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The Influence of the Habitat on the Chemical Composition and Morphology of Silky Bent Grass (*Apera spica-venti* (L.) Beauv.) Occurring in Arable Fields (Lower Silesia, Poland)

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Abstract: One of the most common annual overwintering weeds in various crops worldwide is silky bent grass (*Aspera spica-venti* (L.) Beauv). The aim of this study was to investigate the selected morphological characteristics and chemical composition of *A. spica-venti* from different cultivation fields in Poland, depending on the macronutrient content of the soil. The average pH values of the soil samples, and the average concentration of nitrogen (N) and phosphorus (P) in the samples were statistically different between study sites. In turn, the concentration of potassium (K) was at the same statistical level. The average values of N, P and K concentrations in the straw of *A. spica-venti* (% dry matter) in particular study sites were not statistically different. The mean values of the examined morphological features of *A. spica-venti* did not differ statistically between the individual test sites. Overall, there was no significant impact of the habitat on the chemical composition and morphology of the *A. spica-venti* occurring naturally in arable fields. However, an increase in soil abundance in some macronutrients (mainly K) may positively affect the morphology of this weed as opposed to an increase in nitrogen concentration in the soil, and an increase soil pH. The lack of significant influence of soil conditions and location of APESV sites on the morphology and chemical composition of the weed indicates that it has high plasticity and is able to thrive under varying habitat conditions.

Keywords: *Apera spica-venti*; morphological variability; arable fields; habitat conditions

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1. Introduction

The *Apera spica-venti* (L.) Beauv. is a weed classified as a noxious agrophage and is found in various crops worldwide [1–9] regardless of farming intensity and climate zone [10]. The occurrence of this grass mainly in massive numbers has been recorded for winter crops [5,11–16] and spring crops [3,17]. For example, the threshold for economic damage by infestations of this weed species was from 5 to 10 plants per m^2 in winter wheat (*Triticum aestivum* L.) fields [18]. Therefore, this weed is one of the most important biotic factors which, together with abiotic factors, can significantly reduce the quantitative and qualitative yield of crops [19].

Currently weed biotypes resistant to chemical regulation are receiving much attention; such resistance is mainly due to the inadequate rationing of the active ingredients contained in herbicides. Therefore, most observations on *A. spica-venti* concern its resistance to herbicide active ingredients [6,9,20–24] and its already mentioned impact on crop yields [2,20]. However, there is insufficient information in the literature on the relationship of the development of *A. spica-venti* to its occurrence. There are also no reports about the changes in the morphological features of the weed from different sites of emergence (crop type, soil mineral content) as well as the impact of the increasingly tangible effects of global warming on the morphology of this weed. Against the background of a changing climate, changes in plant morphology are common [25–28]. Specifically, monocotyledons are more sensitive to various changes than dicotyledons [25,27]. However, there is also no data on this related to *A. spica-venti*.

It should be mentioned that Warwick et al. [29] in the 1980s in Canada characterised the morphological conformation of this species, but this is a description of the Canadian population. According to the literature [29,30], this weed prefers fertile, nitrogen-rich, moist, slightly acidic soils, but it can also occur on light clay and sandy soils. However, its massive emergence is favored by high air and soil humidity levels [31]. In addition, precipitation-rich weather may affect the variations in growth and the maturation rates of individual *A. spica-venti* individuals [17]. Further reports by Warwick et al. [32] characterise the Canadian and European populations of *A. spica-venti* in more detail; however, the authors relied on plant material from a greenhouse experiment. In addition, the Canadian population comes from a winter wheat crop where tobacco was the forecrop, whereas the European population is derived from a place where winter wheat was grown, without any information on the forecrop.

The main goal of this research was the first examination of the selected morphological characteristics of silky bent grass (*A. spica-venti* (L.) Beauv.) from different cultivation fields in Poland. Additionally, we determined (1) the chemical composition of the soil in the studied sites and the mineral elements in the dry biomass of the collected plant samples, (2) weed mass, (3) the relationship between the soil mineral nutrient levels (nitrogen (N), phosphorus (P), and potassium (K) and the mineral elements in the dry biomass of weeds, (4) the influence of soil mineral nutrient levels (N, P, and K)/mineral elements in the dry biomass of *A. spica-venti* on the selected morphological characteristics of *A. spica-venti*, as well as (5) the relationship between the mass of *A. spica-venti* and its selected morphological characteristics, the soil mineral nutrient levels (N, P, and K) and the mineral elements in the dry biomass of weeds.

2. Materials and Methods

2.1. Weed Morphology Features

The tested weed (*A. spica-venti*) was sampled randomly from crops located in the Lower Silesia Province (Poland) (Table 1). Plant material was collected in the same areas over the years 2016–2020. Each year after harvest, the plant material collected for this study was protected from seed shedding. However this weed did not occur in the study area in every year (weed harvesting was carried out on cultivated fields). The mature weed plants were harvested on 8–12 July 2016. In 2017, the weed harvest date varied with the place of occurrence and ranged from 6 to 18 July 2017. In 2019, the weed was harvested from 2 to 3 July, whereas in 2020, harvesting took place from 10 to 13 July. The timing of harvesting plants for analysis varied across years due to the uneven maturation of *A. spica-venti*.

Table 1. Places of harvest of *Apera spica-venti* in Lower Silesia, Poland: x—year in which the study was performed.

Study Sites	Locality	Soil WRB (World Reference Base)	Geographical Latitudes	Year of Study			
				2016	2017	2019	2020
I	Wrocław	Fluvic Cambisols	51.11, 17.14	x		x	x
II	Wrocław	Fluvic Cambisols	51.11, 17.14		x	x	x
III	Sucha Wielka	Podzols	51.32, 17,16	x	x	x	x
IV	Wrocław	Fluvic Cambisols	51.11, 17.14		x	x	x
V	Głuchów Dolny	Eutric/Endocalcaric Cambisols	51.28, 17.12	x		x	x

The morphological features of *A. spica-venti* were evaluated for 35 randomly sampled plants. We determined culm length, the number of nodes per culm, panicle length and the number of panicle storeys. In addition, the dry mass of 35 plants (culms and leaves) was determined, measuring with precision to 0.01 g. Culms and panicle lengths were measured to the nearest cm.

