agronomy

Article

The Effects of Potassium Fertilization and Irrigation on the Yield and Health Status of Jerusalem Artichoke (*Helianthus tuberosus* L.)

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Abstract: The objective of this study was to determine the effects of potassium fertilization (applied to soil at 150, 250, and 350 kg K_2O ha^{-1}) and irrigation on the yield (fresh matter yield and dry matter yield of above-ground biomass and tubers) and the health status of tubers and leaves of three Jerusalem artichoke—JA (*Helianthus tuberosus* L.) cultivars (Topstar, Violette de Rennes, Waldspindel). The Topstar cultivar was characterized by the highest total tuber yield (60.53 Mg FM ha^{-1}) and the highest above-ground biomass yield (65.74 Mg FM ha^{-1}). An increase in the rate of potassium fertilizer to 350 kg K_2O ha^{-1} did not affect total tuber yields. The greatest increase in above-ground biomass yields was observed in response to the potassium fertilizer rate of 150 kg K_2O ha^{-1} (64.40 Mg FM ha^{-1}). Irrigation increased tuber yields by 59% and above-ground biomass yields by 42% on average. Phytopathological analyses revealed that JA leaves were most frequently colonized by fungi of the genera *Alternaria*, *Fusarium*, and *Epicoccum*. *Alternaria* and *Fusarium* fungi were more prevalent in non-irrigated than in irrigated plots. A higher number of fungal pathogens was isolated from the leaves of cv. Violette de Rennes grown in a non-irrigated plot fertilized with 250 kg K_2O ha^{-1}. Tubers were most heavily colonized by fungi of the genera *Penicillium*, *Fusarium*, *Alternaria*, *Botrytis*, and *Rhizopus*. Fungal species of the genus *Fusarium* were isolated from tubers in all irrigated treatments, and they were less frequently identified in non-irrigated plots. Only the tubers of cv. Topstar grown in non-irrigated plots and supplied with 150 kg K_2O ha^{-1} were free of *Fusarium* fungi. The number of cultures of pathogenic species isolated from Jerusalem artichoke tubers had a minor negative impact on fresh and dry matter yield.

Keywords: Jerusalem artichoke; mineral fertilization; irrigation; yield; diseases; fungi

1. Introduction

Jerusalem artichoke (JA) has been long grown as a source of animal feed, but in recent years, its popularity increased in the food processing industry, mainly in the production of functional ingredients such as inulin, oligofructose, and fructose [1–4]. The leaves and stems of JA are also a source of bioactive compounds that are used in the treatment of wounds and swelling [5–7].

In recent years, JA tubers have also been recognized as a valuable source of sugars for bioethanol production. Its tubers are more abundant in ethanol (1500–11,000 L ha^{-1}) than sugar beetroots (5000–6000 L ha^{-1}) and maize (2000–6698 L ha^{-1}) [8–15]. Jerusalem artichoke is a promising source of agricultural biomass due to its wide range of applications and low production costs.

Jerusalem artichoke has numerous advantages over other agricultural crops, including a rapid growth rate, tolerance to low temperatures, and high resistance to pests. New

cultivars are characterized by high yields. However, it should be stressed that JA thrives in moist soils and has high fertilization requirements. The goal of every agricultural production system is to maximize yields per unit area. Fecundity is determined by the optimal combination of genetic and agronomic factors. Macronutrient deficiencies, including nitrogen, potassium, and phosphorus, as well as drought compromise yields [8,14,16–20]. According to Rossini [14], JA thrives in regions where annual precipitation exceeds 500 mm. Soja et al. [8] observed that potassium deficiency is more likely to slow down the growth of tubers than aerial plant parts. However, nitrogen has a stronger influence on yields than potassium because it determines the photosynthetic potential of plants and increases their water use efficiency [21]. In turn, potassium speeds up the translocation of sugars from leaves to tubers. Potassium and nitrogen fertilization increases the yield of tubers and improves their quality [22]. According to some authors [16–18], water supply is the key limiting factor in the production of JA. Research indicates that early-maturing varieties are more sensitive to drought that late-maturing varieties. For this reason, drought as well as nitrogen, phosphorus, and potassium (NPK) fertilizers strongly influence the accumulation of dry matter [23,24].

Jerusalem artichoke is colonized by various herbivorous insects and microorganisms, but not all of them contribute to a decrease in yields [14,16]. The threats associated with pathogens are determined by agronomic conditions [25]. According to Doneroy [16], aboveground plant parts are less susceptible to disease than tubers, in particular in the last stages of growth and during storage. The most dangerous pathogens of JA are *Sclerotinia sclerotiorum*, which causes sclerotinia wilt/rot, and *Sclerotium rolfsii* which causes southern wilt, also known as southern blight or collar rot [16,26]. *Sclerotium rolfsii* can decrease JA yields by as much as 60% [27]. Jerusalem artichoke is also susceptible to rust caused by *Puccinia helianthin* and powdery mildew caused by *Erisyphe chicoracearum*, but these pathogens does not compromise yields [16,28]. Various pathogens are responsible for leaf spot diseases in JA. *Alternaria helianthi* causes small yellow spots on leaves, followed by leaf damage and defoliation; it reduces the photosynthetic capacity of plants [29,30] and can decrease sunflower yields by up to 80% [29]. The disease is most severe in tropical regions. In China, JA is susceptible to *Bipolaris zeae* which causes brown spot disease [31]. Pathogens also affect JA tubers. Symptoms of disease are also observed during storage, in particular in tubers that were damaged during harvest. Tuber pathogens include *Botrytis cinerea, Rhizopus nigricans* as well as species of the genera *Fusarium* and *Pennicillum* [32,33].

The aim of this study was to determine the optimal rates of potassium fertilizer applied to soil, and to evaluate the effect of irrigation on the yield and health status of JA tubers.

2. Materials and Methods

2.1. Field Experiment

Jerusalem artichoke was grown in 2018 during a field experiment conducted in the Agricultural Experiment Station in Tomaszkowo (53°42′ N, 20°26′ E, NE Poland). The experiment had a three-factorial split-split-plot design with three replications. The analyzed variables were: (i) cultivar: Topstar (early edible cultivar with yellow-brown tubers), Violette de Rennes (mid-late edible cultivar with red tubers), Waldspindel (mid-late cultivar with red tubers which is processed in herbal and distilling industries); (ii) rate of potassium fertilizer applied to soil (kg K_2O ha^{-1}): 150, 250, 350; and (iii) irrigation: treatments that were and were not irrigation.

The examined cultivars were acquired from an organic farm (Die Topinambur Manufaktur, Heimenkirch, Bavaria, Germany). The tubers were planted in mid-April at a depth of 6–8 cm, with a spacing of 75 × 30 cm. Potassium fertilizer in the form of potassium sulfate (50%), 80 kg N ha^{-1} (urea, 46%), 70 kg P_2O_5 ha^{-1} (enriched superphosphate, 40%), and 90 CaO kg ha^{-1} (ground dolomite, 52% CaO, 37% $MgCO_3$, 48% $CaCO_3$) was applied before planting based on the experimental design. Organic fertilizer was not applied. Fertilizer rates were determined based on the results of an experiment conducted in Germany during 1994–2001 [34].

The moisture content of soil was monitored from the beginning of tuber formation, during plant growth, until leaf ageing and the transfer of sugars to tubers (from mid-June to mid-October). The optimal soil moisture content was established at 14.3–16.5%, i.e., 65–75% of field water capacity at a depth of 30 cm. The soil moisture was measured twice a week. Jerusalem artichoke was irrigated every 5–7 days at 20 dm^3 m^{-2} when field water capacity fell below 60% ($\leq$13.2% soil moisture content). The irrigation schedule was based on the irrigation regime for late potato cultivars (*Solanum tuberosum L.*) and field water capacity for various types of soil [35]. Soil moisture was measured with the SM 150-KIT probe (Geomor-Technik Ltd., Szczecin, Poland). Each irrigation treatment involved 220 mm of water per m^2 of plot area, and 11 treatments were applied during the growing season of *H. tuberosus* (on 13 and 19 June; 3 and 9 July; 10 and 23 August; 3, 11, 20 and 28 September; 6 October).

The tuber fresh matter yield was determined at harvest in each plot. Tuber samples of 0.5 kg each were collected from each plot, and their dry matter was determined by the gravimetric method. Ground analytical samples of 5 g each were dried to constant weight at a temperature of 105 °C for 5–8 h (based on the results of three consecutive measurements) and were left in the desiccator until the achievement of room temperature (SUP 100 W laboratory drier, WAMED Warszawa, Poland). The weight of the harvested tubers was expressed per 1 ha.

Fresh matter yield was also determined in the above-ground biomass harvested from each plot. Dry matter content was determined in approximately 1 kg samples of above-ground biomass (stems, leaves, inflorescence) collected from each plot. The samples were cut into segments with a length of 1 cm, dried at a temperature of 65 °C for 10 h (BINDER GmBH, FED 720 drying oven, Binder Ltd., Tuttlingen, Germany), and weighed. The weight of the harvested aerial plant parts was expressed per 1 ha.

Jerusalem artichoke was grown on Haplic Luvisol loamy sand [36] in plots with an area of 2.7 m^2 each. The preceding crop was oat (*Avena sativa* L.). Composite soil samples were obtained at a depth of 20 cm from each plot to for analyses of the chemical properties of soil. Soil pH was determined at 5.4 with a digital pH meter. Nutrient levels in soil samples were determined at 74 mg P kg^{-1} (Egner-Riehm method), 145 mg K kg^{-1} (Egner-Riehm method) and 69 mg Mg kg^{-1} (AAS) [37]. Tubers were ridged once after planting. Crops were harvested in early November.

2.2. Mycological Analyses of Jerusalem Artichoke Leaves and Tubers

Mycological analyses were carried out in three JA cultivars: Topstar, Violette de Rennes and Waldspindel. Jerusalem artichoke was grown in non-irrigated or irrigated plots with various rates of potassium fertilizer. Plant health was evaluated once, in the last ten days of August in all plots.

