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Commodity Intelligence Report

Impacts on Soybean and Corn Yields in Southern Brazil from Three Consecutive Years of La Niña

Southern Brazil experienced persisent drought conditions from La Niña conditions during the last three years that affected crop yields. While back to back years of La Niña are not considered unusual, the past three years of successive La Niña events ("triple-dip") are a rare occurrence. Such large deviations from precipitation normals have significant impacts on agricultural production. In the semi-arid tropics, these departures from normal are associated with Sea Surface Temperatures (SST) of the Pacific Ocean and formation of climate anomalies such as the El Niño and La Niña phenomena, also known as the El Niño-Southern Oscillation (ENSO).

The National Oceanic and Atmospheric Administration (NOAA) defines the La Niña phase as a weather pattern where surface winds across the entire tropical Pacific are stronger than usual, and a large part of the tropical Pacific Ocean is cooler than normal. During La Niña events, ocean surface temperatures in the central Pacific tend to be cooler than average, whereas in El Niño years, they are warmer than average. This leads to anomalies in rainfall patterns globally, such as below average precipitation in parts of southern South America and above average rainfall in South Africa (Figure 1). NOAA uses the Oceanic Niño Index (ONI) for tracking the 3-month SST anomaly in the eastcentral Pacific (between 120° - 170°W) in the Niño 3.4 region. ONI thresholds characterize the strength and type of ENSO events; ONI values above +0.5 indicate EI Niño and those below -0.5 indicate La Niña when they occur for a period of 6 months or more. Intensity is determined as weak (ONI values between 0.5 to 0.9), moderate (1.0 to 1.4), strong (1.5 to 1.9) and very strong (\geq 2.0) (Figure 2, NOAA 2023b, Trenberth 2023). The El Niño event of 2015/16 was very strong, the La Niña of 2010/11 was strong, and the recent "triple-dip" La Niñas were weak to moderate in strength based on ONI.

During a La Niña event, conditions are generally drier than normal for southern Brazil through spring soybean planting season, which often leads to planting and then harvest delays. Any delays in the soybean calendar then cascade into downstream effects for the *safrinha* corn crop, which is planted immediately after the soybean harvest. The Brazilian state most impacted is Rio Grande do Sul; with Santa Catarina and Paraná at the fringes of La Niña impacts. This Commodity Intelligence Report will focus on the states of Rio Grande do Sul and Paraná which are the largest producers in southern Brazil.

Impacts on Crop Production

Soybean production in the three southern Brazilian states accounts for roughly 26 percent of national soybean production, roughly an average of 40 million metric tons over the last five years (Figure 3a). The below-average precipitation in southern Brazil from 2020 to 2022 occurred during the months from October to December when the La Niña event was considered at its peak (Figure 4). The association between historical soybean vields and ONI for the two large southern states is depicted in Figure 5. The first year of the "triple-dip" La Niña (MY 20/21) saw yields drop somewhat in Paraná, while Rio Grande do Sul yields were at a record high. In the second year (MY 21/22), yields were reduced drastically from initial expectations in Rio Grande do Sul (-58 percent) and Paraná (-41 percent) as the drought occurred during sensitive reproductive crop stages (Figure 6d). During the final consecutive La Niña year, soybean yields were impacted in Rio Grande do Sul (-41 percent from initial reports) but not in Paraná. The yield impacts are displayed using the percent of average seasonal greenness index (Figure 6a-c). The intensity varied for each year with the 20/21 and 22/23 events considered weaker events, with less broad crop impacts, than the 21/22 event when vegetation indices were the lowest for the 22 years of record. In Rio Grande do Sul, 9 of the 17 La Niña years display soybean yields below trend yield, while in Paraná 8 of the 17 years show below average yields for the available data (Figure 5). The previous triple-dip La Niña phase also resulted in 2 of the 3 years below trend yield in Rio Grande do Sul, but relatively minor impacts in Paraná.

The association between soybean yields and ONI during La Niña years is weak; some of the highest yields in southern Brazil were recorded during La Niña events (Rio Grande do Sul MY 16/17 and MY 20/21, Paraná MY 22/23) but also some of the lowest yields (Rio Grande do Sul MY 11/12 and MY 21/22, Paraná MY 21/22, Figure 5) over the 45 year time period. Soybeans are mostly planted in November and December in Rio Grande do Sul, and there were reports of farmers planting soybeans later in December in MY 20/21 to avoid the worst impacts from the peak of La Niña.

Corn production impacts were either direct, affecting the first crop that is planted in the southern hemisphere spring, or indirect, because of delays in the soybean cycle that delayed second crop corn planting. Delays in the planting of the *safrinha* (second-crop) corn increases weather risks toward the end of the *safrinha* growing season. Direct impacts on the first crop can be similarly visualized with both states displaying the same pattern (Figure 7) of greatest yield reduction in MY 21/22 when the "triple-dip" La Niña was the most intense.

Second crop corn yields were assessed only for Paraná as Rio Grande do Sul does not cultivate *safrinha* corn. Paraná's *safrinha* crop only started being cultivated in the 1980s and is planted from February through early April in Paraná (Figure 3b). Unlike the first crop, the yield reduction in Paraná was greatest during the first year of the triple-dip La Niña in MY 20/21 (Figure 8). In MY 21/22, the La Niña had weakened in strength and had less severe of an impact by the time the *safrinha* crop was in mid-season. Additionally,

the yield reduction in Paraná was associated more with frost and storm damage during sensitive pollination crop stages in MY 21/22.