2.2. Chemical Analysis of Soil

Soil for chemical analysis was obtained from all places where *A. spica-venti* was collected. Samples were taken with an Egner stick according to PN-R-04031:1997 [33]. From each site (Table 1), 20 subsamples from 0 to 20 cm depth were taken. Subsamples were mixed to contain one composite sample for the determination of pH by using pH/Jonometr CPI-502 (Elmetron, Zabrze, Poland) (pH determination by potentiometry, precision ± 0.002 pH) and total Kjeldahl N [34,35] using Büchi Distillation Unit K-355 (Büchi, Flawil, Switzerland) (recovery rate $\geq$99.5%, reproducibility (RSD) $\leq$1%, detection limit $\geq$0.1 mg nitrogen).

Total P and K using the Egner–Riehm method [36,37], for P using Thermo Helios Aquamate 9423 AQA 2000E (Thermo Electron Corporation, Altrincham, UK) and K BWB XP flame photometers (BWB Technologies, Newbury, Berkshire, UK) (specificity/K/ = <1% to each other when equal in concentration at <100 ppm), limit of detection (LOD K—0.02 ppm), and limit of quantification (LOQ K—0.05 ppm).

2.3. Chemical Analysis of Plant Material—Straw of *A. spica-venti*

For chemical analysis, straw of *A. spica-venti* was used. Total nitrogen was determined via the Kjeldahl method [37] using Büchi Distillation Unit K-355 (Büchi, Flawil, Switzerland) (recovery rate $\geq$99.5%, reproducibility (RSD) $\leq$1%, detection limit $\geq$0.1 mg nitrogen). Total potassium was determined via flame photometry using BWB XP flame photometers (BWB Technologies, Newbury, Berkshire, UK) (specificity/K/ = <1% to each other when equal in concentration at <100 ppm), limit of detection (LOD K—0.02 ppm) and limit of quantification (LOQ K—0.05 ppm), and total phosphorus via the colorimetric method using SPEKOL 11 spectrophotometer (Jena, Deutschland).

2.4. Statistical Analyses

The data obtained from the study were analysed using the Statitica 13.3 package (StatSoft Polska Sp. z o.o., Kraków, Poland). For this purpose, one-way analysis of variance (ANOVA) and Tukey's HSD (honest significant difference) test at $\alpha \leq 0.05$ were used.

Prior to the ANOVA, the percentage data were transformed to Bliss [38] angular degrees by applying the formula y = arcsin (value%)$^{-0.5}$. After transformation, the variance was approximately constant, allowing the ANOVA to compare particular components [38].

The Pearson (r) correlation coefficient at $\alpha = 0.05$ was used to determine the relation between the mean levels of N, P, and K in the soil and those in the straw (% DM). Subsequently, Pearson (r) correlations were determined for the study's morphological features of *A. spica-venti* and the mean concentration N, P, and K levels in the soil/pH in the straw (% DM) (means from years), and pH soil. Additionally, the correlations between the mass of 35 plants and the morphological features/the concentration of N, P, and K in the straw/in the soil and pH soil were calculated.

3. Results

The average pH values in H_2O of the soil samples and the average concentration of N an P in this samples at sites where *A. spica-venti* occurred were statistically different (Figure 1). The highest pH average value was recorded in study site I (7.93) and the lowest in study sites V (7.17), although the soil pH in locations IV and V did not differ statistically—Figure 1a. In turn, the pH values in the individual years of the study ranged from 6.8 to 8.1 (Table A1 in Appendix A). The highest mean value of N concentration in the soil was recorded in study site V (1.67 g/kg) and the lowest in study site IV (0.34 g/kg)—Figure 1b. In turn, the concentration of N in the soil ranged from 0.13 to 1.86 g/kg in individual years of the study (Table A1). In the case of P concentration in the soil, the highest average value of this component was recorded in study site I (237.2 mg/kg) and the lowest in study site III (83.4 mg/kg)—Figure 1c. The concentration of P in the individual years of the study ranged from 31.2 to 265.1 mg/kg (Table A1). On the other hand, the values of the mean K concentration in the soil samples were at the same statistical level in particular study sites and ranged from 55.0 to 208.3 mg/kg (Figure 1d). In the case of individual years of the study, the concentration of this component in the soil samples ranged from 35.0 to 350.0 mg/kg (Table A1).