To evaluate the health status of plants, three leaves were collected from the middle segment of randomly selected plants in each replication in each treatment. In the laboratory, the collected plant materials were pooled (samples of 9 leaves each), and next six leaves were collected randomly from each treatment. The leaves were cut into 5 mm × 5 mm segments. Leaf segments were rinsed under running water, disinfected in 1% sodium hypochlorite solution for 5 min and in 70% ethyl alcohol for 5 min, and rinsed with sterile distilled water. The prepared specimens were plated on PDA (5 specimens per plate) and incubated at 23 °C in a 12-h dark and 12-h UV light cycle. After 10 days, fungal cultures were transferred onto PDA in sterile Petri plates. After 14 days, fungal colonies were identified to genus and species level based on the literature [37–39].

The health status of the harvested tubers was evaluated in each JA cultivar. Ten tubers were sampled from each cultivar in the first ten days of December. The tubers were washed under running water, disinfected in 1% sodium hypochlorite solution for 5 min and 70% ethyl alcohol for 5 min, rinsed with sterile distilled water, and cut into segments measuring 5 mm × 5 mm × 3 mm. The prepared specimens representing each cultivar and each treatment were plated on PDA (5 specimens per plate, a total of 10 plates) and incubated at

23 °C in a 12-h dark and 12-h UV light cycle. After 10 days, fungal colonies were transferred onto PDA in sterile Petri plates. After 14 days, fungal colonies were identified to genus and species level based on the literature [38–40].

2.3. Analysis of Pathogenic and Saprotrophic Fungi

Relative frequency [*RF*] was calculated with the use of Equation (1), dominance [*Y*]—with Equation (2), species richness [*S*] (number of species colonizing the leaves and tubers of each JA cultivar), and Margalef index [*D'*]—with Equation (3), Shannon–Wiener index [*H'*]—with Equation (4), and the dominance index [λ]—with Equation (5). The calculated indices were used in quantitative analyses of the abundance, distribution preference, and composition of pathogenic and saprotrophic fungal species colonizing Jerusalem artichoke leaves and tubers.

$$RF\ (\%) = \left(\frac{n_i}{N_i}\right) x\ 100\%\ \tag{1}$$

$$Y = \left(\frac{n_i}{N_i}\right) x f_i\ \tag{2}$$

$$D' = (S-1)/lnN_t\ \tag{3}$$

$$H' = -\sum_{i=1}^{s} P_i ln P_i,\ P_i = N_i/N_t\ \tag{4}$$

$$\lambda = \sum_{i}^{s} p_i^2,\ \tag{5}$$

where *Nt* is the number of isolated cultures, *Ni* is the number of isolates belonging to the *i*-th species, and *fi* is the frequency of taxa belonging to a given genus [41].

2.4. Weather Conditions

In 2018, the growing season had 201 days. Jerusalem artichokes were harvested in the first week of November. Weather conditions during the growing season of 2018 are presented in Table 1. The mean monthly air temperatures were similar to the long-term average for 1981–2010. The rapid growth of aerial plant parts and tuber formation began in mid-June. During the growing season, the total rainfall was determined at 418.8 mm, and it was 7% lower than the long-term average (450.1 mm). Rainfall was not evenly distributed across months, and dry spells were observed in May and September. May and September were the driest months (when precipitation was 57% and 64% lower than the long-term average, respectively), and irrigation was required (3, 11, 20, and 28 September). The optimal moisture content of soil was set based on the irrigation regime for late-maturing potato varieties. The precipitation levels in August also failed to meet JA's water needs. July was the only month when rainfall exceeded the long-term average by 90% and the crops' water requirements by 45%. However, the field water capacity fell below 60% (to ≤13.2%), and the plots had to be irrigated.

During crop production, atmospheric drought can be determined by calculating Selyaninov's hydrothermal coefficient (K) with the use of the following formula (Equation (6)):

$$K = \frac{p}{0.1 \sum t}\ \tag{6}$$

where:

P—total monthly precipitation

t—sum of monthly temperatures divided by 10

Values below 1.0 indicate drought, and values below 0.5 denote severe drought. The analyzed growing period was characterized mostly by drought (April, June, and August) and severe drought (May and September). The rapid growth of aerial plant plants and tuber setting begins in the second half of June and ends in late October [35]. According to Denoroy [16], JA is particularly susceptible to drought during seedling emergence, flowering, and late stages of tuber growth. However, water deficit during

seedling emergence is less detrimental to final yields than drought in the remaining two stages which can decrease yields by as much as 20%.

Table 1. Meteorological data for the growing season in 2018 and the long-term average for 1981–2010.

Specification	Month							
	April	**May**	**June**	**July**	**August**	**September**	**October**	**November**
Mean air temperature (°C)	10.8	15.7	17.2	19.7	19.2	14.5	8.7	3.3
30-yr mean	7.7	13.5	16.1	18.7	17.9	12.8	8.0	2.9
Total rainfall (mm)	33.5	25.0	53.7	141.0	44.6	20.3	84.7	16.0
30-yr mean	33.3	58.5	80.4	74.2	59.4	56.9	42.6	44.8
Water requirements of late-maturing potato varieties [35]	-	62	74	97	79	50	-	-
Selyaninov's hydrothermal coefficient (K) * [41,42]	1.03	0.51	1.04	2.30	0.75	0.47	3.14	1.61

* K: 0–0.5—severe drought, 0.6–1.0—drought, 1.0–2.0—moist, >2.1—wet.

2.5. Statistical Analysis

The results were analyzed statistically with the use of one-way analysis of variance (ANOVA) in the Statistica 13.3 program [42,43]. Significant differences ($p < 0.05$) between means were determined in Tukey's (honestly significant difference (HSD) test for multiple comparisons to assess significant differences between means. The results of the F-test for fixed effects in ANOVA are presented in Table 2.

Table 2. *F*-test statistics in ANOVA.

Parameter	**Cv**	**K**	**Irrigation (IR)**	**Cv × K**	**Cv × IR**	**K × IR**	**Cv × K × IR**
Total tuber yield (FM Mg ha^{-1})	9.826 ***	2.696*ns*	59.120 ***	3.105 **	0.601*ns*	3.313 **	1.112*ns*
Total tuber yield (DM Mg ha^{-1})	14.880 ***	2.244*ns*	50.849 ***	3.271 **	0.677*ns*	3.644 **	0.986*ns*
Above-ground biomass yield (FM Mg ha^{-1})	10.896 ***	7.714 **	77.245 ***	6.702 ***	1.403*ns*	3.504 **	2.137*ns*
Above-ground biomass yield (DM Mg ha^{-1})	8.051 ***	5.051 **	54.275 ***	4.158 ***	0.799*ns*	2.098*ns*	1.498*ns*

** significant $p < 0.01$, *** significant $p < 0.001$, *ns*—not significant.

The relationships between above-ground biomass yield, total tuber yield (fresh and dry matter yield), and the number of pathogens and saprotrophic fungi isolated from Jerusalem artichokes were determined with the use of linear regression methods and Pearson's linear correlation coefficients.

3. Results and Discussion

3.1. Total Tuber Yields and Above-Ground Biomass Yields

The total tuber yield was highest in cv. Topstar and similar to that reported by Rodrigues et al. [44] at 65.6 Mg ha^{-1} (Table 3). Topstar is an early cultivar, and its yields exceeded the values noted in mid-late cultivars: by 13.6 Mg ha^{-1} (FM) in comparison with cv. Waldspindel and by 17.5 Mg ha^{-1} (FM) in comparison with cv. Violette de Rennes. The fresh matter yield of JA tubers ranged from 55.5 to 90 Mg ha^{-1} in the work of Conde et al. [45], Baldini et al. [46], and Kim and Kim [47]. The fresh matter yield of JA tubers grown in a high-input system was determined at 30–80 Mg ha^{-1} by Denoroy [16], and Izsaki and Kadi [19]. The lowest tuber yields in the range of 3 to 46 Mg ha^{-1} were reported by Swanton et al. [9] and Pimsaen [48].

Table 3. The effect of the experimental factors on the yields of Jerusalem artichoke tubers and above-ground biomass ($Mg\ ha^{-1}$).

Parameter	Total Tuber Yield FM	Total Tuber Yield DM	Above-Ground Biomass Yield FM	Above-Ground Biomass Yield DM
Cultivar				
Violette de Rennes	43.17 [b]	8.84 [b]	55.97 [b]	20.69 [b]
Waldspindel	46.95 [b]	12.23 [a]	53.39 [b]	19.59 [b]
Topstar	60.53 [a]	14.18 [a]	65.74 [a]	24.42 [a]
Potassium fertilizer (kg $K_2O\ ha^{-1}$)				
150	55.73 [a]	12.77 [a]	64.40 [a]	23.82 [a]
250	47.36 [a]	11.81 [a]	53.70 [b]	19.97 [b]
350	47.55 [a]	10.67 [a]	57.00 [b]	20.93 [ab]
Irrigation				
Irrigated	63.14 [a]	14.64 [a]	68.38 [a]	25.36 [a]
Not irrigated	37.29 [b]	8.86 [b]	48.35 [b]	17.78 [b]

Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test.

The difference in the tuber dry matter yield between cvs. Topstar and Waldspindel reached only 1.95 $Mg\ ha^{-1}$, and it was not significant (Table 3). The tubers of cv. Violette de Rennes were characterized by the lowest dry matter yield which was 5.34 $Mg\ ha^{-1}$ lower than in cv. Topstar and 3.4 $Mg\ ha^{-1}$ lower in than in cv. Waldspindel. In a study by Rodrigues et al. [44], the dry matter yield of JA tubers was much higher at 18.4 $Mg\ ha^{-1}$.

