BANCO DE ESPAÑA
Eurosistema

ECONOMIC BULLETIN
2025/Q2

The impact of drought on agricultural production in Spain

https://doi.org/10.53479/39768

Article 07
08/05/2025

Rationale

Climate change could exacerbate the magnitude and frequency of extreme weather events, increasingly affecting crop yields. This article analyses the effects of drought on the production of a selection of key crops for Spanish agriculture.

Takeaways

- Granular climate data and province-level data on agricultural land and production are used for the period 2000-23 to estimate the relationship between drought and the yields of a selection of crops in Spain.
- The results obtained show that the adverse impact of water scarcity on crop yields differs across crops. Specifically, the impact was found to be greater on wheat, barley and olives (largely rainfed crops) than on oranges and maize (predominantly irrigated crops).
- In 2022 and 2023, Spain experienced prolonged periods of water scarcity. This is estimated to have reduced wheat and barley yields by between 20% and 30%, on average, and olive yields by at least 10%.

Keywords

Drought, crop yields, agricultural production, SPEI.

JEL classification

Q15, Q18, C33.

Authors:

Isabel Molina Vileya
Economics Department
Universidad de Alcalá

Matías J. Pacce
Economic Developments Department
Banco de España

Introduction

In 2023 and 2024, the agriculture and fishing sector accounted for 2.5% of Spanish GDP. In 2023, unprocessed agricultural exports represented 5.2% of Spain's total goods exports.[1]

The yield obtained in each crop season is determined by various factors. Some are directly contingent on the producer, for example, the degree of crop rotation, the correct use of fertilisers or the machinery and technology employed. Others are exogenous, notably climate-related events. For example, the scarcity or abundance of rainfall or the number of days with extreme temperatures can lead to a marked difference in the crop yields[2] obtained, which could affect producer prices and, hence, consumer prices.[3] That is why analysing phenomena such as droughts and how they affect production is particularly useful, in a setting in which climate change could lead to more frequent, severe and longer-lasting extreme weather events (Banco de España, 2022). It is important to note that the negative effects of drought on agricultural production could, in turn, be exacerbated by other climate-related events, with an adverse economic impact on agriculture. For example, Broto and Hubert (2025) show that desertification negatively affects lending to the agricultural sector. Against this backdrop, this article examines the impact of relative water scarcity[4] on the yields of a selection of key crops grown in Spain.

The next section discusses how relative water scarcity is measured in Spain and describes the importance of the selected crops for the country's agricultural production. The third section sets out the econometric model used and the results obtained for the impact of drought on agricultural production. Lastly, the fourth section estimates the effects of drought on the 2021/22 and 2022/23 crop seasons.

Measuring relative water scarcity in Spain

According to the World Meteorological Organization guidelines (WMO, 2023), from a meteorological perspective, drought is defined as a "prolonged absence or marked deficiency

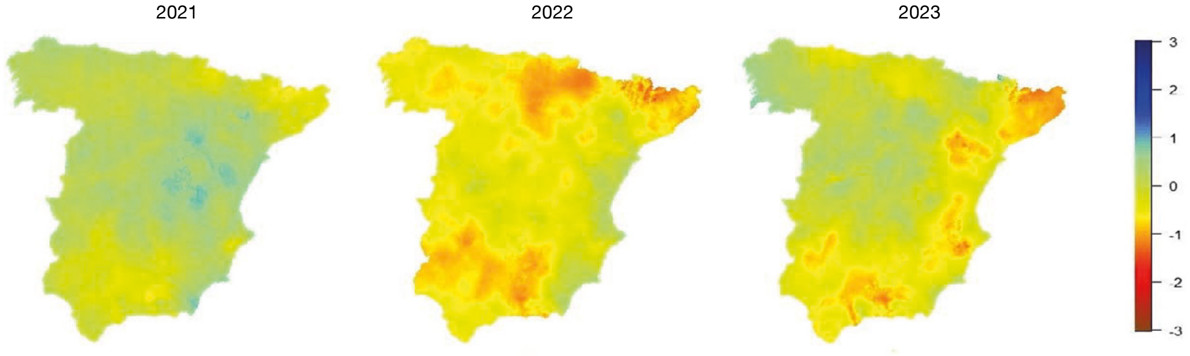
1 The agricultural sector is also a source of critical inputs for the food, beverages and tobacco industry, which accounted for 25.7% of Spain's manufacturing industry in 2023. That same year, agri-food industry (excluding fishing) exports amounted to 16.9% of total goods exports. See Ministerio de Agricultura, Pesca y Alimentación (MAPA, 2024a).