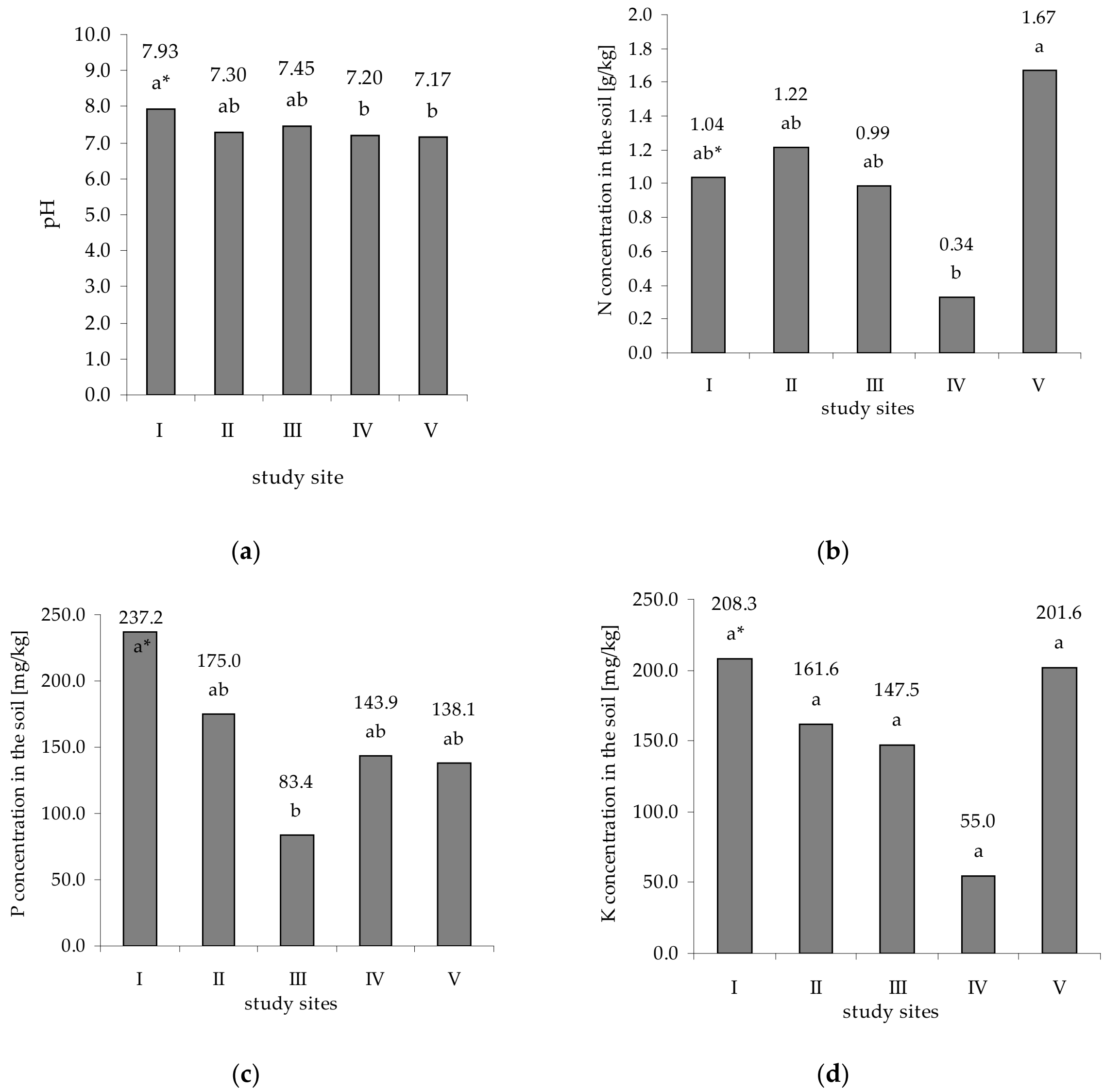

Figure 1. The pH value of soil (**a**) and the levels of soil mineral nutrient at the depth 0–20 cm in particular study sites (see Table 1): N (**b**), P (**c**), and K (**d**). * For each location, the mean values of the tested feature for each year followed by the same letter are not statistically different, and others are (Tukey HSD test, $\alpha \leq 0.05$). Letters indicate the differences between the study sites within a given examined feature.

Overall, the average values of N, P, and K concentrations in the straw of *A. spica-venti* (% dry matter) in particular study sites were not statistically different, and they ranged from 0.56% to 0.87% for N, 0.15% to 0.31 for P, and from 1.25% to 1.53% for K (Figure 2). In turn, the concentrations of N, P, and K in the straw of studied plants for individual years of the study were from 0.40% to 1.27%, from 0.04% to 0.57%, and from 0.74% to 2.11%, respectively (Table A2).