An increase in the mineral fertilizer rate to 350 kg $K_2O\ ha^{-1}$ did not influence the fresh matter yield or the dry matter yield of JA tubers (Table 3). Similar observations were made by Matias et al. [10]; in their study, the total tuber yields were not significantly affected by the applied rate of NPK fertilizer, which could be attributed to high soil fertility resulting from the choice of an adequate preceding crop. Izsaki and Kadi [11] demonstrated that tuber yields peaked at 10 $Mg\ ha^{-1}$ in response to a potassium rate of 120 $Mg\ ha^{-1}$, which was found to be optimal. Izsaki and Kadi [11] and Raso [49] reported no interaction between potassium in the form of potassium sulfate (120 and 240 kg $K_2O\ ha^{-1}$) and nitrogen fertilizers for JA tuber yields (the yield reached 34 $Mg\ ha^{-1}$ in the treatment with 50 kg $N\ ha^{-1}$).

The analyzed JA cultivars also differed in their responses to higher potassium rates—the tuber fresh matter yield was highest in cv. Topstar in plots fertilized with 150 kg $K_2O\ ha^{-1}$ and the lowes in cvs. Violette de Rennes and Waldspindel in plots fertilized with 250 kg and 350 kg $K_2O\ ha^{-1}$ and (Figure 1). Similar observations were made in an analysis of the tuber dry matter yield (Figure 2). In the early cultivar Topstar, the tuber dry matter yield was highest in response to 250 kg $K_2O\ ha^{-1}$ (Figure 2).

The application of 350 kg $K_2O\ ha^{-1}$ increased both tuber fresh matter and dry matter yields only in cv. Waldspindel (Figures 1 and 2).

The lowest tuber dry matter yields were noted in cv. Violette de Rennes fertilized with 350 kg $K_2O\ ha^{-1}$. The difference between the highest yielding cv. Topstar and the lowest yielding cv. Violette de Rennes reached 17.36 Mg FM ha^{-1} and 5.34 Mg DM ha^{-1} (Tables S1 and S2).

Jerusalem artichoke responded strongly to irrigation. Tuber fresh matter and dry matter yields increased by 69.3% and 65.2%, respectively, in response to irrigation (Tables S1 and S2). Irrigation also induced differences in the fresh matter yield of JA tubers in response to an increase in fertilization levels. The highest tuber fresh matter and dry yield peaked in response to 150 kg $K_2O\ ha^{-1}$ in irrigated plots, whereas an the lowest was noted in non irrigated plots with 250 kg $K_2O\ ha^{-1}$ fertilization (Figures 3 and 4, Tables S1 and S2). In the study, no significant effect of potassium fertilization on increase the tuber fresh matter and dry matter yield of Jerusalem artichoke was shown (Tables S1 and S2).

Figure 1. The effect of potassium fertilization on the total tuber yield (fresh matter basis) of the analyzed Jerusalem artichoke cultivars. Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test. * 150, 250, 350 kg K_2O ha^{-1}—potassium fertilization.
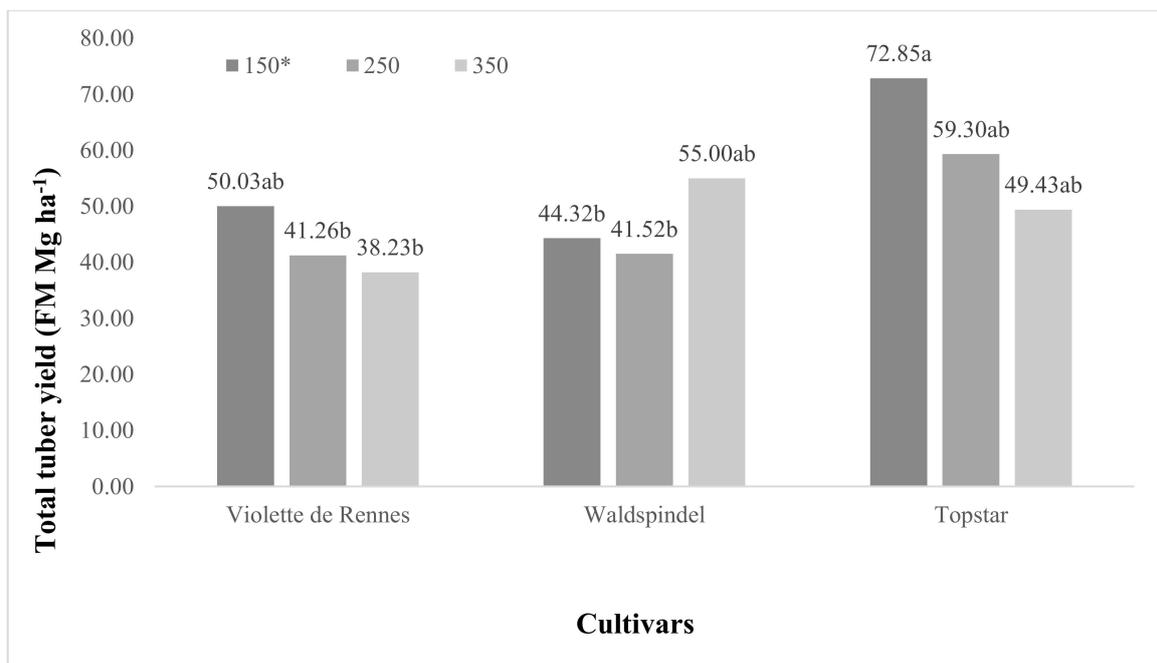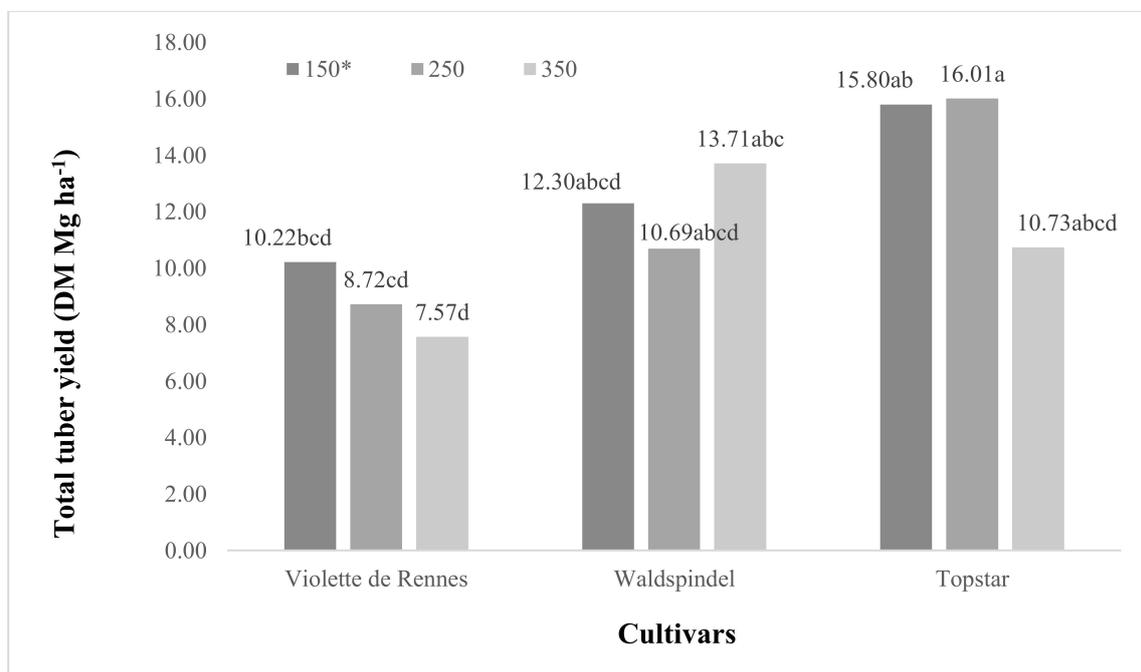

Figure 2. The effect of potassium fertilization on the total tuber yield (dry matter basis) of the analyzed Jerusalem artichoke cultivars. Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test. * 150, 250, 350 kg K_2O ha^{-1}—potassium fertilization.

Figure 3. The effect of irrigation and potassium fertilization on the total tuber yield (fresh matter basis) of Jerusalem artichoke. Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test. * 150, 250, 350 kg K_2O ha^{-1}—potassium fertilization.
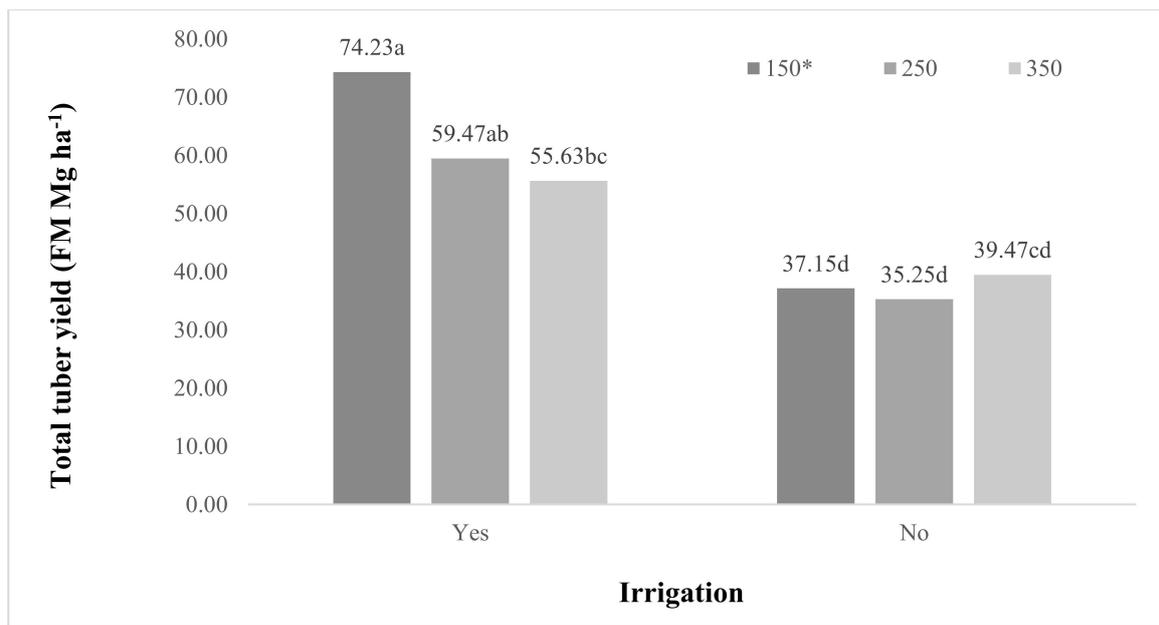

Figure 4. The effect of irrigation and potassium fertilization on the total tuber yield (dry matter basis) of Jerusalem artichoke. Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test. * 150, 250, 350 kg K_2O ha^{-1}—potassium fertilization.

