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Sowing Date as a Factor Affecting Soybean Yield—A Case Study in Poland

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Abstract: Soybean is the crop of the future, especially for countries with a high demand for food and feed protein. Therefore, soybean cultivation is moving north to countries at higher latitudes, where temperatures, photoperiodism, and rainfall distribution are not always able to meet soybean requirements. The aim of this study was to evaluate three sowing dates as a factor influencing soybean cultivars yield and seed chemical composition in agroclimatic conditions of south-western Poland. In the years 2016–2019, a field experiment was conducted in Lower Silesia region, near Wroclaw, with three sowing dates: early (mid-April), 10-day delayed (at the turn of April and May), and 20-day delayed (first half of May), and two soybean cultivars: Merlin and Lissabon. In this location, soybean sowing is recommended in mid-April, possibly at the turn of April and May. The cultivars tested differed in yield and yield component values in the years of research, but generally, the Lissabon was better suited to local conditions. Results were discussed with findings of other domestic research, to investigate the problem of the soybean sowing date in Poland. The recommended sowing date for soybean was found to vary from region to region. These differences are due to the length of the growing season in each location and the varied adaptation of cultivars to the local climatic conditions.

Keywords: soybeans; sowing date; seed yield; protein; fat; region; adaptation

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1. Introduction

Plant biodiversity, including crops, and improvement in cultivation are nowadays the main goals of all developing countries in terms of sustainable agriculture. Sustainable agriculture and care for nature, as well as food safety and the health of people and animals, are the main topics of the European Green Deal, which is the EU's sustainable and inclusive growth strategy [1]. The search for new means to improve the development and yield of plants is necessary in the realities of modern agriculture, which should strive to reduce the use of fertilisers and plant protection products, in favour of nonchemical methods to promote yield. Therefore, the low-input cultivation factor, such as the sowing date, should be investigated to determine its effect on the yield and quality of the main crops cultivated worldwide.

The appropriate date of sowing is crucial to obtain a high-quality and high-quantity yield of thermophilic and photophilic crops at higher latitudes, i.e., in conditions of central-eastern Europe. Poland is located between 49° and 54° N latitude, and the climatic conditions are not favourable for the cultivation of species such as soybeans, sorghum, sunflowers, and maize, but due to the warming of the climate, the possibility of cultivating such crops with high thermal conditions is still expanding. American studies showed that the success of soybean cultivation depends on the course of thermal and humidity conditions during the vegetation period [2,3], and among them, temperature and photoperiodism and their interactions with genotype play the most important roles [4,5].

One of the topics of the European Green Deal is food and feed safety and security [6]. Soybean is the fourth world crop; moreover, the global production of oil and protein is based on soybean seeds [7], due to the high content of protein and fat, on an average of 40% and about 20% of the dry weight of seeds, respectively [8]. Therefore, despite the many limitations related to the climatic requirements of soybeans, it is grown in central and eastern European countries and its cultivation is moving north.

The share of soybean meal in covering the demand for feed protein in Poland is about 62%, followed by rapeseed meal at 23%, sunflower meal at 7.5%, and only 6.5% protein from legumes seeds. An analysis of the feed balance shows that there are currently no alternative high-protein feeds in Poland that can completely replace imported soybean meal [9]. In order to strengthen the feed sector, the cultivation of protein crops, both domestic and alternative species, is being promoted. The area under soybean cultivation in Poland was 21,548 ha in 2021, reaching 44,621 ha in 2023; however, soybean is still considered as a minor crop, due to low and unstable yields. In 2022, soybean seeds production in Poland reached 43,780 t, with an average yield of 2.4 t ha^{-1} [10].

The optimal soybean sowing date in Europe is within a wide range from mid-April to mid-May [11]. However, many studies show that postponing the sowing day after the first week of May usually results in a significant decrease in seed yield [12,13]. Under the climate conditions in Poland, to obtain a satisfactory yield, sowing is recommended for the turn of April/May when the soil temperature reaches 8 °C [14,15]. Other domestic authors have shown that the date of soybean sowing did not have a significant impact on soybean yield, and the yield varied over years of research, depending on weather conditions [16]. Other Polish authors showed that sowing in the turn of April/May had significant effect on soybean yielding in years with a course of weather conditions favourable for this species. When weather conditions were adverse, the date of sowing had no impact on the soybean seed yield. However, the delay in sowing to the first week of May, as the well as limited rainfall during the vegetation, increased the accumulation of protein in the seeds [17].