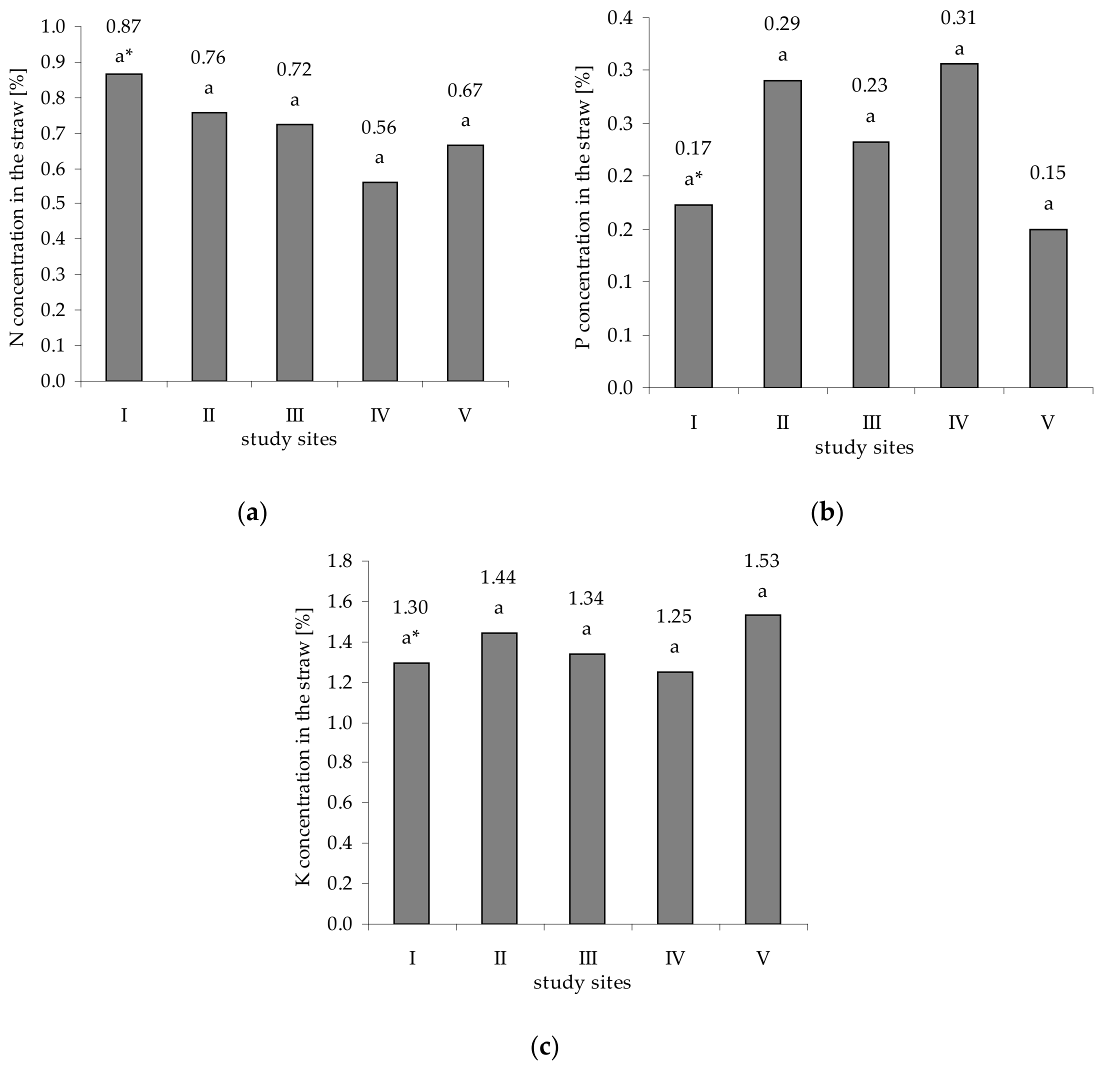

Figure 2. Chemical compositions in the straw of *A. spica-venti* (% dry matter) in particular study sites (see Table 1): (**a**) N concentration in the straw, (**b**) P concentration in the straw, and (**c**) K concentration in the straw. * For each location, the mean values of the tested feature for each year followed by the same letter are not statistically different, and others are (Tukey HSD test, $\alpha \leq 0.05$). Letters indicate the differences between the study sites within a given examined feature.

Overall, the mean values of the examined morphological features (culm length, panicle length, number of nodes per culm, and number of panicle storeys) of *A. spica-venti* did not differ statistically between the individual test sites (Figure 3). Although these values in the given years showed statistical differences (Tables A3 and A4). Culm length ranged from 73.31 to 129.00 cm (Table A3), with an average of 95.05 to 118.57 cm across all years (Figure 3a). In turn, number of nodes ranged from 4.20 to 5.29, depending on the sampling site (Table A3). The average number of nodes per culm was similar for all years, with mean values from 4.59 to 4.86 (Figure 3c). Panicle length ranged from 19.65 to 33.89 cm (Table A4), with a significant variation depending on the sampling site. However, the mean values did not significantly differ among years, with an average of 25.99 to 28.36 cm (Figure 3b). The number of panicle storeys varied largely depending on the sampling site and year (Table A4), ranging from 5.25 to 10.11. However, the mean values per year were not significantly different, with an average of 6.68 to 8.25 (Figure 3d).