2 A specific crop yield is the harvested production per unit of harvested area.

3 Although analysis of these effects on prices is beyond the scope of this article, some aspects are worth mentioning. For instance, the impact may vary depending on the crop type. It will be less severe for crops whose prices are set on the international markets and for which Spain is not a major global producer (for example, cereals such as barley or wheat). But for products such as olive oil or oranges, in which Spain is a leading global exporter, the fall in production due to drought could have a significant impact on domestic and international prices. Lastly, drought episodes outside Spain could also affect consumer food prices locally, although the severity of the impact will depend on the aggregate effect on the global production of the crop in question.

4 The term "relative" refers to the fact that the SPEI measures water scarcity at a given time compared to a reference period, as explained in the following section.

Chart 1
SPEI for mainland Spain in 2021, 2022 and 2023



SOURCE: Authors' calculations drawing on Vicente-Serrano et al. (2017).
NOTE: The chart shows the annual average SPEI, using aggregated three-month precipitation and soil evapotranspiration data, for 2021, 2022 and 2023.

of precipitation". These guidelines also indicate that meteorological drought can lead to agricultural drought, which not only means precipitation shortages, but also higher evapotranspiration[5] and moisture deficit in the soil. Different measures can be used to analyse the degree of drought in a given geographical area and moment in time. One of these is the standardised precipitation-evapotranspiration index (SPEI),[6] which measures the amount of accumulated precipitation and potential soil evapotranspiration relative to those of a reference period. This index is published weekly, with values ranging from –3 to 3. A lower (higher) index value is interpreted as a higher (lower) level of relative water scarcity.[7] Chart 1 illustrates the average value of the SPEI in mainland Spain for 2021, 2022 and 2023. More intense red (blue) colours indicate a higher (lower) relative water shortage. The chart shows that water was scarcer in 2022 and 2023 than in 2021, particularly in regions such as Andalusia, Catalonia, the Basque Country, Aragon and Valencia.

Chart 2 provides an aggregate view of the changes in relative water scarcity in the Spanish regions in the period 2000-23, calculating the SPEI for each region.[8] More intense red (blue) colours indicate greater (less) water scarcity. As can be expected, water scarcity is fairly widespread across the regions at similar times, as was the case, for example, in 2005, 2009, 2011-12, 2017 and, more recently, in 2022-23. This last episode was the most severe in terms of

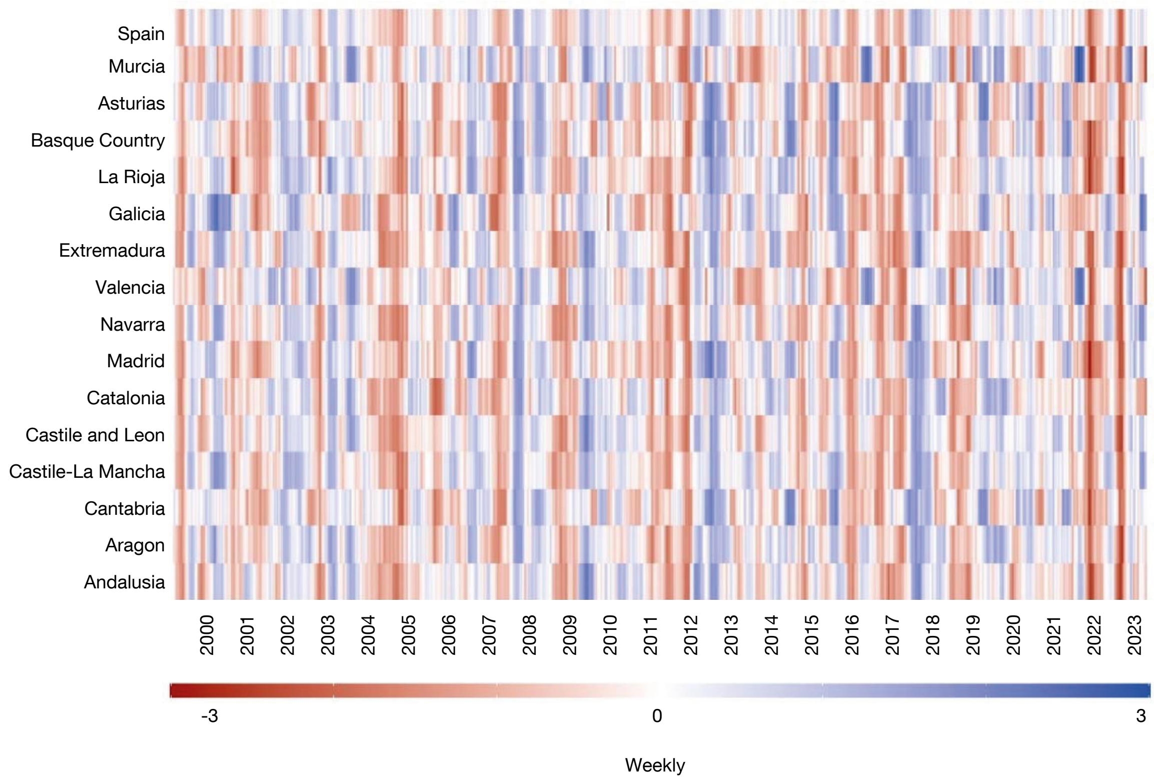
5 The Food and Agriculture Organization of the United Nations (FAO) defines evapotranspiration as "the combination of two separate processes whereby water is lost on the one hand from the soil surface by evaporation and on the other hand from the crop by transpiration".