A review of existing knowledge on the effect of the date of sowing on soybean yield in conditions in central and eastern Europe contributed to the research that is the subject of this article. The following work hypothesis was formulated: How does the date of sowing contribute to the quantity and quality of the soybean seed yield of soybean cultivars under the variable weather conditions of Poland?

2. Materials and Methods

2.1. Research Background

Soybean is cultivated all over the world under different soil and climatic conditions and at different sowing dates. In south-western Poland, moving the sowing date from mid-April to first half of May can reduce the sum of day length by 8% and the sum of average daily temperatures by 5% during the soybean growing season [18]. Therefore, soybean production in countries at higher latitudes, where temperature and insolation may be inadequate, is still the subject of investigation that should be transferred to agricultural praxis.

Thus, a multi-annual programme of the Polish Ministry of Agriculture and Rural Development was implemented between 2016 and 2020 to improve the cultivation of soybean, as well as other legumes, as a source of domestic feed protein. Experiments were carried out in six different parts of Poland to assess the influence of different agronomic factors, including sowing date, on soybean yield. The experimental methodology was as identical as possible. Locations were as follows (Figure 1):

- near Wrocław—Lower Silesia region (51°10′ N, 17°06′ E; length of growing season: approx. 250 days),

- near Poznań—Greater Poland region (52°40′ N, 16°92′ E; length of growing season: approx. 225 days),
- near Bydgoszcz—Kuyavia-Pomerania region (53°12′ N, 18°01′ E; length of growing season: approx. 210–220 days),
- near Olsztyn—Warmia-Masuria region (53°78′ N, 20°48′ E; length of growing season: approx. 190–200 days),
- near Puławy—Lublin region (51°41′ N, 21°97′ E; length of growing season: approx. 200–210 days),
- near Rzeszów—Subcarpathia region (50°04′ N, 22°01′ E; length of growing season: above 220 days)

Figure 1. Map of Poland with six locations of experiments conducted under the multi-annual Programme of the Polish Ministry of Agriculture and Rural Development in years 2016–2020.

The area of Poland lies in the humid continental climate zone [19]. Its climate is also defined as transitional between a warm and rainy temperate climate and a snowy and forested boreal climate. Various air masses clash over Poland as a result of its location in the centre of Europe and the latitudinal arrangement of its geographical regions. The country is surrounded by other climate types from the temperate zone—maritime in the west and continental in the east [20]. The average annual precipitation in Poland currently reaches 500–600 mm, but its distribution is uneven throughout the year and in terms of the country's area. The average insolation for the area of Poland is 1600 h. The average air temperature in 2022 in Poland was 9.5 °C and was 0.8 degrees higher than the annual average for the multi-year period (climatological normal period 1991–2020). The year 2023 in Poland turned out to be the second warmest year of the 21st century. The average annual temperature for the country was 10 °C [21].

2.2. Details of Field Experiment

Field experiments were conducted in 2016–2019 to examine the effect of sowing date on yield and seed quality of soybean cultivars. The trials were performed in the field of the Wrocław University of Environmental and Life Sciences (51°10′ N, 17°06′ E in the Lower Silesia, Wrocław, Poland), in a split-plot design with two variables. The sowing dates were assigned in the main plots: I—10–20 April, II—10 days later than the first date, III—20 days later than the first date. And two soybean cultivars were assigned in subplots.

The examined cultivars were Lissabon (000, late cv., 133–140 days of vegetation, Saatbau Linz, Austria) and Merlin (000++, semi-late cv., 127–132 days of vegetation, Saatbau Linz, Austria), both non-GMO. There were four replicates in the experiment and the area of a single subplot amounted 15 m^2 (10 m × 1.5 m). After harvesting the winter wheat, the stubble was ploughed to a depth of 8 cm. This was followed by pre-winter ploughing to a depth of 25 cm. In spring, harrowing and pre-sowing fertilisation with P and K was carried out. The seeds of both cultivars were treated with an inoculant dedicated to soybean, based on *Bradyrhizobium japonicum*. The soybeans were seeded in a 15 cm row spacing; the number of seeds sown was 90 per 1 m^2, according to the scheme of the experiment.

Sowing dates during the study years were as follows:

- 2016—19 April, 29 April, 9 May;
- 2017—21 April, 10 May, 19 May;
- 2018—17 April, 27 April, 7 April;
- 2019—16 April, 26 April, 6 May.