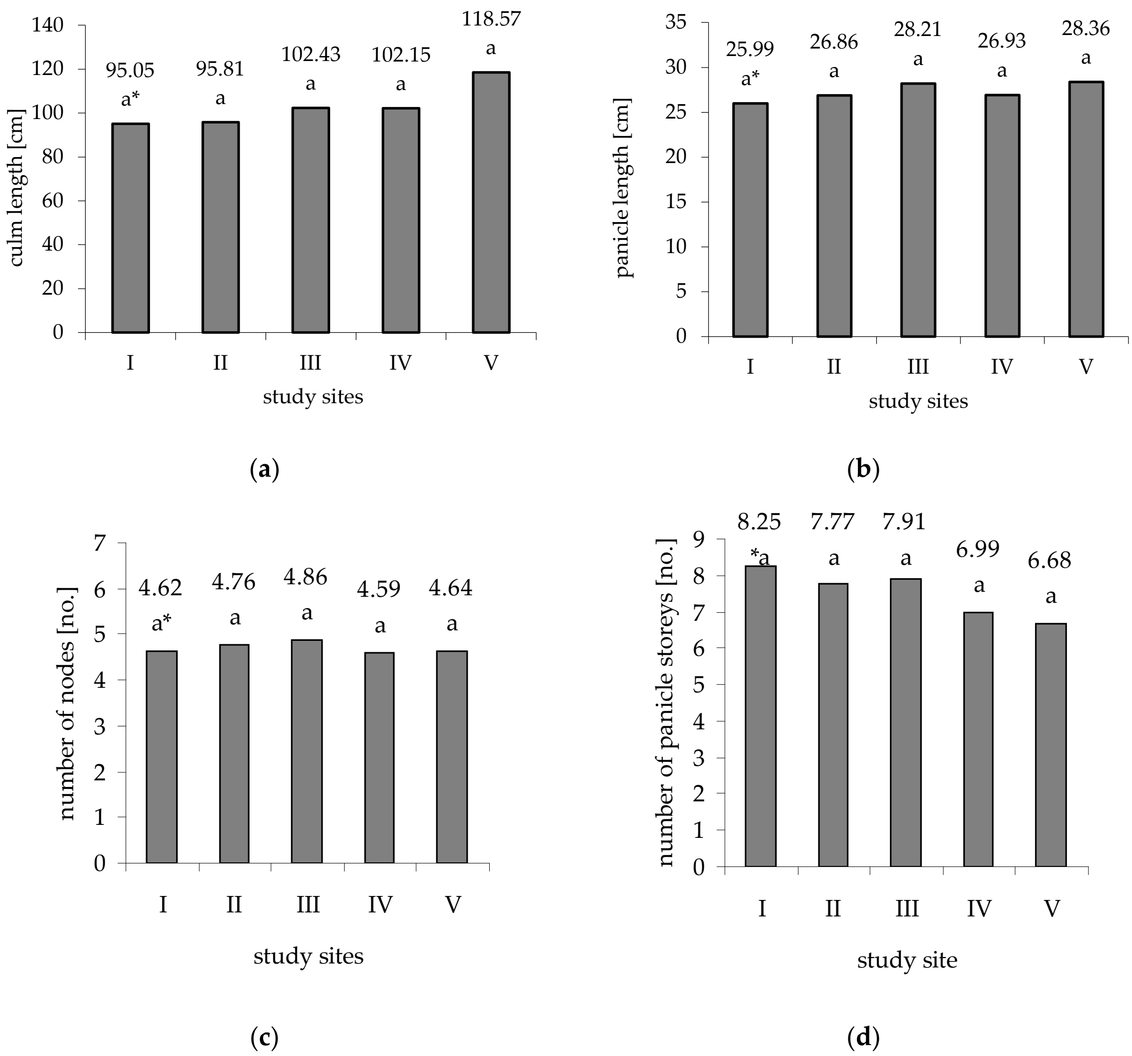

Figure 3. The influence of study sites (see Table 1) on (**a**) culm length, (**b**) panicle length, (**c**) number of nodes per culm, and (**d**) number of panicle storeys. * For each location, the mean values of the tested feature for each year followed by the same letter are not statistically different, and others are (Tukey HSD test, $\alpha \leq 0.05$). Letters indicate the differences between the study sites within a given examined feature.

The average values of dry mass of 35 plants ranged from 34. 50 to 54.89 g; however, this difference was not statistically significant (Figure 4). In turn, the mass of *A. spica-venti* in the individual years of the study ranged from 26.42 to 71.87 g (Table A5).

The concentration of N in the straw (% dry matter) correlated positively with and the concentration of N in the soil ($p < 0.05$; $r = 0.37$), but no similar positive relationships were found between the other two components tested ($p < 0.05$; $r = -0.15$ for P, and $r = -0.13$ for K)—Table A6, Figure S1 in Supplementary Materials. In turn, no clear trends were observed in the case of relationships between the concentration of N, P, and K in the soil/the straw (% dry matter) and selected morphological features of *A. spica-venti* such as culm length, panicle length, number of nodes per culm, and number of panicle storeys (Table A6, Figures S2–S7). Positive relationships were noted only between the N concentration in the soil and culm length of *A. spica-venti* ($p < 0.05$; $r = 0.12$), N concentration in the soil and number of nodes per plant ($p < 0.05$; $r = 0.10$), the concentration of P in the soil and number of panicle storeys ($p < 0.05$; $r = 0.06$), as well as the concentration of K in the soil and number of nodes per culm ($p < 0.05$; $r = 0.24$), and number of panicle storeys ($p < 0.05$; $r = 0.50$)—Table A6, Figures S2–S4. In the case of the concentration of P and K in the straw and the morphological features of the plant, positive correlations were found only between the concentration of P and culm length ($p < 0.05$; $r = 0.17$), panicle length ($p < 0.05$; $r = 0.55$), and number of nodes per culm ($p < 0.05$; $r = 0.44$), as well as between the concentration of K and panicle length ($p < 0.05$; $r = 0.18$). On the other hand, no correlation was found between the concentration of N in the straw and all studies with morphological features of *A. spica-venti* (Table A6, Figures S5–S7). Positive relationships were noted between the *A. spica-venti* dry mass and its morphological features ($p < 0.05$; $r = 0.23$ for culm length, $r = 0.07$ for panicle length, between the mentioned plant mass and the concentration of N in the soil ($p < 0.05$; $r = 0.38$) as well as the concentration of N and K in the straw ($p < 0.05$; $r = 0.14$, $r = 0.42$, respectively). In turn, relationships between the mass of plants of *A. spica-venti* and number of nodes per culm, and the concentration of P and K in the soil as well as P in the straw were negative (Table A6, Figures S8–S10). Concenring the influence of soil pH on selected morphological features of *A. spica-venti* and the concentration of N, P, K in the straw as well as its mass, the correlation was negative in most cases. We found positive Persona correlations only for the relationship between the soil pH and the concentration of N in the straw ($p < 0.05$; $r = 0.53$), number of panicle storeys ($p < 0.05$; $r = 0.03$), and number of nodes per culm ($p < 0.05$; $r = 0.01$)—Table A6, Figures S11 and S12.

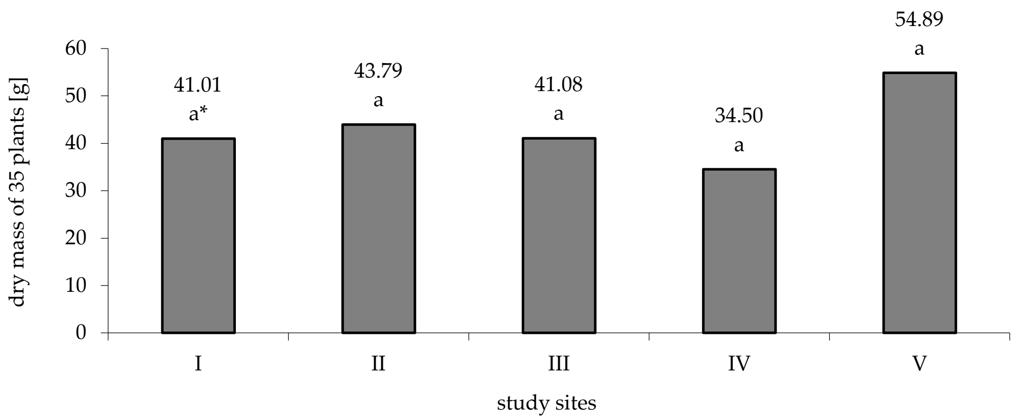

Figure 4. The dry mass of plants depending on the study sites (see Table 1): * For each study site, the values of mass followed by the same letter are not statistically different, and others are (Tukey HSD test, $\alpha \leq 0.05$). Letters indicate the differences between study sites within a given examined feature.