6 See Vicente-Serrano, Beguería and López-Moreno (2010).

7 The SPEI has a spatial resolution of 1.1 km^2 and is available for different aggregation periods of precipitation and potential soil evapotranspiration data, where these periods denote the number of months accumulated up to the specific date (aggregation periods of 1, 3, 6, 9, 12, 24, 36 and 48 months). The time series began in January 1961. For the purposes of this analysis, the three-month cumulative SPEI is used.

8 Each municipal-level observation is weighted by the total municipal area relative to the total area of the region.

Chart 2
SPEI for mainland Spain by region (2000 to 2023)



SOURCE: Authors' calculations drawing on Vicente-Serrano et al. (2017).
NOTE: The chart shows the SPEI, using aggregated three-month precipitation and soil evapotranspiration data, for each week in each region and in Spain as a whole between 2000 and 2023.

relative water scarcity, which is also reflected in the far lower levels of average rainfall and water reserves in Spain than those observed, on average, over the previous 22 years.[9]

However, it is important to note the regional heterogeneity in the severity and duration of drought episodes.[10] In this respect, Chart 2 shows that the relative water scarcity in the period 2022-23 appears to have continued uninterruptedly in regions such as Murcia, Catalonia, Navarre or the Basque Country, while in others the situation seems to have eased somewhat during the winter of 2023. This heterogeneity is also observed in the average rainfall for 2022-23 which, compared with 2000-21, was 37.9% lower in Catalonia's internal river basin and around 31% lower in the southern and Guadalquivir basins, but remained stable in the Tagus basin.

9 According to the Spanish Meteorological Agency (Agencia Estatal de Meteorología, 2024), the average rainfall in Spain in the period 2022-23 was 556 mm per year, compared with an average of 660.6 mm per year in the previous 22 years (18% higher). The average volume of water stored in reservoirs was 46% of total capacity in 2022-23, compared with the average of 51.5% of capacity in the previous 22 years (MAPA, 2024b).

10 By way of example, in 2005, in Cantabria, Valencia and Murcia water appears to have been less scarce than in other regions. By contrast, Valencia and Murcia suffered a level of relative water scarcity in 2014 not observed in other regions.

Crops analysed

As mentioned in the introduction, this article focuses on five key crops in Spanish agriculture. Specifically, wheat (soft and hard), barley (two-row and six-row), maize, sweet oranges and olives (for pressing). These crops were selected based on their significance in terms of cultivated area, Spain's importance as a global exporter, or the variability of the production system in place (rainfed or irrigated). The selected crops represented around 47% of the total cultivated area in Spain in 2022,[11] with a 7.6% share of total Spanish agri-food exports. Moreover, Spain is the European Union's leading producer of olives for pressing and oranges (67.1% and 43.2% of the total, respectively) and also one of the world's top exporters of olive oil[12] and oranges.

A significant aspect in agricultural production is the type of system in place, the most prominent being rainfed or irrigated systems. In the former, crops rely entirely on a natural water source (rainfall), while the latter requires an added, artificial supply of water. Irrigated crops are therefore less dependent on weather conditions. According to the survey on cropland and yields (ESYRCE, by its Spanish abbreviation) (MAPA, 2024c), in 2023 21.6% of cropland was under irrigation,[13] with the five selected crops representing just under half (46%) of that area. A total of 93% and 92%, respectively, of maize cropland and orange groves in Spain are irrigated, and 32% of olive groves.

As for the geographical distribution of production in Spain, the crops analysed are present in most regions, albeit concentrated in some areas. Barley and wheat, for example, are grown in large areas of the country, notably in Castile and Leon, Castile-La Mancha and Andalusia. Maize is mainly cultivated in Castile and Leon, Aragon and Catalonia,[14] while orange production is concentrated in Valencia and Andalusia. Lastly, 60% of olive groves can be found in Andalusia.

The impact of drought on crop yields: model and results

We base our analysis of the impact of drought on crop yields on the approach proposed by Kuwayama, Thompson, Bernknopf, Zaitchik and Vail (2019) which relates the yield obtained from a given crop to the number of weeks – within each crop season – in which that crop was exposed to greater or lesser relative water scarcity. Specifically, where r_{it} is the logarithm of a crop yield in province i[15] and in year t, the following equation is defined:

---

11 Wheat, barley and olive groves covered 45% of the total cultivated area in Spain in 2022, while maize and sweet orange trees accounted for 1.5% and 0.9%, respectively.