Transitioning to an El Niño Cycle

NOAA released an update in late September confirming an El Niño phase with above average sea surface temperatures since March 2023 (Figure 9). During El Niño years, the equatorial waters of the Pacific Ocean are warmer than normal leading to changes in global weather patterns and overall warmer temperatures. The weather models predict a strengthening of the El Niño from December 2023 until February 2024. This occurs in the middle of the soybean, rice, and first crop corn seasons in Brazil. Typically, precipitation patterns in southern Brazil are flipped from the La Niña phase, with greater than average precipitation (Figure 9). However, the eastern and northern regions are drier than average. This has the agriculture sector nervous due to the potential for further disruptions.

The state of Rio Grande do Sul, which suffered from the worst impacts during the tripledip La Niña, generally achieves higher than trend yields for soybeans during El Niño events. For the period of record, 13 of the 15 years during El Niño years attained above trend yield in Rio Grande do Sul and 10 of the 15 years were above trend yield in Paraná for soybeans (Figure 5). Similarly, the majority of years during El Niño were above the trend yield for the first-crop corn in Rio Grande do Sul (Figure 7); however, both first crop and second crop corn in Paraná display no discernible pattern related to El Niño events (Figures 7-8).

The largest soybean producing state of Mato Grosso also does not exhibit clear weatheryield teleconnections with ENSO events, with about half of the years during El Niño years attaining below trend soybean yield (Figure 10). Nonetheless, producers are worried about a repeat of the 2015/16 strong El Niño that led to a 10-percent reduction in soybean yield and a 33-percent reduction in *safrinha* corn yields from initial forecasts. Research from the northeastern regions also indicates potential for corn yield impacts due to longer dry periods with lower rainfall volume (Nogueira et al. 2023). Cropping intensity with multiple crops additionally affects soil water availability with larger yield variability for the *safrinha* corn crop, particularly in the central states of Goiás and Mato Grosso do Sul, and in Paraná (Anderson et al. 2023).

Current USDA forecasts are available at PSD Online.



La Niña and Precipitation Teleconnections

Figure 1. Typical global rainfall anomalies during La Niña years (1951-2016). Source: International Research Institute (IRI) for Climate and Society (Lenssen et al. 2020)



Oceanic Niño Index (ONI) from 1990-2023

Figure 2. Strength of El Niño–Southern Oscillation (ENSO) events from 1990 to 2023 measured with the Oceanic Niño Index (ONI). Source: The National Oceanic and Atmospheric Administration (NOAA)



Crop Production Averaged over a 3-Year Period (2019-2021)

(b)

Plant

Mid-Season

Harvest

Figure 3. Soybean, first and second crop corn production averaged over 3 years from 2019-2021. Source: IBGE municipality data

Mid-Season

Plant

Precipitation Anomalies from October-December for 2020-2022



IRI Multi–Model Probability Forecast for Precipitation for October–November–December 2020, Issued September 2020





IRI Multi–Model Probability Forecast for Precipitation for October–November–December 2022, Issued September 2022



Figure 4. Global 3-month precipitation anomaly patterns during consecutive La Niña years from 2020 to 2022. In 2021, the intensity of La Niña was particularly strong in southern Brazil. Source: International Research Institute (IRI) for Climate and Society.

Rio Grande do Sul Soybean Yields



Paraná Soybean Yields



Figure 5. Soybean yield (planted area) association to El Niño–Southern Oscillation (ENSO) events in the two large southern Brazilian states of Rio Grande do Sul and Paraná. Source: CONAB yield data, ENSO defined by the Oceanic Niño Index (ONI) from NOAA-CPC.

Percent of Average Seasonal Greenness (PASG) from January to March during 3 Consecutive Years of La Niña



Brazil: 3-Month Standardized Precipitation Index (SPI) Nov 1, 2021 to Jan 31, 2022



⁽d)

Figure 6. PASG for 3 years from 2020-2022. (a) Yield not impacted and record yield in Rio Grande do Sul in 2020/21, (b) intensification of La Niña led to large losses in yield across southern Brazil in 2021/22, (c) only Rio Grande do Sul was affected by the third year of La Niña with about 41 percent yield loss in 2022/23, (d) MY 2021/22 drought visualized using SPI. Source: NASA MODIS 3-month PASG, GDA Soybean Crop Masks, UCSB CHIRPS SPI.

Rio Grande do Sul First Crop Corn Yields



Paraná First Crop Corn Yields



Figure 7. First crop corn yield (planted area) association to El Niño–Southern Oscillation (ENSO) events in the two large southern Brazilian states of Rio Grande do Sul and Paraná. Source: CONAB yield data, ENSO defined by the Oceanic Niño Index (ONI) from NOAA-CPC.

Paraná Second (safrinha) Crop Corn Yields



Figure 8. Second crop corn yield (planted area) association to El Niño–Southern Oscillation (ENSO) events in Paraná. Source: CONAB yield data, ENSO defined by the Oceanic Niño Index (ONI) from NOAA-CPC.

El Niño Sea Surface Temperature



El Niño and Precipitation Teleconnections



Figure 9. Typical global rainfall anomalies during El Niño years (1951-2016). Source: International Research Institute (IRI) for Climate and Society (Lenssen et al. 2020)

Mato Grosso Soybean Yields



Mato Grosso Safrinha Corn Yields



Figure 10. Soybean and *safrinha* crop corn yield associations to El Niño–Southern Oscillation (ENSO) events in Mato Grosso. Source: CONAB yield data, ENSO defined by the Oceanic Niño Index (ONI) from NOAA-CPC.

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