4. Discussion

Currently, most of the research about *A. spica-venti* concerns, as already mentioned, chemical control due to this species being known to have the ability to acquire resistance to active ingredients in herbicides [6,9,20–24]. Moreover, many publications [3,8,39–41] refer to morphological descriptions of *A. spica-venti* provided more than three decades ago by Warwick et al. [29,32], and less often Kukowski [42] without themselves re-examining the morphology of this species. Therefore, our research brings new knowledge about the morphology of silky bent grass in the age of global warming and the only knowledge about the influence of the habitat on the chemical composition and morphology of this plant occurring naturally in arable fields.

In the present study, culm lengths in *A. spica-venti* from different sites ranged from 73.31 to 129.00 cm. Mean culm length varied from year to year from 95.05 to 118.57 cm, depending on site. This partly agrees with Warwick et al. [29,32], who report culm lengths of up to 100 cm. However, Warwick et al. [32] observed plants growing in a greenhouse, while in the present study plants were sampled from the natural environment. The present study also partly agrees with Kukowski [42], who reported that culm lengths can reach means from 76 to 156 cm.

Our research shows that the number of plant nodes in *A. spica-venti* ranged from 4.20 to 5.29 depending on site, while the average number of nodes from year to year was between 4.59 and 4.86. These values are lower than those reported by Warwick et al. [32], who found that European populations of *A. spica-venti* had a higher number of nodes, on average 6.5 for an *A. spica-venti* population from Poland and the average for the five other European populations was 7.3 nodes. Our results provide values closer to those found by Warwick et al. [32] for Canadian populations, where the number of nodes averaged 5.9 and ranged from 5.2 to 6.5. We attribute these differences to growth environment, as Warwick et al. [32] studied growth and development of *A. spica-venti* in a greenhouse, where conditions are closer to optimal. In field grown plants, factors such as drought and excessive rainfall can induce stress in plants that can reduce growth and alter morphology [43,44].

Based on our observations, panicle lengths of *A. spica-venti* averaged from 25.99 to 28.36 cm depending on site. However, when analysing the data for individual sites and years, values of panicle length partly overlap with those of Warwick et al. [29]. They indicate that panicle length can be from 10 to 25 cm; however, their data were based solely on Canadian populations [29]. Subsequent observations by Warwick et al. [32] were expanded to include European populations, for which the authors report average panicle lengths of 20.4 cm for European populations and 20.6 cm for Canadian populations, which are within the range of values reported in Warwick et al. [29]. However, as previously noted, data from Warwick et al. [32] are for plants grown in a greenhouse. Moreover, their study sampled only 11 or 15 plants, depending on population, while our observations are based on 35 grass plants from each site. In part, similar results to the present study were obtained by Kukowski [42], where the author reports that panicle lengths can reach means of from 7 to 32 cm.

Currently, there are no reports quantifying panicle storeys, while Warwick et al. [29,32] only deal with the total number and length of panicle branches. However, we showed that the number of panicle storeys of *A. spica-venti* varied largely depending on the sampling site and year, ranging from 5.25 to 10.11 and the mean values per year were not significantly different, with an average of 6.68 to 8.25. In turn, panicle length ranged from 19.65 to 33.89 cm (with a significant variation depending on the sampling site. However, the mean values did not significantly differ among years, with an average of 25.99 to 28.36 cm.

All our research presented above indirectly confirms that plant morphology may possibly be altered by environment. For example, according to Peters et al. [27], morphological changes can occur in weed species due to climate change. Moreover, as shown by Barnes et al. [25], reduction of the ozone layer and the related increase in UV-B radiation can alter plant morphology, especially in monocotyledonous plants. However, as Peters et al. [27] suggest, changes in plant structure are the result of complex factors, because changes in structure caused by environment occur due to evolutionary pressure resulting in genotypic selection. Furthermore, cultivation can alter environment and create selection pressure on plants [45].

A chemical analysis of the soil showed variation in soil pH across sites. According to the literature [29,30], *A. spica-venti* prefers slightly acidic soil. However, based on our analyses, *A. spica-venti* was also present on sites with higher pH, where the soil was slightly alkaline. As reported by Warwick et al. [29] and Warcholińska [30], weeds tend to prefer nutrient-rich soils. A study showed that soils sampled in our research were characterised by high or very high phosphorus content and potassium content was from very low to medium and high to very high [46].

Kukowski [42] examined the concentration of NPK at different developmental phases of plants. Chemical analysis of straw from *A. spica-venti* in full maturity showed concentration of 0.77% for N, 0.38% for P_2O_5, and 1.38% for K_2O. These concentration were the lowest concentrations recorded. At earlier stages, at the stem shoot, respectively, N, P_2O_5, K_2O were 2.43, 0.82, 3.30 and flowering stages, respectively, N, P_2O_5, K_2O were 1.54, 0.68, 2.10%.

Chemical analysis of straw from *A. spica-venti* showed a similar mean nitrogen concentration to that in winter wheat straw [47,48]. Meng et al. [48] reported the average concentration of N (% in DM) in straw was 0.63%, while Mazur et al. [47] demonstrated that with nitrogen fertilisation N in wheat straw was from 0.44 to 0.70%. Harasim [49] showed varying levels of N (%DM) depending on the type of straw tested: A—straw with chaff; B—straw without stalks fragmentes and chaff; C—stubble at height about 15 cm; these were, respectively, 0.59, 0.52, 0.48%). In our study, nitrogen concentrations were tested from straw with stem fragments without chaff.