12 Olive oil is obtained from olives for pressing, grown in olive groves for oil production which in 2023 accounted for 88% of total olive groves in Spain. In 2023, Spain was the world's leading exporter of olive oil (with a 36.2% market share), followed by Italy (18.3%). (MAPA, 2024d).

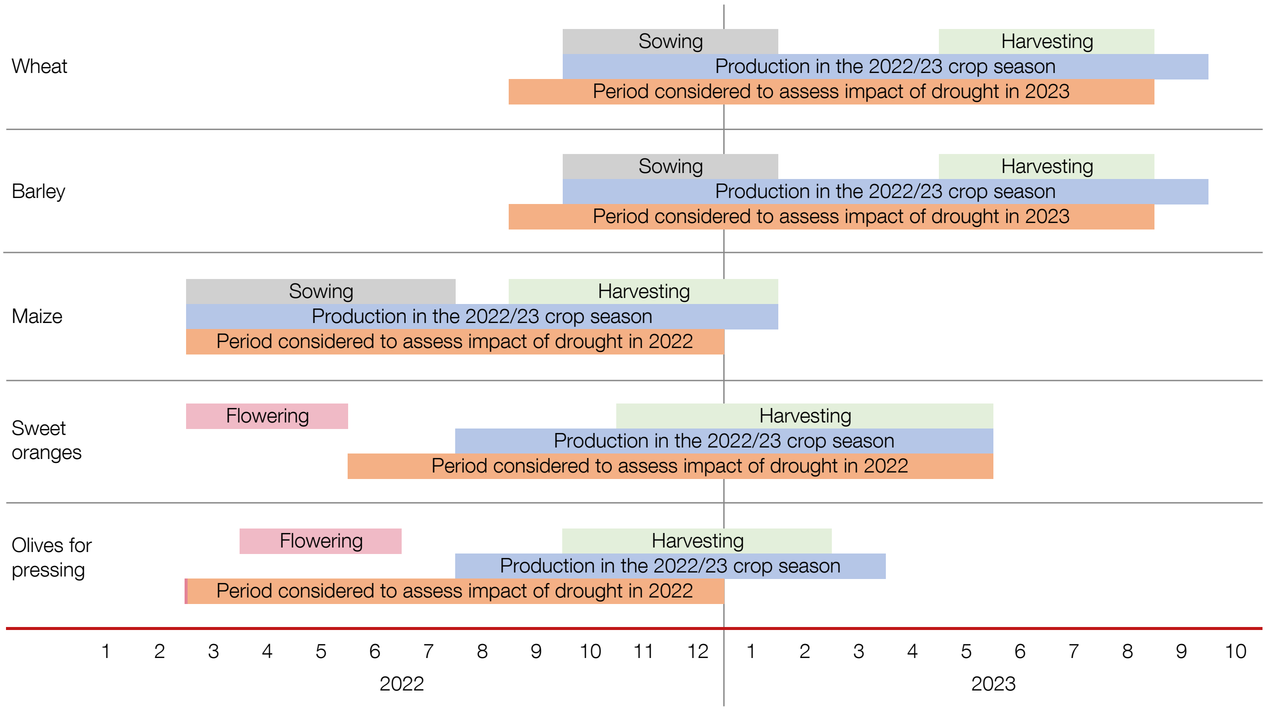
13 According to the MAPA, Spain is the EU country with the largest area of irrigated agriculture.

14 Rainfed maize production is mainly concentrated in Galicia.

15 Municipal-level information on cultivated area is available for the 32 provinces belonging to the regions of Andalusia, Aragon, Murcia, Valencia, Catalonia, Castile and Leon, and Castile-La Mancha. However, not all the crops selected are produced in all 32 provinces, which is why, depending on the crop, the number of provinces in the sample varies from 11 (sweet oranges) to 32 (barley).

Figure 1

Example of time (in months) for allocation of production and period considered to assess the impact of drought in each crop season



SOURCE: Devised by authors drawing on MAPA (2021) and MAPA (2024e).
Note: The orange bars cover the period considered to assess the impact of drought in each crop season, while the blue bars denote the months considered by the MAPA for allocation of production in each crop season. See MAPA (2021) for the crop calendar and MAPA (2024e) for allocation of the monthly production of each crop to the respective harvest.

$$r_{it} = \alpha + \beta_1 D_{i1t} + \beta_2 D_{i2t} + \beta_3 D_{i3t} + \gamma_t + \rho_i + \varepsilon_{it} \quad [1]$$

where D_{i1t}, D_{i2t} and D_{i3t} are the number of weeks during crop season t in which the SPEI index was within three predetermined water scarcity classes (moderate, severe and extreme drought, respectively). Hence, β_1, β_2 and β_3 capture the impact of an additional week in each water scarcity class on the yield of the crop analysed.[16] For the province-level SPEI index, the number of weeks in each class is weighted by each municipality's share of the sown or planted area of the crop analysed as a proportion of the total cultivated area of that crop in the province in question.