More information on soybeans cultivation is presented in Table 1.

Table 1. The main elements of soybean cultivation in the years 2016–2019.

Specification	Detailed Information
Preceding crop	Winter wheat
Pre-sowing fertilisation	
P_2O_5 (46% triple superphosphate)	60 kg·ha^{-1}
K_2O (60% sylvinite)	120 kg·ha^{-1}
Plant protection	
Herbicides	prosulfocarb 800 g L^{-1} (4.0 L ha^{-1}) fluazifop-P-butyl 150 g L^{-1} (1.5 L ha^{-1}) bentazone 480 g L^{-1} and imazamox 22.4 g L^{-1} (1.25 L ha^{-1}) with adjuvant (0.6 L ha^{-1})

The harvest was carried out at the full maturity stage (BBCH 90) when 95% of the pods were ripe, the seeds turned a typical colour, and were dry and hard.

The seed yield from the plots was converted to the yield per hectare taking into account 15% moisture.

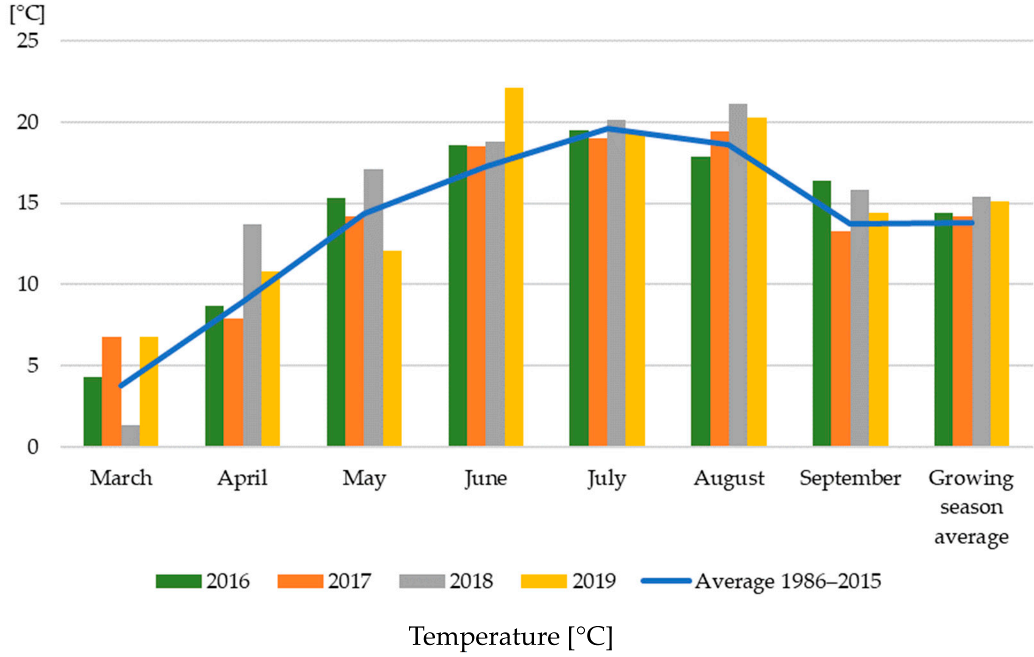
2.3. Soil Properties and Meteorological Conditions

The field experiment was set up on Cutanic Stagnic Luvisol [22]. Each year before the experiments were established, soil samples were taken for chemical analyses in which the nutrient content and soil pH were determined. Phosphorus and potassium assimilable for plants were established using the Egner–Riehm method, with the application of calcium lactate buffered to pH = 3.6 as the extraction solution. Magnesium was extracted from the soil with a 0.01 M $CaCl_2$ solution and established by spectrophotometry. The establishment of soil pH was carried out using the potentiometric method in 1 M KCl (Table 2). Regarding average for 2016–2019, pH of soil was slightly acidic, P concentration was very high, and the K and Mg concentration was high [23].

Table 2. Nutrient concentration [mg·kg^{-1}] and soil pH in 2016–2019.