We showed that an increase in soil pH and the concentration of N in the soil results in an increase in the concentration of N in the straw of *A. spica-venti* ($p < 0.05$; $r = 0.53$, $r = 0.37$, respectively), but an increase in soil pH adversely affects the culm length of this plant ($p < 0.05$; $r = -0.43$). Moreover, an increase in N concentration in straw of *A. spica-venti* adversely affects the length of its culm and panicle as well as the number of nodes per culm ($p < 0.05$; r $= -0.59$, $r = -0.40$, $r = -0.42$, respectively).

Our study in 2019 and 2020 showed that potassium and phosphorus concentrations in *A. spica-venti* straw were comparable to concentrations of these elements in the straw of winter wheat [47]. Comparable concentrations were also presented by Harasim [49], where, depending on the type of straw and on the cereal crop species, the concentration of P (%DM) in cereal straw was from 0.07 to 0.18. In turn, the concentration of K (%DM) was from 1.2 to 2.07. The similarities of nitrogen, potassium, and phosphorus concentrations in *A. spica-venti* and winter wheat, in our opinion, confirm the thesis of Rola and Żurawski [50], that there is strong competition for nutrients between a given weed and crop plant.

Currently, there are no reports on the influence of phosphorus and potassium on the growth and development of *A. spica-venti*. We detected moderate positive correlations between the selected morphological traits of *A. spica-venti* and its weight with the K and P content in soil and/or in straw. Namely, the increase in the concentration of K in the soil resulted in an increase in the number of panicle storeys and number of nodes per culm ($p < 0.05$; $r = 0.50$, $r = 0.24$, respectively). Moreover, the increase in the concentration of K in the straw resulted in an increase in the plant mass ($p < 0.05$; $r = 0.42$). Thus, the results of our studies indirectly confirm that potassium is an essential nutrient for plant growth and it is associated with the movement of water, nutrients, and carbohydrates in plant tissue [51].

The increase in the panicle length and the number of nodes per culm was closely related to the increase in the concentration of P in the straw ($p < 0.05$; $r = 0.55$, $r = 0.44$, respectively). Therefore, our research confirms the general reports on phosphorus—that it positively influences the growth and development of grain crops [52,53]. Moreover, authors [52,53] have demonstrated the beneficial effect of fertilisation with phosphorus on plant height and straw yield, among other attributes. On the other hand, it should be mentioned that an excess of soil phosphorus can have negative effects on plants and cause disorders in development and yield. The main reason for these disorders is the negative effect of excess phosphorus on soil microorganisms [54]. Kaminsky et al. [54] have demonstrated that alfalfa produces less biomass and fewer nodules when grown in soil with high phosphorus content or in soil to which micro-organisms are transferred from soil with high phosphorus content. This is probably why we found that an increase in the phosphorus content in the soil causes a reduction in the length of culm, the length of the pancile of *A. spica-venti* ($p < 0.05$; $r = -0.43$ and -0.21, respectively), and the number of nodes per plant ($p < 0.05$; $r = -0.27$).

As reported by Harper and Lynch [55] and Wójcik-Wojtkowiak [56], decay of post-harvest straw residues may cause the formation of toxic compounds that can impair the quality of the site and suppress the development of new growing plants. It should be noted that post-harvest residues contain not just crop plant material but also weed residues. *A. spica-venti* seed highly contaminates cereal crop seed and therefore it is very likely that the straw of this weed is present in the straw of cereal plants. As reported by Kraska and Kwiecińska-Poppe [57], aqueous extracts of dry straw of *A. spica-venti* reduced the germinative capacity and energy of winter rye and winter triticale. These soluble straw extracts also slowed the growth of embryonic roots and the emergence of the first leaf of cereals. Our research showed high similarity in the content of mineral nutrients (NPK) in *A. spica-venti* straw compared to winter wheat straw. However, additional research is needed to examine the presence of other chemical components in weed straw that could reduce the growth and development of new plants.

Our research showed that the dry mass of plants in the individual years of the study ranged from 26.42 to 71.87, while the average mass from year to year was between 34.50 and 54.89 g. Moreover, the increase in the weight of *A. spica-venti* resulted in an increase in the length of its culm ($p < 0.05$; $r = 0.23$), and the mass of this plant was positively correlated with the concentration of N in the soil ($p < 0.05$; $r = 0.38$).

Currently, there are no new reports regarding information on the mass of the plant of *A. spica-venti* for naturally occurring plants in crop fields. Kukowski [42] in the 1970s showed that the dry weight of weed depended on the number of weed infestations. The author reports that 16, 236, 302, and 471 plants per m^2 reached weights, respectively, of 11.3, 168.0, 243.0, and 310.0 g. In addition, the author showed that the weight depended on the study site. Weed growing also in the winter wheat crop but in different locations, at the weed infestation rate of 31 and 632 plants per m^2, reached weights of 5.0 and 417.1 g, respectively. Moreover, in the 1970s, both Kukowski [42] and Warwick et al. [32] conducted pot experiments in which they determined the dry weight of plants of weed. However, they are quite contrary and difficult to compare. According to Kukowski [42], 20 weed plants grown in pure sowing in the pot reached dry weights ranging from 11.5 to 23.97 g depending on the soil moisture level. In contrast, in the mixed sowing, 20 weed plants and 10 winter wheat, the dry weight of weed ranged from 6.9 to 12.53 g depending on the varying moisture content maintained. Warwick et al. [32] report the average dry weight per plant, separately for culm, panicle, and leaves. According to the studies, the average dry weight of the culm depended on the population, and was 8.85 g for the European population and 7.46 g for the Canadian population. The dry weight of leaves per plant was 2.23 g for the European population and 1.84 g for the Canadian population. The dry weight of panicles per plant 4.20 g for the European population and 3.89 g for the Canadian population. In total, weight for European population was 15.28 g and for Canadian population it was 13.19 g per plant. But their study sampled only 11 or 15 plants, depending on population.