Figure 1 illustrates the crop season (in months) considered by the MAPA for each of the crops analysed (blue bars). In some cases this period does not cover the entire sowing or flowering period, when water scarcity may affect yields. In consequence, to assess the impact of drought on production, the period considered is adapted – for each of the crops analysed – to ensure that it includes all months with potential impact on yield. Accordingly, this analysis takes into account the sowing or flowering and harvesting of each crop (orange bars).[17] In the case of maize and

16 α, γ_t and ρ_i capture, respectively, the constant, the fixed effects that affect all provinces within each year and the fixed effects for each province i that are constant over time. In turn, ε_{it} is the part of each crop yield that is not explained by the model. See the annex attached for a detailed explanation of the construction of the variables and the sources used.

17 To define the period considered, the information from the latest official crop calendar (MAPA, 2021) is taken into account.

Table 1
Results of estimation of impact of drought on production

	Wheat		Maize		Barley		Olives		Oranges	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Moderate drought	-0.00869***	-0.00796***	-0.00100	0.00137	-0.00999***	-0.00685***	-0.00489***	0.00109	0.00037	-0.00120
	(0.00119)	(0.00119)	(0.00094)	(0.00101)	(0.00077)	(0.00118)	(0.00185)	(0.00198)	(0.00247)	(0.00271)
Severe drought	-0.01840***	-0.01505***	-0.00060	0.00078	-0.02433***	-0.02100***	-0.01838***	-0.01243***	-0.00699**	-0.00662**
	(0.00130)	(0.00145)	(0.00097)	(0.00095)	(0.00085)	(0.00142)	(0.00174)	(0.00188)	(0.00283)	(0.00288)
Extreme drought	-0.03343***	-0.02438***	0.00125	0.00210*	-0.04871***	-0.03959***	-0.01008***	-0.00374	-0.00142	0.00133
	(0.00173)	(0.00219)	(0.00106)	(0.00113)	(0.00115)	(0.00191)	(0.00227)	(0.00256)	(0.00369)	(0.00401)
Precipitation		0.06780***		0.02880***		0.08238***		0.08963***		0.03526**
		(0.00966)		(0.00578)		(0.00888)		(0.01360)		(0.01687)
Precipitation^2		-0.01907***		0.00664**		-0.00663		-0.00065		-0.02045**
		(0.00487)		(0.00258)		(0.00441)		(0.00556)		(0.00973)
Provinces	22	22	19	19	32	32	23	23	11	11
Periods	25	25	24	24	25	25	24	24	24	24

SOURCE: Authors' calculations.
NOTE: Columns (1), (3), (5), (7) and (9) show the results of estimating equation [1]. Columns (2), (4), (6), (8) and (10) present the results obtained when precipitation and precipitation squared are added to the equation. Moderate, severe and extreme drought show the β coefficients of the model related to class 1, 2 and 3 of drought, respectively. (*), (**) and (***) denote the significance of the coefficients at 10%, 5% and 1%. The values in brackets are the standard deviation of each coefficient estimated. All the specifications include fixed province and year effects.

olives, the entire harvesting period is not included, as in the final months of harvesting climate does not have a significant effect on the yield obtained. For wheat, barley and olives, the month before the start of flowering or sowing is included. Lastly, for orange trees, the first months of flowering are excluded as they have a relatively minor impact on total production, but the months during which the different varieties of oranges grow is included.

Equation [1] is estimated, for the period 1999-2023, drawing on the information available for the crop season of each crop analysed. The results of this estimation are set out in Table 1, in which columns 1, 3, 5, 7 and 9 present, for each crop, the value obtained for the β coefficients of equation [1]. These findings show that relative water scarcity has a negative and significant effect on crop yields for wheat, barley and olives. For instance, in the case of wheat, an additional week of moderate drought within a crop season reduces yield by 0.9% (β_1), while an additional week of severe drought and an additional week of extreme drought reduce it by 1.8% and 3.3% (β_2 and β_3), respectively. In other words, the effects found increase as water scarcity increases. This is also the case for barley and olives, although for olives the effect is somewhat smaller in the most extreme level of drought than in the intermediate level (severe drought).

For these three crops, water scarcity has most impact on barley, wheat and olives, in that order. The effect of drought on maize and sweet orange trees is generally found to have the expected sign, although the coefficient is only significant for orange trees in the case of severe drought.[18]

18 In the case of maize, Kuwayama, Thompson, Bernknopf, Zaitchik and Vail (2019) also find that drought has a low impact on yield in the United States.