Year	pH 1N KCl	P	K	Mg
2016	6.1 (slightly acidic)	90 (very high)	211 (very high)	93 (very high)
2017	5.9 (slightly acidic)	111 (very high)	154 (medium)	101 (very high)
2018	6.4 (slightly acidic)	62 (medium)	148 (medium)	76 (high)
2019	6.3 (slightly acidic)	166 (very high)	234 (very high)	88 (high)
Average	**6.2 (slightly acidic)**	**107 (very high)**	**187 (high)**	**90 (high)**

Precipitation and temperature are important factors that limit the growth, development, and yielding of soybeans. Figure 2 presents the average temperature and precipitation during vegetation periods in the years 2016–2019 and a 30-year average (1986–2015).



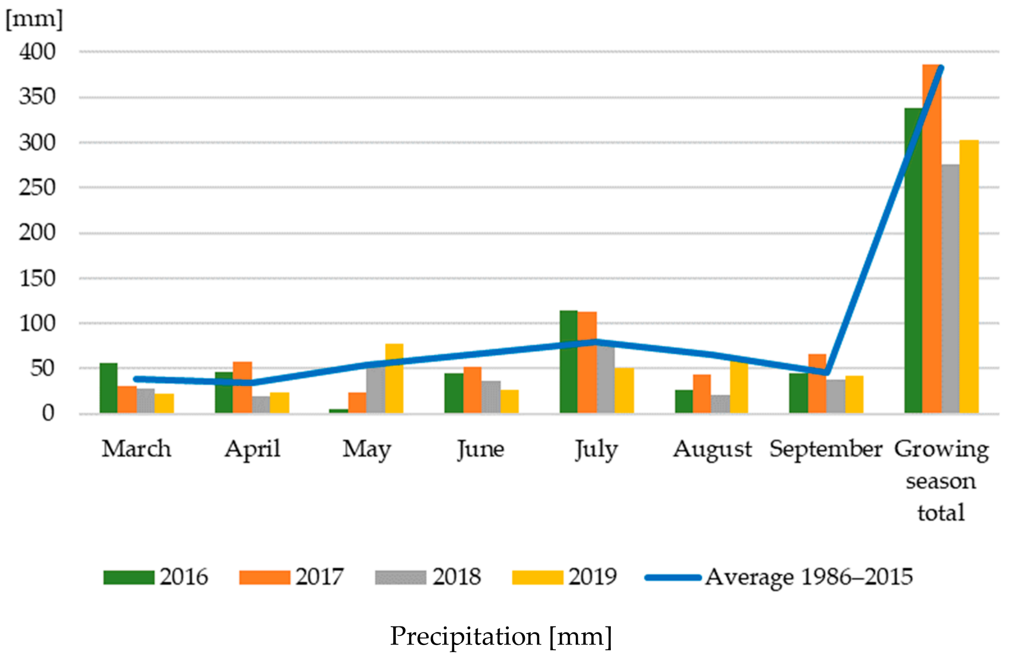


Figure 2. Weather patterns in years 2016–2019 compared to the 30-year average (Wrocław, Lower Silesia, Poland): temperature [°C] and precipitation [mm].

In 2016, the thermal conditions were beneficial for soybean development. The average temperature for the vegetation period reached 14.4 °C and was slightly higher than the 30-year average (13.8 °C). The precipitation deficit in May was very unfavourable for soybeans and shortened the vegetative development of plants. Soybean blooming began in the second week of June, and from then until the end of July, high rainfall was observed. In the first and second weeks of August, a rainfall deficit was observed again. This accelerated the maturation of the pods. In the first week of September, precipitation was low and combined with high air temperatures accelerated soybean harvest.

In 2017, the average air temperature for the vegetation period was comparable to the long-term average temperature for the years 1986–2015 and beneficial for the development of soybean plants. The total precipitation and its distribution were not favourable for the plants. In April and July, very high precipitations were observed, but in other months of the vegetation period, precipitation was very low. In particular, a rainfall deficit in May was very significant for the poor emergence of soybeans. High rainfall in September delayed soybean harvesting.

In 2018, the average air temperature was the highest among years of research and was 1.6 °C higher than the long-term average temperature. Soybean development occurred under the condition of a lack of precipitation. In each month of the vegetation period, precipitation was lower than the long-term average.

In 2019, the thermal conditions favoured the development of soybeans. Only the average temperature in May was lower than the long-term average. In other months of the vegetation period, average air temperatures were higher, compared to the average for the years 1986–2015. The vegetation period was characterised by low precipitation. In May, total rainfall was higher than the long-term average, and in other months, rainfall was sparse.

