasonal cycle of the Earth, the cycle is sufficiently consistent for estimating the risk of drought during six-year periods. During the “high-risk” six years the chance of drought any given year is 33% and during the subsequent 12 to 13 years the chance of drought any given year is 8%.

The “Benner Risk” for the 2002 crop season is an 8% chance of drought. Because the subsoil moisture is near normal across the Corn Belt the risk is little changed from that value. So the odds favor an above trend line corn yield insofar as the initial conditions are concerned.

**ENSO**

The El Niño/La Niña events have a significant impact (signal) on crop yield probabilities in many, if not most, crop producing locations. The U.S. corn yield tends to be above trend during El Niño years. During the past 100 years there have been no wide-spread drought events during an El Niño. The very cold and wet year that substantially reduced national crop yield in 1993 was, however, an El Niño year.

The primary indicator of the changing status of the ENSO (El Niño/Southern Oscillation) is the Southern Oscillation Index (SOI). During 1999-2001 the index indicated moderate La Niña conditions most of the time. However, each of those years the index weakened and even moved
to the El Niño side of neutral during the growing season resulting in less drought risk than would be expected during a La Niña year.

Research has shown that having an El Niño event doubles the chance of a high yield in the U.S. Corn Belt and reduces the chance of a very low yield slightly. Conversely a La Niña event doubles the initial condition risk of drought and halves the chance of a very large yield. Some researchers anticipated that El Niño conditions would develop in late 2001. However, through November there was no indication that conditions could be expected to be anything other than near neutral. If the SOI deviates from zero by more than 0.8 points, the appropriate risk should be included in the crop risk analysis.

Often a likely value can be associated with possible yields. For example: In 2001 it was anticipated that a national yield of 112 bu/a would result in harvest time prices of about $3.15 at Chicago. If the national yield was 142 bu/a the expected value was $1.95. The fall yield estimate from the statistical reporting service as about 138 bu/a and the value was about $2.05.

Nine-ty-day Outlook-
If you know assuredly the 90-day weather, do you know what to do in crop production and marketing? If you only know the normal distribution of weather, do you know what to do? There are several ways to consider the weather risk. The Quadrant method is based on deviation from the average. It can be warmer or colder than normal and have above average or below average precipitation. There are 4 possible combinations: If the combination is "Hot and Dry" the chance of the bottom quartile of yield is more likely than usual. If "cold and moist" the chance of the top quartile of yield is more likely than usual. The other two combinations increase the likelihood of a near trend-line yield. The 90-day forecast probabilities can be applied to the computation of the quartile possibilities.

The long range forecast gives the normal range" for the middle 1/3 of all years. The yield history may be divided into the highest 1/3 of all years, the middle 1/3, and the lowest 1/3. Using the "aridity index" concept the risk of each category can be computed. The NWS outlook may say the center precipitation amount is 9-11 inches and the temperature is 77-84 F. The computation of risk may be based on the standardized deviation from the average temperature and precipitation or it may be based on the possibility of being in the quartile.

Management Approximation of Risk

The "approximant" assessment is a simplified method of combining risk. It is not fully valid, but is sufficient for initial assessments and decision-making. The method combines the perceived risks in a cumulative way. Remember that risk is not certainty and hence is never 100% nor is it ever 0%. Using the risk of rain as an example: A farmer wishes to know the risk of rain falling on the curing hay in local fields. The weather forecast gives a 50% chance of rain tonight, also tomorrow and again tomorrow night. The farmer wonders if there is a 50% chance the hay will receive rain during the coming 36 hours or is it greater? The farmer looks at the
chance it will not rain each period and begins to combine the probabilities: \(0.5 \times 0.5 \times 0.5 = 0.125\) for a 12.5% chance it will not rain (or an 87.5% chance there will be rain on the hay during the 36 hour period). This method is approximate because the 12-hour periods are not fully independent of each other. An actual chance for a 24-hour period comprised of 18% and 27% is 35%, the simplified method gives \(0.82 \times 0.73 = 0.6\) chance of dry or 40% chance of rain. When combining probabilities as if they were independent and indeed they are not, the user needs to realize that the estimate is slightly too high (in the case of precipitation). If you are analyzing the risk associated with coin flipping the method is exact.

Risk associated with ongoing conditions can be continually assessed by the method used in the example for assessing the likelihood of rain above. By keeping a current risk assessment the producer can make well-informed decisions concerning management and marketing.
Raw RISK of Drought
U.S. Corn Yield

17 droughts in the past 100 years

Long-term Yield Risk

23%
29%
31%


**Leading Indicator #1**

**National Crop Moisture**

Weekly Value for Period Ending 27 OCT 2001

Short Term Need vs. Available Water in 5 Ft Profile

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**19 yr Dry/Wet**

Tree rings indicate climate cycles.

Droughts Western 2/3 of USA

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147
Farmer Benner
In 1885 noted dry/wet cycle. A Chart Found More Than Fifty Years Ago-1885

Dust Bowl

1992-2004

100 110 120 130 140 150

Farmers


History forecast

U.S. Corn Yield
Bushels/Acre

Year


148