In a study by Baldini et al. [46], irrigation increased the tuber dry matter yield by 24.2%. Schittenhelm [50] reported a 12 Mg FM ha^{-1} and 5.1 Mg DM ha^{-1} under water stress conditions and concluded that JA was more sensitive to drought than sugar beetroots and chicory.

In the present study, cv. Topstar was characterized by the highest fresh matter and dry matter yields of aerial plant parts. The yields of the early cv. Topstar exceeded the values

noted in the mid-late cultivars by 9.8 Mg FM ha^{-1} and 3.7 Mg DM ha^{-1} (cv. Violette de Rennes) and by 12.3 Mg FM ha^{-1} and 4.8 Mg DM ha^{-1} (cv. Waldspindel) (Table 3).

In the work of Baldini et al. [46], the fresh matter yield of above-ground biomass ranged from 29.5 to 58.7 Mg ha^{-1} and was similar to that noted in this study (58.4 Mg ha^{-1} on average). Izsaki and Kadi [19] and Monti et al. [23] observed that plants grown in irrigated fields adapted to water stress with the growth and development of the root system. Under favorable water conditions, tubers compete with aerial plant parts for water [16].

An increase in the potassium fertilizer rate to 250 kg K$_2$O ha^{-1} decreased the fresh matter and the dry matter yields of above-ground biomass by around 10.7 and 3.8 Mg ha^{-1}, respectively, relative to plots fertilized with 150 kg K$_2$O ha^{-1}. When the potassium rate was increased to 350 kg K$_2$O ha^{-1}, a minor and non-significant increase was noted in fresh matter yield (3.3 Mg ha^{-1}) and dry matter yield (1.0 Mg ha^{-1}). The lowest potassium rate (150 kg K$_2$O ha^{-1}) exerted the greatest yield-forming effect (Table 3).

The influence of higher fertilizer rates on the fresh matter and dry matter yield of aerial plant parts also differed among the analyzed JA cultivars. In cv. Topstar fresh matter yield peaked in response to 150 kg K$_2$O ha^{-1} (Figures 5 and 6, Tables S3 and S4). The lowest fresh matter yields were observed for the cultivar Violette de Rennes with with application of 250 and 350 kg K$_2$O ha^{-1} and cv. Waldspindel with 150 and 250 kg K$_2$O ha^{-1} doses (Figure 5). Similar relationships were observed in the dry matter yield of above-ground biomass (Figure 6).

Figure 5. The effect of potassium fertilization on the above-ground biomass yield (fresh matter basis) of the analyzed Jerusalem artichoke cultivars. Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test. * 150, 250, 350 kg K$_2$O ha^{-1}—potassium fertilization.
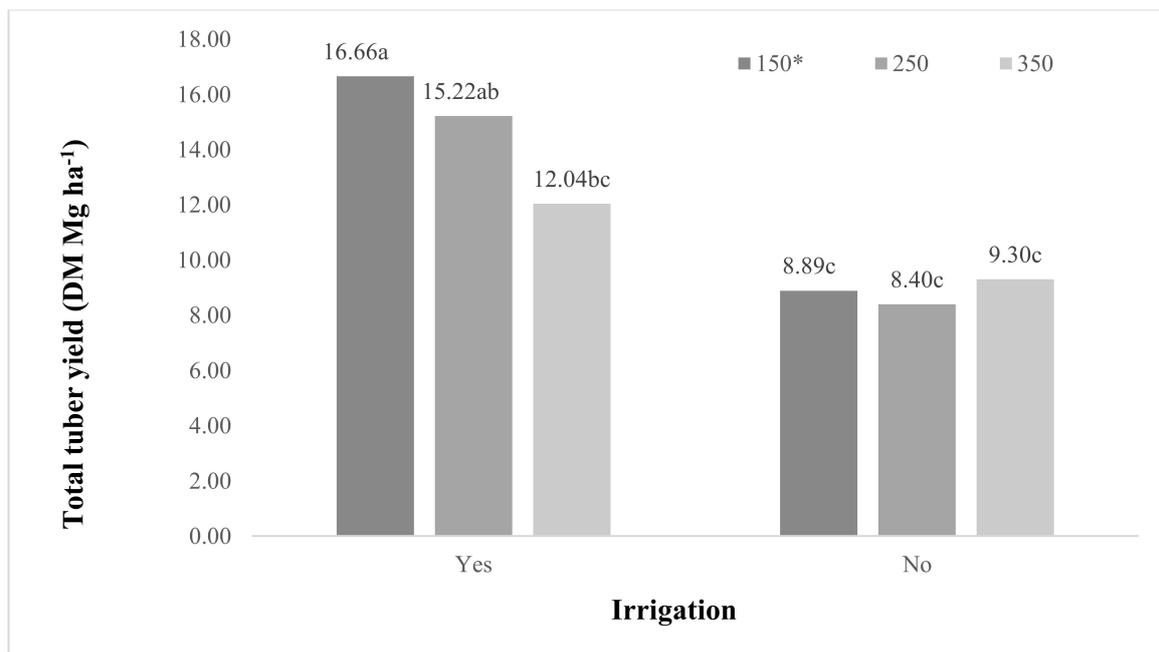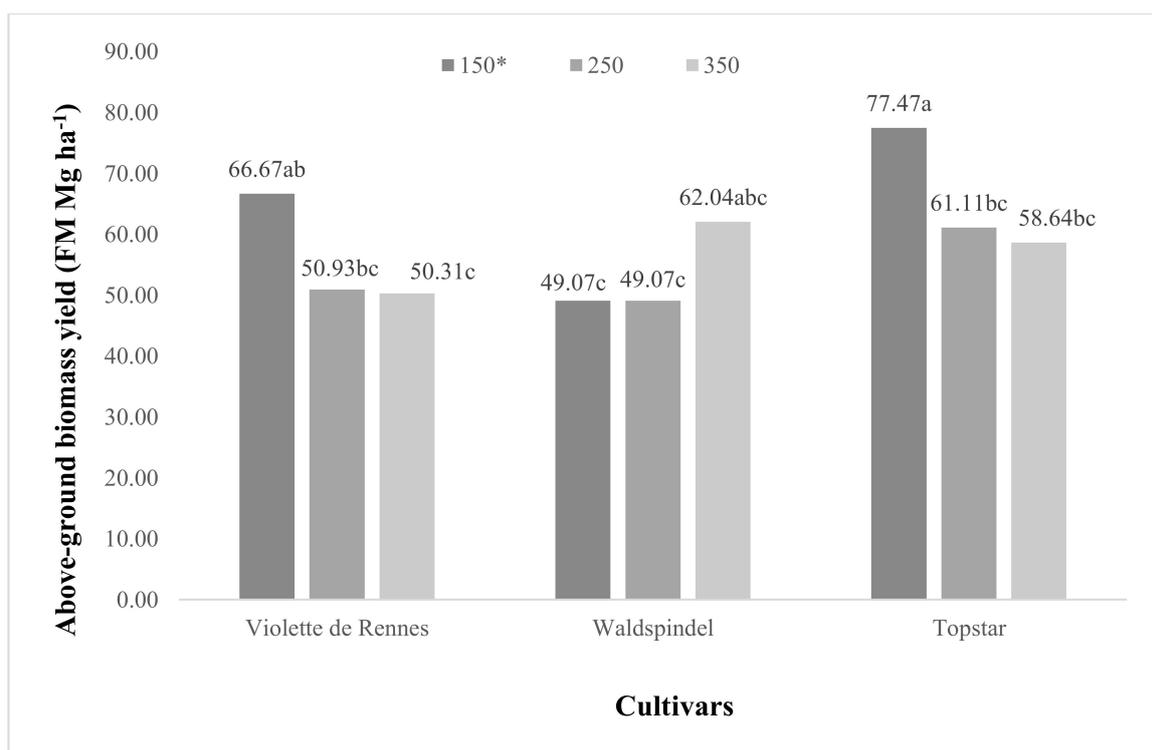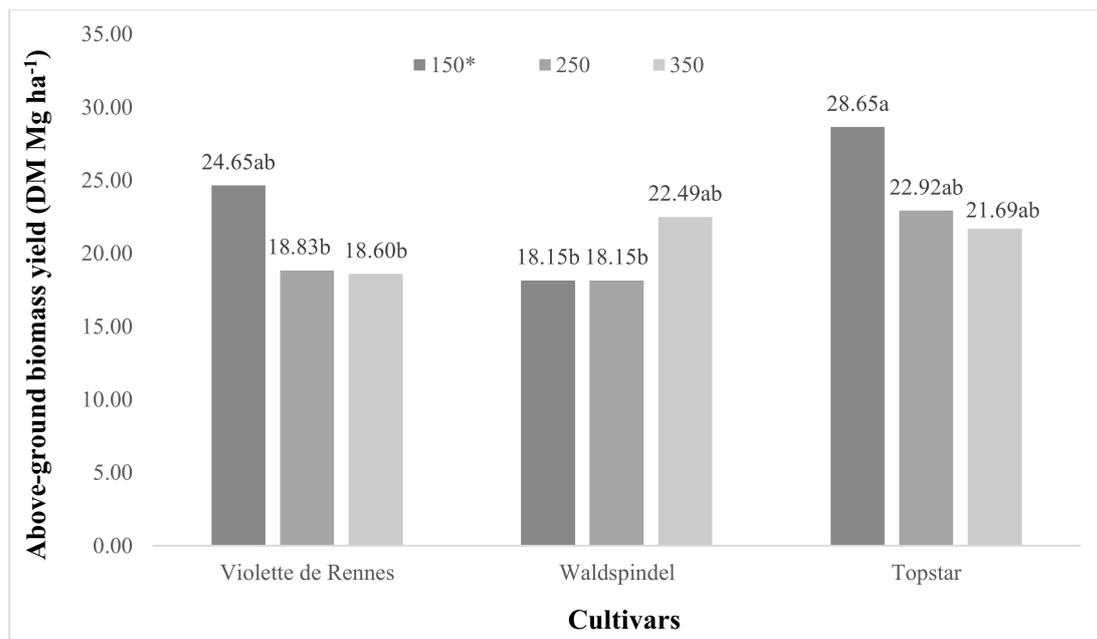
Figure 6. The effect of potassium fertilization on the above-ground biomass yield (dry matter basis) of the analyzed Jerusalem artichoke cultivars. Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test. * 150, 250, 350 kg K_2O ha^{-1}—potassium fertilization.