The weather conditions in the years of the experiment varied greatly, but it was observed that in all years of this study, the average temperature of the vegetation period was higher and the total rainfall was lower (excluding 2017) than the average of 30 years for Wroclaw (Lower Silesia, Poland).

2.4. Data Collection

The density of the plants per 1 m^2 was estimated immediately prior to harvest (BBCH 86–87) in each subplot. In a sample of 10 randomly chosen plants from each subplot, the following yield components were measured: the number of pods per 1 plant and the number of seeds per 1 plant.

After harvest, thousand seed weights were defined from each plot in accordance with the International Rules for Seed Testing [24], and the seed yields. The seed yields of the plots into seed yields per hectare were converted with 15% moisture.

To evaluate the quality of the seeds, total protein and the crude fat were examined. Total protein content was determined using the modified Kjeldahl method. N concentration was determined in the seeds and calculated into crude protein content with the factor 6.25. The crude fat content was determined using the Soxhlet method. The seeds were ground and dried in a dryer for 4 h in 105 °C, then crude fat was extracted using liquid ether in the Soxhlet apparatus. Dry matter was established by gravimetric method (drying of material at 105 ± 2 °C during 5 h).

Based on the results of chemical analyses (dry matter, total protein, and crude fat content) and the seed yield obtained, the protein yield and the fat yield were calculated in dry seed matter from an area of 1 ha.

2.5. Statistical Analyses

Analysis of variance (three-way ANOVA) was performed at the significance level $p < 0.05$ using Statistica 13.1 software (StatSoft, Kraków, Poland). The experiment consisted of three factors: four years, three sowing dates, two cultivars, and four randomised replicates set up in a split-plot arrangement. Homogeneous groups were determined using Tukey's multiple range test using consecutive letters starting from 'a', the most beneficial value, to 'n', the least beneficial in terms of the traits analysed.

3. Results

An analysis of variance (ANOVA) conducted showed that weather conditions in the study years had a significant effect on all the traits analysed. The sowing date modified all quantitative traits, but not qualitative traits—protein content and fat content. The tested cultivars differed significantly in all the parameters analysed, except protein content and fat yield.

The interaction of year and sowing date, as well as the interaction of year and cultivar, impacted all quantitative traits but had no significant effect on the chemical composition of the seeds, protein, and fat content. The interaction of sowing date and cultivar had no effect on the characteristics studied.

The synergistic effect of all factors examined was observed only in pre-harvest plant density, number of pods per plant, and number of seeds per plant among the parameters tested (Table 3).

Table 3. ANOVA for the effect of year, sowing date, and cultivar on the investigated parameters.

Factor	PD	PP	SP	TSW	SY	PC	PY	FC	FY
	***p*-Value**								
Year (Y)	0.0000	0.0000	0.0000	0.0059	0.0000	0.0133	0.0000	0.0011	0.0000
Sowing date (SD)	0.0000	0.0000	0.0000	0.0023	0.0000	0.1642	0.0000	0.2064	0.0000
Cultivar (C)	0.0000	0.0001	0.0000	0.0021	0.0172	0.8458	0.0116	0.0195	0.9943
Y × SD	0.0000	0.0000	0.0000	0.0001	0.0000	0.2151	0.0001	0.5618	0.0000
Y × C	0.0000	0.0000	0.0000	0.0032	0.0001	0.1419	0.0000	0.2927	0.0006
SD × C	0.6687	0.5178	0.5521	0.7617	0.4192	0.7577	0.4804	0.0722	0.1894
Y × SD × C	0.0039	0.0107	0.0002	0.8263	0.8806	0.5000	0.1023	0.5000	0.3295

PD—plant density per 1 m^2 before harvest, PP—number of pods per plant, SP—number of seeds per plant, TSW—1000-seed weight, SY—seed yield, PC—protein content in seeds, PY—protein yield, FC—fat content in seeds, FY—fat yield.

All quantitative traits studied were modified by weather course during the study years. The highest pre-harvest plant density was observed in 2016. The highest number of pods per plant was observed in 2016 and also in 2019. The highest number of seeds per plant was also observed in 2019. Thousand-seed weight was highest in 2016 and 2017. The most important trait from an economic point of view is seed yield. In the first year of this study, this parameter was the most favourable (Table 4).

Table 4. The effect of year, sowing date, and cultivar on quantitative traits of soybeans—means for factors.