Table 2
Results of estimation of impact of drought on production. Alternative specification

	Wheat	Maize	Barley	Olives	Oranges
	Rainfed	Irrigated	Rainfed	Rainfed	Irrigated
Moderate drought	-0.01199***	0.00142	-0.00704***	0.00097	-0.00156
	-0.00129	-0.00115	-0.00148	-0.00193	-0.00269
Severe drought	-0.01740***	-0.00157	-0.02141***	-0.01740***	-0.00713**
	-0.00139	-0.00116	-0.00139	-0.00220	-0.00288
Extreme drought	-0.03456***	0.00556***	-0.03732***	-0.01198***	0.00110
	-0.00209	-0.00142	-0.00223	-0.00267	-0.00400
Precipitation	0.11261***	0.02518***	0.14779***	0.06722***	0.03502**
	-0.01225	-0.00642	-0.00976	-0.01709	-0.01668
Precipitation²	-0.02667***	0.00488*	-0.01687***	0.00609	-0.01853*
	-0.00581	-0.00293	-0.00527	-0.00754	-0.00957
Reservoirs		-0.00186**			0.00224
		-0.00091			-0.00150
Provinces	22	16	32	23	11
Periods	25	24	25	24	23

SOURCE: Authors' calculations.
NOTE: The columns for wheat, barley and olives show the results of estimating equation [1], including precipitation and precipitation squared only for rainfed cultivation. The columns for maize and sweet oranges present the results of estimating equation [1], including precipitation and precipitation squared and reservoir levels only for irrigated cultivation. Moderate, severe and extreme drought show the β coefficients of the model related to class 1, 2 and 3 of drought, respectively. (*), (**) and (***) denote the significance of the coefficients at 10%, 5% and 1%. The values in brackets are the standard deviation of each coefficient estimated. All the specifications include fixed province and year effects.

These results could indicate that the relationship between drought and yield in these crops cannot be fully captured through equation [1], owing to the importance of irrigation in their production.

We also studied how the results change if we include in equation [1], in addition to water scarcity in terms of SPEI, the accumulated rainfall during the sowing or flowering period of each crop.[19] For the three crops for which drought was found to have a significant effect (barley, wheat and olives), these results generally hold, although the effect is somewhat lower. The results obtained show that more rainfall during the sowing or flowering period increases crop yields in each case (columns 2, 4, 6, 8 and 10 of Table 1). However, for orange trees, wheat and barley, the coefficient associated with precipitation squared has a negative sign, which suggests that, beyond a certain threshold, the relationship between yield and accumulated precipitation during the sowing or flowering period can become negative.

To assess the impact of whether the crops cultivated are rainfed or irrigated, Table 2 shows the results obtained if only rainfed cultivation is included for the three crops for which drought was

19 This variable is created from the observed value of the SPI index – which only considers precipitation, excluding soil evapotranspiration – in the last week of sowing or flowering of the crops analysed, except for orange trees where rainfall in late spring is considered. This is taken as a proxy of the level of precipitation accumulated in those periods. As with the SPEI, for the SPI index the levels accumulated (in this case, precipitation levels) during the last three months are taken and each municipal SPI is weighted by the sown/planted area of each crop in each municipality within each province.

found to have a significant effect. Comparing the results obtained with those for overall production (columns 2, 6 and 8 of Table 1), we find that for these three crops the effects of drought on yield are generally greater when only rainfed cultivation is considered. In the case of maize and sweet orange trees, which are mainly irrigated crops, we analyse the possible effect that the level of water reserves may have on the yields obtained. To this end, a variable is added to equation [1] reflecting the number of weeks in each crop season in which water reserves in the reservoir closest to each municipality are below the emergency threshold.[20] The results obtained show that, in the case of maize, a low level of water reserves has a negative impact on yields, probably because, with levels below the emergency threshold, irrigation restrictions start to become tighter and more frequent. However, these results must be taken with caution, as in the case of sweet orange trees no significant effects are found.

The effects of the drought in the 2021/22 and 2022/23 crop seasons

To quantify the impact on crop yields of the drought suffered in the 2021/22 and 2022/23 crop seasons, we calculated first the yield predicted by the model represented in equation [1], using the weeks of drought observed in those periods, and second the yield predicted using the number of weeks of drought observed on average in the period 1999-2021, excluding 2005 and 2012 which were both years of severe water scarcity. The difference between the two predicted yields can be interpreted as the fall in yield in the 2021/22 and 2022/23 crop seasons caused by the greater water scarcity in those years. We conducted this exercise for the three crops – barley, wheat and olives – for which a significant effect was found for the coefficients related to the impact of water scarcity on yields.