Jerusalem artichoke above-ground fresh and dry matter basis biomass yield responded strongly to irrigation. Irrigation increased the fresh matter and dry matter yields of aerial plant parts by 42% and 43%, respectively (Table 3).

Irrigation also induced differences in the fresh matter yield of above-ground biomass in response to higher fertilizer rates. The fresh matter yield of aerial plant parts was the highest after the application of 150 kg K_2O ha^{-1}, but it significantly decreased by 14.4 Mg ha^{-1} when the potassium rate was increased to 350 kg K_2O ha^{-1} and 16.3 Mg ha^{-1} with a dose of 250 kg K_2O ha^{-1} on irrigated plots (Figure 7). The lowest fresh matter yields were recorded in plots without irrigation (Figure 7).
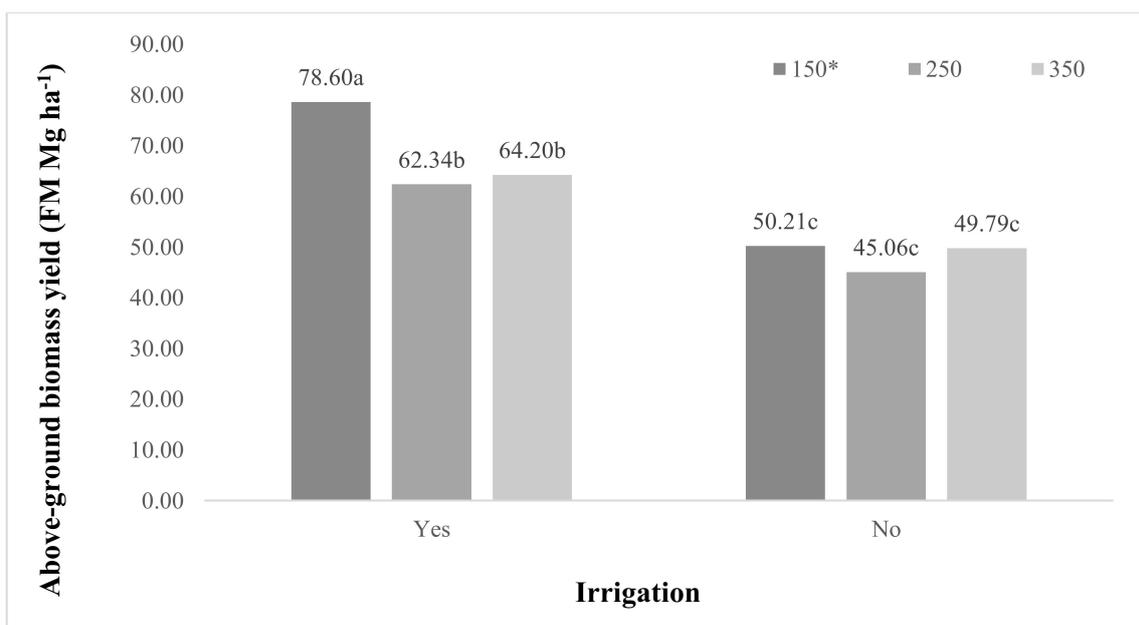

Figure 7. The effect of irrigation and potassium fertilization on the above-ground biomass yield (fresh matter basis) of Jerusalem artichoke. Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test. * 150, 250, 350 kg K_2O ha^{-1}—potassium fertilization.

According to Gao [51], irrigation significantly improves the yields of aerial plant parts as well as tubers.

3.2. Mycological Analyses of Tubers and Aerial Plant Parts

Jerusalem artichoke is resistant to biotic stresses such as pests and disease [52] and potentially resistant to abiotic stresses, including drought, frost, and high temperature [53]. However, there is considerable evidence [14,16,25,26,33,54] to indicate that similar to other crops, JA is susceptible to various pathogens, in particular fungi. Phytopathogens exert a negative influence on plant growth and development, and they compromise the quality of crops. In the current study, various fungal species and genera were identified on aerial plant parts (leaves) and tubers of three JA cultivars. A total of 355 fungal isolates were obtained from 900 cultured leaf segments. Of those, 164 isolates were obtained from leaves grown in irrigated treatments, and 191 from leaves grown in non-irrigated treatments (Table 4). Phytopathological analyses revealed that JA leaves were colonized mostly by fungi of the genera *Alternaria*, *Fusarium*, and *Epicoccum*. The most prevalent fungal species of the genus *Fusarium* were *Fusarium avenaceum* and *F. sporitrichioides*. Jerusalem artichoke leaves were also colonized by *Botrytis cinerea*, *Epicoccum nigrum*, *Nigrospora sphaerica*, *Didymella pinodella* as well as *Mucor* spp., *Penicillium* spp., and *Chaetomium* spp. (Table 5). The analysis of the composition of saprotrophs and pathogens revealed that pathogenic species were predominant on Jerusalem artichoke leaves, which was confirmed by nearly all biodiversity indicators (Table 5). The number of fungal isolates obtained from the analyzed cultivars was similar in irrigated plots (54–56 isolates). In non-irrigated treatments, fungal pathogens were most frequently isolated from the leaves of cv. Violette de Rennes and were least prevalent on the leaves of cv. Waldspindel (Table 4, Figure 8A,B). Fungi of the genera *Alternaria* and *Fusarium* were more prevalent in non-irrigated than in irrigated plots (Table 4).

(**A**)   (**B**)
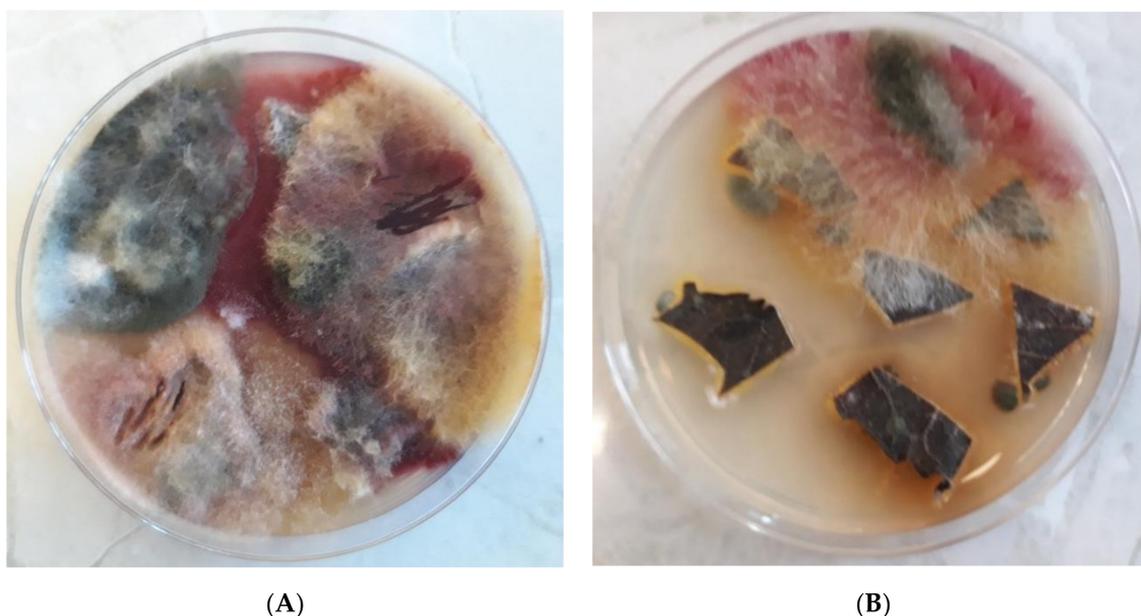
Figure 8. (**A**,**B**) Jerusalem artichoke leaves (segments) infected by fungi.

The values of Rf, Y, S, D', Shannon–Wiener and dominance indicators were higher in the non-irrigated plots than in the irrigated ones (Table 5).

According to the literature, leaf spot diseases caused by the fungi of the genus *Alternaria* can reduce the photosynthetic capacity of leaves and decrease yields [30,54]. Similar observations were made by Lagopidi and Thanassoulopoulos [55] who investigated sunflower leaf spot caused by *A. alternata* in Greece. In recent years, Alternaria leaf blight caused by *Alternaria alternata* emerged as the predominant disease of sunflowers in the