Factors	PD	PP	SP	TSW	SY
Year					
2016	75.2a	22.3a	45.0b	167a	3.30a
2017	47.1c	20.6b	41.0c	168a	2.18d
2018	59.0b	17.1c	34.1d	160b	2.47c
2019	41.4d	23.2a	47.7a	160b	2.76b
Sowing date					
I	62.5a	18.8b	37.9c	168a	2.79a
II	57.8b	19.6b	40.2b	165a	2.74a
III	46.7c	24.1a	47.8a	159b	2.50b
Cultivar					
Lissabon	53.1b	21.7a	44.7a	168a	2.73a
Merlin	58.2a	20.0b	39.2b	159b	2.63b

PD—plant density per 1 m^2 before harvest, PP—number of pods per plant, SP—number of seeds per plant, TSW—1000-seed weight [g], SY—seed yield [Mg ha^{-1}]. Sowing dates: I—the earliest, II—10 days later than the first date, III—20 days later than the first date. Letters represent significant differences (Tukey's multiple range test).

Sowing date significantly affected all the traits shown in Table 4. The earliest sowing date resulted in the highest pre-harvest plant density, thousand-seed weight, and seed yield. The latest sowing date (20 days later than the earliest) contributed to the highest number of pods and seeds per plant. However, these traits were less related to seed yield, as shown in the table above.

Lissabon cultivar was characterised by higher values for examined features than Merlin cultivar, with the exception of pre-harvest plant density (Table 4).

The protein and fat content differed between the years of this study. The highest protein content was found in 2019 and the lowest in 2018. For fat content, the highest content was found in 2018. Protein and fat yields in seeds were the highest in 2016, and were stronger related to seed yields than to seed compound content.

Sowing date only modified protein and fat yield, and the highest values for these parameters were obtained in 2016 and 2017.

Genotype influenced protein yield and fat content. A higher protein yield was observed for the Lissabon cultivar, while a higher fat content was observed for the Merlin cultivar (Table 5).

Table 5. The effect of year, sowing date, and cultivar on protein and fat content in soybean seeds and protein and fat yields—means for factors.

Factors	**PC**	**PY**	**FC**	**FY**
Year				
2016	340bc	984a	220b	637a
2017	359ab	686c	216b	412c
2018	334c	722c	244a	528b
2019	371a	896b	221b	534b
Sowing date				
I	352a	855a	229a	557a
II	359a	858a	225a	539a
III	343a	753b	222a	486b
Cultivar				
Lissabon	352a	838a	221b	527a
Merlin	351a	807b	229a	528a

PC—protein content in seeds [g kg^{-1}], PY—protein yield [kg ha^{-1}], FC—fat content in seeds [g kg^{-1}], FY—fat yield [kg ha^{-1}]. Sowing dates: I—the earliest, II—10 days later than the first date, III—20 days later than the first date. Letters represent significant differences (Tukey's multiple range test).

A synergistic effect of year and sowing date was observed for all quantitative traits, but not for qualitative traits: protein and fat content (Table S1). The highest pre-harvest plant density was observed in 2016, especially at the earliest sowing date, but also at both late dates. The lowest plant density was observed in 2019 at all sowing dates compared to other years. In 2017 and 2018, the following trend can be observed: the later the sowing date, the lower the pre-harvest plant density. The highest number of pods per plant and number of seeds per plant was observed in 2017 at the latest sowing date and the lowest in 2018 at the earliest sowing date. Thousand-seed weight was very weakly dependent on the interaction of year and sowing date. The highest seed yield was obtained in 2016 at the earliest and 10-day delayed sowing date. For this interaction (Y × SD), seed yield was shown to be more strongly dependent on plant density than on other yield components (Table S1).

The effect of interaction between year and sowing date on protein and fat yields was similar for these two traits. The highest yields were stated in 2016 at the earliest sowing date, while the lowest were in 2017 at the latest sowing date (Table S2).

The interaction between year and cultivar affected all examined yield components and seed yield (Table S3). The highest pre-harvest plant density was observed in 2016 for both cultivars, Lissabon and Merlin. The highest number of pods per plant and number of seeds per plant were recorded in 2019 for Lissabon, and the lowest values for these traits were found in 2018, also for Lissabon. The effect of interaction between year and cultivar was very weak on thousand-seed weight. Seed yield was strongly modified by the analysed interaction. The highest seed yield was obtained in 2016 from Merlin cultivar, while the lowest in 2017 was also from Merlin. For this interaction (Y × C), seed yield appeared to be more strongly correlated with plant density than with other investigated yield elements (Table S3).