The results of the exercise are set out in Table 3, which shows, for instance, that the fall in wheat yields attributable to the drought amounts to 15% in the 2021/22 crop season and to 27% in the 2022/23 season; that is, an average decrease of 21% over the two periods. For barley, the drop in yields attributable to the drought is 20% in the 2021/22 crop season and 36% in the 2022/23 season, or an average drop of 28% over the two periods. For olives, the model shows a smaller fall in yields attributable to drought: 10% in the 2021/22 crop season and 11% in the 2022/23 season, giving an average fall of 10.5% over the two periods. If we compare the effects found with the variation in crop yield observed in the whole of Spain in the average of the two crop seasons (compared with the average yield obtained between 1999 and 2021, excluding the two years of drought mentioned above), the impact of the drought on wheat and barley explains around 85% and 90%, respectively, of the fall in yield. In the case of olives, the effects found are smaller than might be expected, given the sharp drop in yields in the 2021/22 and 2022/23 crop seasons. In particular, the effect of the drought explains around 30% of the decrease in yields in the average of the two periods.

It is important to underline that some caution should be exercised when analysing the results obtained. First, the model specification does not rule out the possibility that part of the effect of

20 The emergency threshold is defined in accordance with the emergency scenario established by the Catalan water authority (Agencia Catalana del Agua). As in the case of the drought or precipitation variables, the number of weeks below the threshold is weighted by each municipality's share of the sown/planted area of the crop analysed as a proportion of the total cultivated area of that crop in the respective province.

Table 3
Estimated impact of the drought in the 2021/22 and 2022/23 crop seasons on barley, wheat and olive yields

%	Change in yield owing to number of weeks in each crop season in each drought class	
	2021/22	2022/23
Barley	-20	-36
Wheat	-15	-27
Olives	-11	-10

SOURCE: Authors' calculations.
NOTE: The impact of the drought on crop yields in the 2021/22 and 2022/23 crop seasons is proxied by estimating, first the yield predicted by the model represented in equation [1], using the weeks of drought observed in those periods, and second the yield predicted using the number of weeks of drought observed on average in the period 1999-2021 (excluding 2005 and 2012 which were both years of severe water scarcity). The difference between the two predicted yields can be interpreted as the fall in yield in the 2021/22 and 2022/23 crop seasons caused by the greater water shortage in those years. Only the provinces included in the estimation of the model are included (see footnote 15).

the drought may be captured by the year effect (γ_1 in equation [1], common to all provinces).[21] In addition, climate variability between provinces may not be sufficient to separate the two effects, given the concentration of production in certain geographical areas. Second, the impact of low rainfall or high temperatures may be more significant at certain stages of the crop season and this may possibly not be captured in the estimate due to the annual variables used in this study. Accordingly, the results could be interpreted as a lower limit of the impact of drought on these three crop yields.

REFERENCES

Agencia Estatal de Meteorología. (2024). *Informe sobre el estado del clima de España 2023.* Ministerio para la Transición Ecológica y el Reto Demográfico. https://doi.org/10.31978/666-24-003-2

Banco de España. (2022). "Chapter 4. The Spanish economy and the climate challenge". In Banco de España, *Annual Report 2021,* pp. 221-272. https://repositorio.bde.es/handle/123456789/21115

Broto, Carmen, and Olivier Hubert. (2025). "Desertification in Spain: Is there any impact on credit to firms?". Documentos de Trabajo, 2513, Banco de España. https://doi.org/10.53479/39119

Kuwayama, Yusuke, Alexandra Thompson, Richard Bernknopf, Benjamin Zaitchik and Peter Vail. (2019). "Estimating the Impact of Drought on Agriculture using the U.S. Drought Monitor". *American Journal of Agricultural Economics,* 101(1), pp. 193-210. https://doi.org/10.1093/ajae/aay037

Ministerio de Agricultura, Pesca y Alimentación (2021). *Calendario de siembra, recolección y comercialización 2014-2016.* https://www.mapa.gob.es/es/estadistica/temas/estadisticas-agrarias/01-calendariosiembra-nuevo-sencilla-1_tcm30-514260.pdf

Ministerio de Agricultura, Pesca y Alimentación. (2024a). *Informe anual de comercio exterior agroalimentario y pesquero 2023.* https://www.mapa.gob.es/es/ministerio/servicios/analisis-y-prospectiva/informecomextanual2023_2_tcm30-690655_tcm30-690655.pdf

Ministerio de Agricultura, Pesca y Alimentación. (2024b). *Anuario de Estadística 2023.* https://www.mapa.gob.es/estadistica/pags/anuario/2023/global%202023/ANUARIO_2023.pdf

21 This coefficient captures the effects of a given year that are common to all provinces, for instance, the effect of COVID-19 on agricultural production.