Republic of South Africa [56,57]. In severely infected plants, pathogenic changes can lead to defoliation and plant death [58]. Pathogens can also infect seeds, compromise seed germination, and decrease yields [59]. In a study by Lagopidi and Thanassoulopoulos [55], sunflower leaf spot caused by *A. alternata* decreased the number of seeds per head by 16–65% and reduced seed weight by 15–79%. According to Viriyasuthee et al. [54], relative humidity can be the main determinant of conidial development, leaf penetration by pathogens, and the progression of infections caused by *Alternaria* spp. In the cited study, relative humidity was higher in the early (72–97%) than late rainy season, which increased the area under the disease-progress curve (AUDPC) and the disease severity index (DSI). Maldaner et al. [60] examined the effect of irrigation and fungicides on the prevalence of infections and yields in two sunflower genotypes. They found that irrigation increased sunflower yields, but only in periods when weather conditions hindered the development of diseases caused by *Alternaria* spp. and *Sclerotinia* spp. Viriyasuthee et al. [30] evaluated the effectiveness of *Trichoderma harzianum* isolate T9 in protecting resistant JA genotypes against Alternaria leaf spot in treatments supplied with two different fertilizer rates. Most disease parameters were more severe in treatments with a lower fertilizer rate. The applied *T. harzianum* isolate was not effective against *Alternaria* leaf spot. According to Wright [61], plant nutrition can also play a role in combatting Alternaria leaf spot. In turn, Blachinski et al. [62] found that foliar urea ($CO(NH_2)_2$) and potassium nitrate (KNO_3) fertilizers did not reduce the severity of infections caused by *Alternaria* spp. in field-grown potatoes and cotton relative to the control treatment. In the present study, *Alternaria* spp. were most frequently isolated from JA leaves. Alternaria leaf spot was more severe in non-irrigated than in irrigated plots. Potassium (K_2O) fertilizer did not exert a clear influence on leaf colonization by *Alternaria* spp. Different potassium rates did not affect the severity of fungal infections in cvs. Topstar and Waldspindel, but in cv. Violette de Rennes, the number of fungal isolates increased in non-irrigated plants supplied with 250 kg K_2O ha^{-1} (Table 4). According to Denoroy [16], Koike [26], and Jansopa et al. [63], the above-ground parts of JA are most susceptible to southern wilt (also known as southern blight or collar rot) caused by *Sclerotium rolfsii*, as well as sclerotinia wilt/rot caused by *Sclerotinia sclerotiorum*. These pathogens can lead to the death of whole plants. Excessive nitrogen fertilization and low soil pH contribute to the development of *S. sclerotiorum*, whereas *S. rolfsii* thrives in moist and warm environments [16]. Avad and Ahmed [64] analyzed the influence of three types of fermented organic fertilizers, including farmyard, poultry and pigeon manure, and their combinations on the incidence of southern blight (caused by *Sclerotium rolfsii*), vegetative growth parameters, chemical composition, yield, and yield components in *Helianthus tuberosus* L., and found that all fertilizer combinations minimized the severity of infections.

The linear regression analysis did not reveal significant relationships between above-ground biomass yield (fresh and dry matter yield) and the number of cultures of pathogenic and saprotrophic fungal species (Figure 9). These findings indicate that despite a high number of pathogenic species (confirmed by the values of biodiversity indicators), their effect on biomass yield was not significant.

Table 4. Fungi colonizing Jerusalem artichoke leaves grown in treatments with different potassium fertilizer rates and different soil moisture levels.

Fungal Genus/Species	Irrigated									Total	Not Irrigated									Total
	Topstar			Waldspindel			Violette de Rennes				Top Star			Waldspindel			Violette de Rennes			
	\<-- Number of fungal isolates --\>																			
	150 *	250	350	150	250	350	150	250	350	Σ	150	250	350	150	250	350	150	250	350	Σ
Alternaria alternata (Fr.) Keissl.	9	13	16	12	15	14	8	13	11	111	14	14	19	10	9	7	12	22	13	**120**
Alternaria spp.		3	2		1		1	4	2	13	2	5	3	1			1	4		**16**
Botrytis cinerea Pers.										0				1						**1**
Chaetomium spp.										0							1			**1**
Cladosporium cladosporioides (Fresen.) G.A. de Vries			2	1					1	4				2		1		4		**7**
Epicoccum nigrum Link		3		3	1	1	5	3	2	18	4	2		2			4	1	2	**15**
Fusarium avenaceum (Fr.) Sacc.	1				1		1	1	1	5		1			3			3	4	**11**
Fusarium culmorum (Wm. G. SM.) Sacc.	2									2					1	2		1		**4**
Fusarium equiseti (Corda) Sacc.	1									1										**0**
Fusarium poae (Pack) Wollenw.				1				1		2										**0**
Fusarium tricinctum (Corda) Sacc.								1		1										**0**
Fusarium sporitrichioides Scherb.										0			1		2	1		6	1	**11**
Fusarium spp.	1	1			1					3										**0**
Mucor spp.							1			1										**0**
Nigrpospora sphaerica (Sacc.) E.W. Mason				1						1										**0**
Penicillium spp.				1						1	3		1					1		**5**
Didymella pinodella (L.K. Jones) Qian Chen&L.Cai				1						1										**0**
Total	14	20	20	18	21	15	16	23	17		23	22	24	16	15	11	18	42	20	
Total for cultivars		54			54			56				69			42			80		
Total for irrigated/ non-irrigated plots					164										191					

* 150, 250, 350 kg K$_2$O ha^{-1}—potassium fertilization.

Table 5. Diversity analysis of pathogenic and saprotrophic fungi isolated from Jerusalem artichoke leaves grown in treatments with different potassium fertilizer rates and different soil moisture levels.

| Diversity Index	Group of Fungi	Irrigated									Σ	Not Irrigated									Σ
		Topstar			Waldspindel			Violette de Rennes				Top Star			Waldspindel			Violette de Rennes			
		150	250	350	150	250	350	150	250	350		150	250	350	150	250	350	150	250	350	
Relative frequency [Rf]	pathogens	3.94	5.63	5.07	4.51	5.63	4.23	4.23	6.48	4.51	44.2	5.63	6.2	6.48	3.94	4.23	2.82	4.79	10.4	5.63	50.1
	saprotrophs	0	0	0.56	0.56	0.28	0	0.28	0	0.28	1.97	0.85	0	0.28	0.56	0	0.28	0.28	1.41	0	3.66
Dominance [Y]	pathogens	0.16	0.32	0.26	0.2	0.32	0.18	0.18	0.42	0.2	19.6	0.32	0.38	0.42	0.16	0.18	0.08	0.23	1.09	0.32	25.1
	saprotrophs	0	0	0	0	0	0	0	0	0	0.04	0.01	0	0	0	0	0	0	0.02	0	0.13
Species richness [S]	pathogens	5	4	2	3	6	2	4	6	4	9	3	4	3	4	4	3	3	6	4	7
	saprotrophs	1	1	1	2	1	1	1	1	1	4	1	1	1	1	1	1	1	2	1	3
Marglef index [D′]	pathogens	0.68	0.51	0.17	0.34	0.85	0.17	0.51	0.85	0.51	1.36	0.34	0.51	0.34	0.51	0.51	0.34	0.34	0.85	0.51	1.02
	saprotrophs	0	0	0	0.17	0	0	0	0	0	0.51	0	0	0	0	0	0	0	0.17	0	0.34
Shannon-Wiener index [H′]	pathogens	154	256	355	155	256	354	154	256	355	44.2	156	256	356	154	254	353	155	260	356	50.1
	saprotrophs	0.16	0.32	0.82	0.77	0.6	0.18	0.46	0.42	0.49	21.6	1.17	0.38	0.7	0.72	0.18	0.36	0.51	2.51	0.32	28.9
Dominance index [λ]	pathogens	154	256	356	155	256	354	155	257	355	65.8	157	257	357	155	254	353	155	263	356	78.9
	saprotrophs	6	5	3	5	7	3	5	7	5	13	4.01	5	4	5	5	4	4	8.02	5	10.1
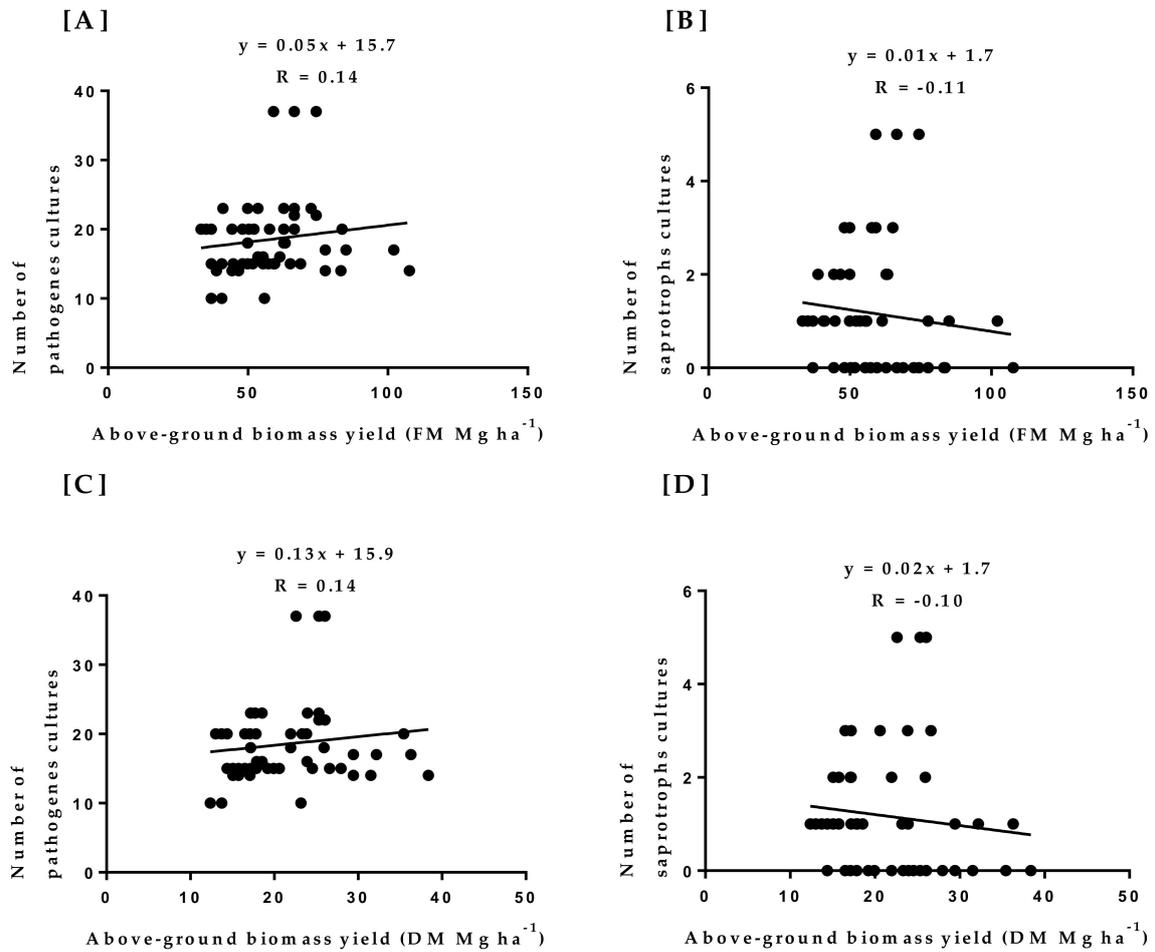
Figure 9. Analysis of linear regression between above-ground biomass yield (fresh matter yield) of Jerusalem artichokes and the number of cultures of pathogenic (**A**) and saprotrophic (**B**) fungal species; above-ground biomass yield (dry matter yield) and the number of cultures of pathogenic (**C**) and saprotrophic (**D**) fungal species.