The interaction between year and cultivar significantly modified protein and fat yields (Table S4). The highest yields were noted in 2016, for protein yield in Merlin, and for fat yield in both cultivars. The lowest yields were noted in 2017 for Merlin cultivar.

Detailed data on the effects of interactions the factors studied on the soybean traits analysed can be found in the supplementary file (Tables S1–S4).

For information about the effect of triple interaction between year, sowing date, and cultivar on the following traits, pre-harvest plant density, number of pods per plant, and number of seeds per plant, refer to the Supplementary File (Figures S1–S3).

4. Discussion

The success of soybean cultivation is influenced by many factors, in particular the cultivar characteristics, the course of the weather during the growing season, and any agrotechnical treatments, including the sowing date, which is a no-cost factor.

Many authors have shown that soybean seed yield depends on climatic conditions: air temperature, rainfall totals and distribution, and optimal water supply [17,18,25,26]. In most parts of Europe, soybean requires about 500 mm of precipitation during the growing season, including at least 300 mm during the flowering and pod setting stages [27].

The results of the present study showed that weather conditions during the growing seasons, both as a factor and in interactions, had a very strong influence on the development of soybean plants, resulting in variations in the yield components studied and in seed yield. The weather pattern in 2016, although not favourable for soybean development due to the uneven distribution of rainfall, contributed to the highest seed yields, as a result of high pre-harvest plant density, number of pods per plant, and 1000-seed weight. The average air temperatures during the soybean vegetation period in year 2017 were lower compared to 2016; in addition, the uneven distribution of precipitation during the growing season (despite a higher annual total) resulted in lower yields by 34% in reference to yields in 2016. In turn, the years 2018 and 2019 were very dry; precipitation was lower than the multi-annual average by 107.1 mm in 2018 and 80 mm in 2019. Good thermal conditions did not compensate for the drought and yields were lower by 25.2% in 2018 and by 16.4% in 2019, in reference to 2016. Similarly, a decrease in seeds yield in dry years was reported by Borowska and Prusiński (the Kuyavia-Pomerania region) [15]. In addition, only years among the factors analysed had an effect on seed quality traits: protein and fat content. The protein and fat content varied in the years of the study. The highest protein content was found in 2019 and the lowest in 2018. For fat content, the highest was found in 2018. This shows the typical inverse relationship between protein and fat content in pulses seeds. Protein and fat yields were stronger related with seed yield than with protein or fat content in seeds and were the highest in the year 2016, which is in line with research conducted near Bydgoszcz (the Kuyavia-Pomerania region) in northern Poland [15]. Other results are mixed and show that soybean development and yield, as well as chemical composition of seeds, are strongly influenced by the local climate, especially temperatures, rainfall distribution, and spring frosts [16,17,26,28].

The date of sowing is a factor widely researched as an important part—the literal start of the relevant cultivation. Any discussion on the effect of sowing dates on soybean development and yield is a challenging issue, as soybean cultivars of varying maturity are farmed all over the world in a wide range of latitudes and evolving climatic conditions. Even present Polish studies on the impact of sowing date on soybean development and yield show different results, indicating a very strong dependence on light and thermal conditions in the growing area. In Poland, soybean sowing should be carried out when the average daily soil temperature reaches 8 °C [16,18]. The most favourable weather conditions for soybean cultivation are in Lower Silesia, near Wrocław, in the south-western part of Poland, where the climate has continental characteristics and the growing season is longer than in the rest of the country. The study showed that in the Lower Silesia region, the best sowing date for soybean seeds yield and protein and fat yields is the earliest date (second half of April), and possibly 10 days later. According to analysed and discussed research, the earliest sowing date for soybean is recommended only in the Lower Silesia region and in the Subcarpathia region, near Rzeszów, where no significant impact of the sowing date on soybean has been found, and early sowing (mid-April) is possible when weather conditions are favourable [16]. These two locations are the most southerly of those compared. However, in other regions, similar research led to other conclusions. The 10-days delayed sowing date (in the turn of April and May) was the most beneficial for soybean yielding in northern Poland, near Bydgoszcz [15] and in Puławy (western Poland) [17], while the latest sowing date in the first half of May contributed to the highest yields in Poznań—the Greater Poland region [28] and Olsztyn [26]. Olsztyn is located in the north-eastern part of Poland, characterised by the shortest growing season, frequent and late spring frosts, lower temperatures, and a lower risk of prolonged drought than in the rest of the country [26].