Ministerio de Agricultura, Pesca y Alimentación. (2024c). *Encuesta sobre Superficies y Rendimientos de Cultivos. Año 2023.* https://www.mapa.gob.es/es/estadistica/temas/estadisticas-agrarias/boletin20231_tcm30-690544.pdf

Ministerio de Agricultura, Pesca y Alimentación. (2024d). *Informe de producto: Aceite de oliva.* https://www.mapa.gob.es/fr/ministerio/servicios/analisis-y-prospectiva/aceitedeoliva2023_tcm36-693146.pdf

Ministerio de Agricultura, Pesca y Alimentación. (2024e). *Avances de Superficies y Producciones de Cultivos. Abril,* p. 11. https://www.mapa.gob.es/es/estadistica/temas/estadisticas-agrarias/cuaderno_abril2024_tcm30-686500.pdf

Vicente-Serrano, Sergio M., Santiago Beguería and Juan I. López-Moreno. (2010). “A Multiscalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index”. *Journal of Climate,* Vol. 23, pp. 1696-1718. https://doi.org/10.1175/2009JCLI2909.1

Vicente-Serrano, Sergio M., Miquel Tomas-Burguera, Santiago Beguería, Fergus Reig, Borja Latorre, Marina Peña-Gallardo, M. Yolanda Luna, Ana Morata and José C. González-Hidalgo. (2017). “A High Resolution Dataset of Drought Indices for Spain”. *Data,* 2(3), pp. 22. https://doi.org/10.3390/data2030022

World Meteorological Organization. (2023). *Guidelines on the Definition and Characterization of Extreme Weather and Climate Events.* https://library.wmo.int/idurl/4/58396

Annex

To construct the yield variable (r_{it}) in equation [1] we use information from the MAPA's *Anuario de Estadística* (Statistical Yearbook). Specifically, for each of the crops analysed, we consider production, in thousands of tonnes, in province i during crop season t (P_{it}), and the sown/planted area (S_{it}), in hectares.[22]

To construct the variable D_{it}, we use mainly SPEI data (see second section). First, we take the SPEI in municipality m of province i in week τ, $SPEI_{mi\tau}$, and we define the following drought classes for each week τ:

$$D_{mi\tau} = \begin{array}{lll} D1_{mi\tau} & \text{(moderate drought)} & -0.5 < SPEI_{mi\tau} \leq -1 \\ D2_{mi\tau} & \text{(severe drought)} \quad \text{if} & -1 < SPEI_{mi\tau} \leq -1.5 \\ D3_{mi\tau} & \text{(extreme drought)} & SPEI_{mi\tau} < -1.5 \end{array}$$

We use the sum of weeks in each class to obtain the vector $D_{mit} = [\Sigma_{\tau \in t} D1_{mi\tau}\ \Sigma_{\tau \in t} D2_{mi\tau}\ \Sigma_{\tau \in t} D3_{mi\tau}]$. To group the variables D_{mit} at province level, D_{mit} is weighted by the municipality's share of the cultivated area of the crop analysed within the province.[23] This allows us to define the variable D_{it}, for each crop in each province i and year t, according to the following specification:

$$D_{it} = \frac{\sum_{m=1}^{N} D_{mit} * S_{mi}}{\sum_{m=1}^{N} S_{mi}}$$

where S_{mi} is the cultivated area of the crop analysed in municipality m of province i.

The municipal-level data on cultivated area come from regional sources. In each case, we use the last year for which information is available and assume that the municipality accounts for the same proportion of the cultivated area of the crop analysed within the province throughout that period.

When the precipitation and precipitation squared variables are added to equation [1], we use the three-month cumulative SPI index observed at the end of the sowing or flowering period (according to the crop analysed). As in the case of the SPEI, the SPI variable is weighted by each municipality's share of the total cultivated area of the crop within the province in question.

22 The crop yield in province i and crop season t is defined as $r_{it} = P_{it} / S_{it}$. Kuwayama, Thompson, Bernknopf, Zaitchik and Vail (2019) focus on the yields observed for different crops in the United States with greater geographical disaggregation, as they have county-level data on production and crop area and, therefore, on yields, within each state. Given data availability, our study focuses on province-level crop yields.

23 The share refers to the cultivated area of the crop analysed in a given municipality as a proportion of the cultivated area of that crop in the province to which the municipality belongs. The SPEI associated with a municipality is proxied by the SPEI closest to the coordinates defined, for each municipality, in the geographical nomenclature. Alternatively, the simple average of the number of weeks each municipality (within a given province) lies in each of the classes defined could be used. However, this would give equal weight to the SPEI observed in each municipality of the province, regardless of whether the crop in question is grown there. In other words, for instance, it would take into account water scarcity in desert areas.

To add the variable indicating the number of weeks in which water reserves were below the emergency threshold in province i during crop season t, we consider the water level in the reservoir closest to each municipality, weighted by each municipality's share of the total cultivated area of the crop within the province in question.

How to cite this document

Molina Vileya, Isabel, and Matías J. Pacce. (2025). "The impact of drought on agricultural production in Spain". *Economic Bulletin - Banco de España*, 2025/Q2, 07. https://doi.org/10.53479/39768

ISSN 1695-9086 (online edition)