An evaluation of the health status of JA tubers supported the identification of 10 fungal genera (total of 946 isolates) (Table 6, Figure 10A,B).
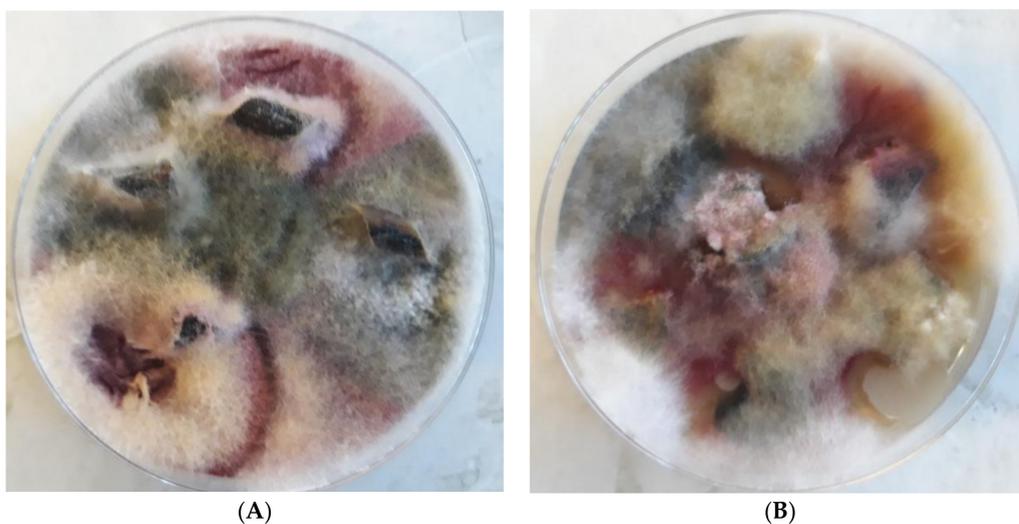

(**A**)   (**B**)

Figure 10. (**A**,**B**) Jerusalem artichoke tubers (segments) infected by fungi.

Table 6. Fungi colonizing Jerusalem artichoke tubers grown in treatments with different potassium fertilizer rates and different soil moisture levels.

Fungal Genus/Species	Irrigated									Total	Not Irrigated									Total
	Topstar			Waldspindel			Violette de Rennes				Topstar			Waldspindel			Violette de Rennes			
	Number of Fungal Isolates																			
	150 *	250	350	150	250	350	150	250	350	Σ	150	250	350	150	250	350	150	250	350	Σ
Alternaria alternata	7	7	8	3	4	5	2	6	2	44		2	2	5		5	2	1	1	18
Aspergillus spp.				2			1		1	4	1	1	1			1				4
Botrytis cinerea		2	1	6	12	1	10		2	34	14		1		20	5	1	11	1	43
Cladosporium cladosporioides		5		1		1	1	3		11			2					3		5
Cylindrocarpon spp.		5								5										0
Epicoccum nigrum	1				1			1		3										0
Fusarium avenaceum	5	1	2	3	2	2		1	1	17		1	1	10	2	1			2	18
Fusarium culmorum	6									6										0
Fusarium equiseti	1						3		2	6								3		3
Fusarium oxysporum	1					2	1	1		5				1						1
Fusarium tricinctum	3									3										0
Fusarium sambucunum				1		2	1		1	5						2		1		3
Fusarium solani	1	2	1	4	1	4	3	2	2	20			1	3		2		1		7
Fusarium sporitrichioides	2									2										0
Fusarium spp.	1	1		2	1	1		1		7		4		1	3		1		2	11
Mucor spp.	1			2	1	4	4	1		13		1	1	1			2		1	6
Penicillium spp.	25	21	25	24	22	30	22	33	32	234	27	31	35	23	31	18	25	28	22	240
Rhizopus nigricans Ehrenb.																				
Rhizopus spp.	11	4	13	4	8		4	6	8	58	11	13	10	13	12	12	10	7	13	101
Total	65	48	50	52	51	53	52	54	52		53	53	54	57	70	44	41	55	42	
Total for cultivars		163			156			158				160			171			138		
Total for irrigated/non-irrigated plots					477										469					

* 150, 250, 350 kg K$_2$O ha^{-1}—potassium fertilization.

The most prevalent fungal genera were *Penicillium, Fusarium, Alternaria, Botrytis*, and *Rhizopus*. A similar number of fungal isolates was obtained from JA tubers grown in irrigated and non-irrigated plots (477 and 469, respectively).

According to the literature, tuber rot diseases in JA are caused by *Sclerotium rolfsii, Sclerotinia sclerotiorum* [65], *Botrytis cinerea, Rhizopus stolonifera, Penicillium* spp., *Fusarium* spp. [25], as well as *Rhizoctonia solani* [66]. In a study by Ghoneem et al. [67], JA tubers were colonized by 17 fungal species belonging to 12 genera, including *S. rolfsii* (61.7%), *Fusarium incarnatum* (22%) and *Geotrichum candidum* (2.7%). AbdAl-Aziz et al. [33] isolated 24 species belonging to more than five fungal genera from rotten JA tubers. *Alternaria, Aspergillus, Fusarium, Pencillium*, and *Trichoderma* were the most prevalent inulinolytic genera that accounted for more than 90% of the isolated fungi. This study demonstrated that pathogenic species were characterized by higher species richness (S) and higher values of the Marglef index (D′) (Table 7), but the values of the remaining biodiversity indicators revealed that the analyzed communities were dominated by saprotrophic species. In the current study, *Penicillium* spp. were isolated from irrigated and non-irrigated tubers (Table 4). Tubers from irrigated treatments were abundantly colonized by fungi of the genus *Fusarium*, including *F. solani, F. avenaceum, F. culmorum. F. equiseti, F. oxysporum, F. sambusinum, F. tricinctum* and *F. sporotrichioides*, as well as *Alternaria* spp. *Fusarium* spp. were isolated from tubers from all irrigated plots, and their prevalence ranged from 5% to 32.30%.

In pathogenic species, the values of species dominance indicators Y and λ were higher in irrigated than in non-irrigated plots (Table 7). In irrigated plots, the values of the remaining biodiversity indicators (species richness index, Marglef index and Shannon–Wiener index) were also higher for pathogenic species. *Fusarium* fungi were less prevalent in non-irrigated plots, and they were absent only in cv. Topstar fertilized with 150 kg K_2O ha^{-1} (Table 5). Ghoneem et al. [67], identified several *Fusarium* pathogens, including *F. incarnatum, F. vertocilioises, F. oxysporum*, and *F. solani*, as well as *Penicillium* spp. and *Alternaria alternata* from tubers. According to Kays and Nottingham [25], high temperature contributes to blue mold (*Penicillium* spp.) and Fusarium rot in JA tubers. In the present study, *Rhizopus* spp. was also a common pathogen, but it was less frequently isolated from irrigated plots (Table 5). Kays and Nottingham [25] observed that tubers stored in winter are susceptible to fungal infections and can develop symptoms of soft rot. The cited authors isolated *Rhizopus stolonifer* from chill-stored JA tubers. Yang et al. [68] demonstrated that *R. arrhizus* caused soft rot of JA tubers in China and that the disease resulted in the loss of 30–50% of stored tubers each year. In the current study, *Botrytis cinerea* was isolated from tubers grown in both irrigated and non-irrigated plots. In irrigated treatments, *B. cinerea* infections were identified in 0–23.53% tubers. This pathogen was not isolated from cv. Topstar fertilized with 150 kg K_2O ha^{-1} and from cv. Violette de Rennes supplied with 250 kg K_2O ha^{-1}. The prevalence of *B. cinerea* in non-irrigated treatments ranged from 0 to 27.78%. The pathogen was not isolated from cv. Topstar fertilized with 250 kg K_2O ha^{-1} and cv. Waldspindel supplied with 150 kg K_2O ha^{-1} (Table 5). According to Doehlemann et al. [69], *B. cinerea* is the most common cause of grey mold, a serious disease that leads to significant economic losses around the world. Grey mold is devastating for senescent and damaged tissues in dicotyledonous plants. The pathogen penetrates host tissues in early stages of plant development, and it may remain inactive until environmental conditions and the host's physiological status are favorable for colonization. This mechanism of action explains serious losses during the storage of seemingly healthy crops. In the present study, the prevalence of fungal infections in tubers was highest in cv. Waldspindel in non-irrigated plots and in cv. Topstar in irrigated treatments. Different potassium fertilizer rates exerted varied effects on fungal colonization.

Table 7. Diversity analysis of pathogenic and saprotrophic fungi isolated from Jerusalem artichoke tubers grown in treatments with different potassium fertilizer rates and different soil moisture levels.