In the year 2024, 44 cultivars of soybean are admitted to the Polish National List [29]. By breeder country, the number of varieties is as follows: 12 Austrian, 11 German, 7 French, 3 Canadian, 2 Swiss, 1 Belarusian, and only 8 Polish among which 2 cultivars are typically Polish and 6 bred by Ukrainian breeding companies. Currently, due to the political situation, Ukrainian breeders have registered their businesses in Poland and their cultivars have automatically become Polish. However, they are not well adapted to Polish agroclimatic conditions. Breeding progress should be focused on the selection of cultivars suitable for Poland's varied agroclimatic conditions, tolerating higher soil humidity, colder temperatures, and a short growing season [30]. For testing, cultivars Lissabon and Merlin were chosen as popular in the years of research. The Lissabon cultivar produced more pods per plant, more seeds per plant, and a higher 1000-seed weight, which ultimately resulted in a higher yield than the Merlin cultivar, when analysed as a factor. In a study by Faligowska et al. [28], located near Poznań, no significant differences were observed between the yield obtained from the Lissabon and Merlin cultivars. According to the findings of Księżak and Bojarszczuk (Puławy), there were no differences between the yields of Lissabon and Merlin at the early and the 10-day delayed sowing dates, but at the latest, 20-day delayed date, Merlin yielded higher [17]. Researchers from Bydgoszcz and Olsztyn found that Merlin yielded higher than Lissabon [15,26].

The triple interaction of the year (weather conditions), sowing date, and variety is very difficult to interpret due to the significances that form many homogeneous groups and relationships. However, one correlation is clearly visible: the lower the pre-harvest plant density, the higher the number of pods per plant and the number of seeds per plant (year 2017, latest sowing date, for both cultivars). The poor plant density was most likely due to the water deficit in May 2017. Plants can compensate for yield by producing a large number of pods and seeds. Such a phenomenon is reported in the available literature [31–33].

The differences between results are due to the different lengths of the growing season in each location and the varied adaptation of the cultivars to the cultivation region and local climatic conditions. Soybean cultivation is difficult and risky in countries at higher latitudes, and Poland is a very good example of this. In individual regions of the country, there is great variation in weather patterns, which means that general cultivation recommendations are inadequate and must be adapted to specific local conditions. Testing varieties and recommending them for plantation locations is key to achieving high seed and protein yields.

5. Conclusions

In Lower Silesia, near Wrocław (south-western Poland), soybean sowing is recommended in mid-April, and if weather conditions do not allow such an early sowing, then in the turn of April and May. The cultivars tested differed in yield and yield component values in the years of this study, but the Lissabon cultivar was more adapted to local conditions. The weather course during the study years strongly influenced soybean yield and seed chemical composition.

A conclusion that also came out of this study is that lower soybean plant densities can lead to higher yields due to the production of more pods and seeds per plant. However, further research for adjusting the soybean sowing date in Poland is needed, including the testing of new cultivars under global climate changes and differences, that are, indeed, also evident locally.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agriculture14070970/s1, Table S1. The effect of interaction between year and sowing date on quantitative traits of soybeans; Table S2. The effect of interaction between year and sowing date on protein and fat yields of soybean seeds; Table S3. The effect of interaction between year and cultivar on quantitative traits of soybeans; Table S4. The effect of interaction between year and cultivar on protein and fat yields of soybean seeds; Figure S1. The effect of interaction between year, sowing date and cultivar on soybean plants density before harvest. Sowing dates: I—the earliest, II—10 days later than the first date, III—20 days later than the first date. Cultivars: L—Lissabon, M—Merlin. Letters represent significant differences (Tukey's multiple range test); Figure S2. The effect of interaction between year, sowing date and cultivar on number of pods per one soybean plant. Sowing dates: I—the earliest, II—10 days later than the first date, III—20 days later than the first date. Cultivars: L—Lissabon, M—Merlin. Letters represent significant differences (Tukey's multiple range test); Figure S3. The effect of interaction between year, sowing date and cultivar on number of seeds per one soybean plant. Sowing dates: I—the earliest, II—10 days later than the first date, III—20 days later than the first date. Cultivars: L—Lissabon, M—Merlin. Letters represent significant differences (Tukey's multiple range test).

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