Diversity Index	Group of Fungi	Irrigated										Not Irrigated									
		Topstar			Waldspindel			Violette de Rennes			Σ	Top Star			Waldspindel			Violette de Rennes			Σ
		150 *	250	350	150	250	350	150	250	350		150	250	350	150	250	350	150	250	350	
Relative frequency [Rf]	pathogens	2.960	1.903	1.268	2.008	2.114	1.903	2.114	1.163	1.163	11.95	1.480	0.740	0.529	2.114	2.854	1.374	0.423	1.797	0.634	10.99
	saprotrophs	3.911	3.700	4.017	3.488	3.277	3.700	3.383	4.545	4.334	34.36	4.123	4.863	5.180	3.911	4.545	3.277	3.911	4.017	3.805	37.63
Dominance [Y]	pathogens	0.088	0.036	0.016	0.040	0.045	0.036	0.045	0.014	0.014	1.43	0.022	0.005	0.003	0.045	0.081	0.019	0.002	0.032	0.004	1.21
	saprotrophs	0.153	0.117	0.161	0.122	0.107	0.137	0.114	0.207	0.188	11.62	0.170	0.236	0.268	0.153	0.207	0.107	0.153	0.161	0.072	6.33
Species richness [S]	pathogens	10	6	4	6	5	8	6	5	7	13	2	3	4	5	4	4	3	5	4	8
	saprotrophs	3	2	2	4	3	2	4	3	3	4	3	4	4	3	2	3	3	2	3	4
Marglef index [D′]	pathogens	1.313	0.730	0.438	0.730	0.584	1.022	0.730	0.584	0.876	1.75	0.146	0.292	0.438	0.584	0.438	0.438	0.292	0.584	0.438	1.02
	saprotrophs	0.292	0.146	0.146	0.438	0.292	0.146	0.438	0.292	0.292	0.44	0.292	0.438	0.438	0.292	0.146	0.292	0.292	0.146	0.292	0.44
Shannon–Wiener index [H′]	pathogens	0.164	0.105	0.068	0.112	0.106	0.112	0.112	0.067	0.074	0.65	0.062	0.043	0.035	0.109	0.126	0.076	0.028	0.092	0.041	0.42
	saprotrophs	0.155	0.135	0.155	0.150	0.135	0.140	0.148	0.175	0.162	0.65	0.161	0.185	0.198	0.157	0.167	0.138	0.157	0.159	0.154	0.67
Dominance index [λ]	pathogens	0.004	0.003	0.002	0.002	0.004	0.002	0.003	0.001	0.001	0.05	0.004	0.001	0.000	0.004	0.007	0.002	0.000	0.003	0.000	0.04
	saprotrophs	0.012	0.008	0.013	0.010	0.009	0.013	0.009	0.015	0.015	0.16	0.013	0.016	0.017	0.012	0.016	0.009	0.012	0.013	0.011	0.18

* 150, 250, 350 kg K_2O ha^{-1}—potassium fertilization.

In irrigated plots, disease severity increased only in cv. Topstar supplied with 150 kg K_2O ha^{-1}, whereas in non-irrigated treatments, infections were more frequently noted in cvs. Waldspindel and Violette de Rennes fertilized with 250 kg K_2O ha^{-1} (Table 5). According to the literature [25,26,65,67,70], tuber rot caused by *S. rolfsii* is a devastating disease of both field-grown and stored crops. The pathogen can decrease yields by as much as 60% [27]. *Sclerotium rolfsii* was not isolated from JA in the current study. According to Kosaric et al. [32], frozen storage can minimize the spread of pathogenic fungi on tubers.

In this study, the number of pathogenic species isolated from Jerusalem artichoke tubers had a minor negative impact on fresh (R = −0.37) and dry matter (R = −0.41) yield (Figure 11). These findings suggest that despite the low abundance and frequency of pathogenic species relative to saprotophicspecies, as well as the dominance of saprotrophic species in all plots (indicators *Y* and *λ*), pathogenic species exerted a considerable influence on JA plants.
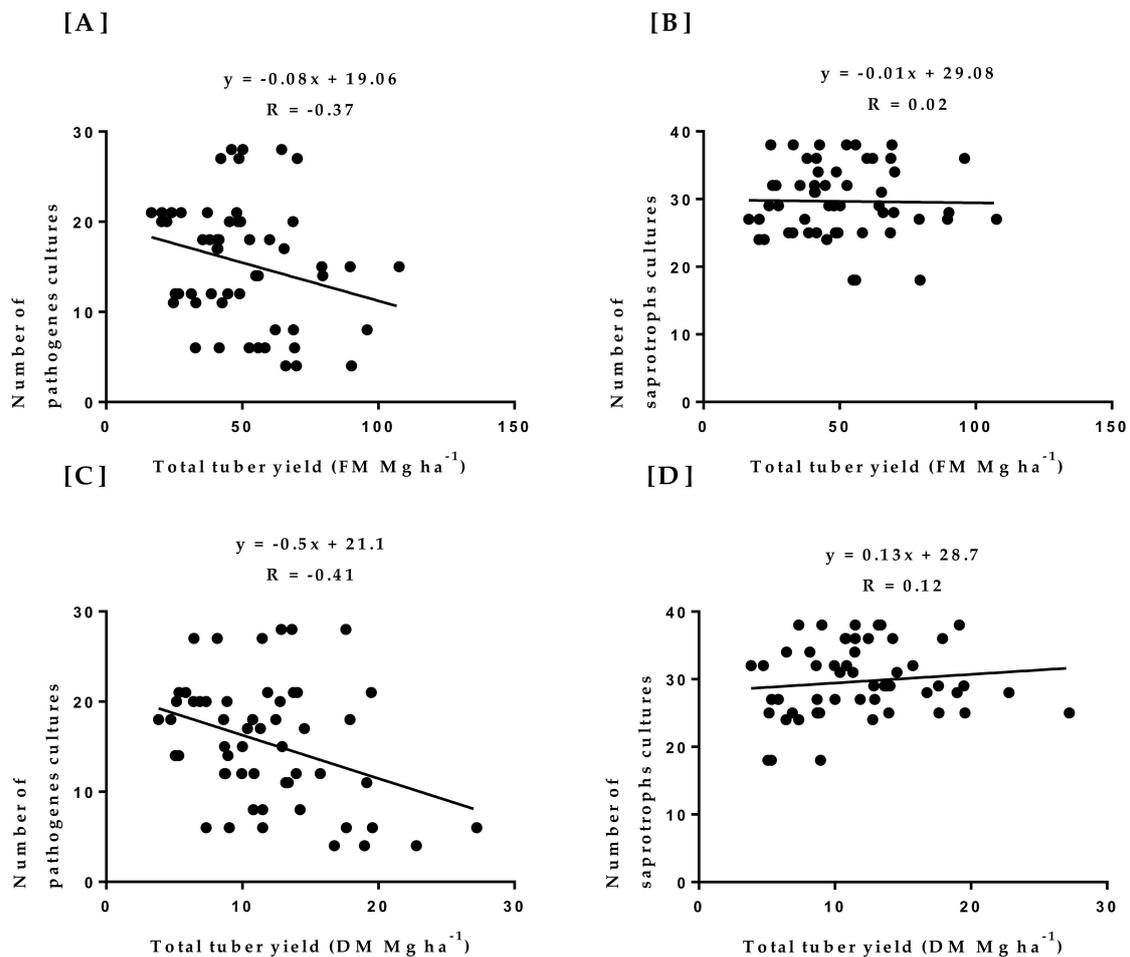

Figure 11. Analysis of linear regression between: total tuber yield (fresh matter yield) of Jerusalem artichokes and the number of cultures of pathogenic (**A**) and saprotrophic (**B**) fungal species; total tuber yield (dry matter yield) and the number of cultures of pathogenic (**C**) and saprotrophic (**D**) fungal species.

4. Conclusions

In the present study, JA cv. Topstar was characterized by the highest total tuber and above-ground biomass yields. An increase in the rate of mineral fertilizer applied to soil to 350 kg K_2O ha^{-1} did not affect the total tuber yields. Potassium fertilizer applied at the optimal rate of 150 kg K_2O ha^{-1} contributed to the greatest increase in the above-ground biomass yield of JA. Irrigation had a significant effect on total tuber and above-ground biomass yields, which increased by 59% and 42%, respectively, on average.

Phytopathological analyses of aerial plant parts revealed that fungi of the genera *Alternaria* and *Fusarium* were more prevalent in non-irrigated than in irrigated plots. In non-irrigated treatments, fungal pathogens were most frequently isolated from the leaves of cv. Violette de Rennes and were least prevalent in cv. Waldspindel. The severity of fungal infections increased only in cv. Violette Rennes fertilized with 250 kg K_2O ha^{-1}. Jerusalem artichoke tubers were most abundantly colonized by fungi of the genera *Penicillium*, *Fusarium*, *Alternaria*, *Botrytis cinerea*, and *Rhizopus*. The prevalence of fungal pathogens in tubers was similar in irrigated and non-irrigated plots. The severity of tuber infections was highest in cv. Waldspindel in non-irrigated treatments and in cv. Topstar in irrigated treatments. The applied potassium fertilizer rates exerted varied effects on tuber colonization by fungi. The analysis of the composition of pathogens and saprotrophs revealed that pathogenic species were predominant on Jerusalem artichoke leaves, which was confirmed by nearly all biodiversity indicators (*Relative frequency*, *Dominance*, *Species richness*, *Margalef index*, *Shannon–Wiener index* and, *Dominance index*). The number of cultures of pathogenic fungal species isolated from Jerusalem artichoke tubers exerted a negative influence on fresh and dry matter yield.

Further research involving long-term field experiments should be conducted in the future to examine the effects of fertilization and crop protection agents on the health, yield and quality of the produced crops.

Supplementary Materials: The following are available online at https://www.mdpi.com/2073-4395/11/2/234/s1, Table S1. The effect of irrigation and potassium fertilization on the total tuber yield (fresh matter basis) of the analyzed Jerusalem artichoke cultivars. Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test. Table S2. The effect of irrigation and potassium fertilization on the total tuber yield (dry matter basis) of the analyzed Jerusalem artichoke cultivars. Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test. Table S3. The effect of irrigation and potassium fertilization on the above-ground biomass yield (fresh matter basis) of the analyzed Jerusalem artichoke cultivars. Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test. Table S4. The effect of irrigation and potassium fertilization on the above-ground biomass yield (dry matter basis) of the analyzed Jerusalem artichoke cultivars. Means with the same letters do not differ significantly at $p \leq 0.05$ in Tukey's test.

Author Contributions: Conceptualization, methodology, B.B., methodology A.P., formal analysis, writing—original draft preparation, B.B., A.P., A.O. and K.J. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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