5. Conclusions

Our study contributes to gaining new knowledge about the influence of the habitat on the chemical composition and morphology of silky *A. spica-venti* occurring naturally in arable fields. There was no significant influence of the habitat on the examined morphological features (culm and panicle length, number of nodes per culm, and panicle storeys) of *A. spica-venti*, its mass, and NPK concentration in its straw, even though we found significant differences in soil pH and N and P concentrations in the soil between individual study sites. However, an increase in soil abundance in some macronutrients (mainly K) may positively affect the morphology of this weed as opposed to an increase in nitrogen concentration in the soil and an increase soil pH. Moreover, we showed that *A. spica-venti* have a similar nitrogen concentration to that of winter wheat straw, and the number of plant nodes in this weed were lower than those described in the current literature. In turn, panicle lengths of *A. spica-venti* were longer than previously reported. The lack of significant influence of soil conditions and location of APESV sites on the morphology and chemical composition of the weed indicates that it is highly plastic and able to thrive under varying habitat conditions. The variation in morphological/biometric traits of APESV over the years indicates the need for more research on the effects of weather on the development and competitiveness of this weed.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agronomy12081883/s1, Figure S1. Relationship between: (a) the concentration of N in the straw [% dry matter] and N concentration in the soil ($p < 0.05$; $r = 0.37$); (b) the concentration of P in the straw [% DM] and P concentration in the soil ($p < 0.05$; $r = -0.15$, and (c) the concentration of K in the straw [% DM] and K concentration in the soil ($p < 0.05$; $r = -0.13$). Figure S2. Relationship between the N concentration in the soil and selected morphological features of *A. spica-venti*: (a) culm length ($p < 0.05$; $r = 0.12$), (b) panicle length ($p < 0.05$; $r = -0.05$), (c) number of nodes per culm ($p < 0.05$; $r = 0.10$), and (d) number of panicle storeys ($p < 0.05$; $r = -0.43$). Figure S3. Relationship between the P concentration in the soil and selected morphological features of *A. spica-venti*: (a) culm length ($p < 0.05$; $r = -0.43$), (b) panicle length ($p < 0.05$; $r = -0.21$), (c) number of nodes per culm ($p < 0.05$; $r = -0.27$), and (d) number of panicle storeys ($p < 0.05$; $r = 0.06$). Figure S4. Relationship between the K concentration in the soil and selected morphological features of *A. spica-venti*: (a) culm length ($p < 0.05$; $r = -0.13$), (b) panicle length ($p < 0.05$; $r = -0.29$), (c) number of nodes per culm ($p < 0.05$; $r = 0.24$), and (d) number of panicle storeys ($p < 0.05$; $r = 0.50$). Figure S5. Relationship between the N concentration in the straw [% dry matter] and selected morphological features of *A. spica-venti*: (a) culm length ($p < 0.05$; $r = -0.59$), (b) panicle length ($p < 0.05$; $r = -0.40$), (c) number of nodes per culm ($p < 0.05$; $r = -0.42$), and (d) number of panicle storeys ($p < 0.05$; $r = -0.16$). Figure S6. Relationship between the P concentration in the straw [% dry matter] and selected morphological features of *A. spica-venti*: (a) culm length ($p < 0.05$; $r = 0.17$), (b) panicle length ($p < 0.05$; $r = 0.55$), (c) number of nodes per culm ($p < 0.05$; $r = 0.44$), and (d) number of panicle storeys ($p < 0.05$; $r = -0.05$). Figure S7. Relationship between the K concentration in the straw [% dry matter] and selected morphological features of *A. spica-venti*: (a) culm length ($p < 0.05$; $r = -0.05$), (b) panicle length ($p < 0.05$; r = 0.18), (c) number of nodes per culm ($p < 0.05$; $r = -0.75$), and (d) number of panicle storeys ($p < 0.05$; $r = -0.37$). Figure S8. Relationship between the dry mass of 35 plants of *A. spica-venti* and selected morphological features of *A. spica-venti*: (a) culm length ($p < 0.05$; $r = 0.23$), (b) panicle length ($p < 0.05$; $r = 0.07$), (c) number of nodes per culm ($p < 0.05$; $r = -0.23$), and (d) number of panicle storeys ($p < 0.05$; $r = -0.01$). Figure S9. Relationship between the dry mass of 35 plants of *A. spica-venti* and the concentration of N, P, K in the soil: (a) N ($p < 0.05$; $r = 0.38$); (b) P ($p < 0.05$; $r = -0.08$), and (c) K ($p < 0.05$; $r = -0.03$). Figure S10. Relationship between the dry mass of 35 plants of *A. spica-venti* and the concentration of N, P, K in the straw [% dry matter]: (a) N ($p < 0.05$; $r = 0.14$); (b) P ($p < 0.05$; $r = -0.20$), and (c) K ($p < 0.05$; $r = 0.42$). Figure S11. Relationship between the soil pH and the concentration of N, P, K in the straw [% dry matter] and dry mass of 35 plants: (a) N ($p < 0.05$; $r = 0.53$); (b) P ($p < 0.05$; $r = -0.01$), (c) K ($p < 0.05$; $r = -0.08$), and (d) mass of 35 plants ($p < 0.05$; $r = -0.15$). Figure S12. Relationship between the soil pH and selected morphological features of *A. spica-venti*: (a) culm length ($p < 0.05$; $r = -0.43$), (b) panicle length ($p < 0.05$; $r = -0.12$), (c) number of nodes per culm ($p < 0.05$; $r = 0.01$), and (d) number of panicle storeys ($p < 0.05$; $r = 0.03$).

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Appendix A

Table A1. Chemical compositions of the soil at the depth 0–20 cm: [1] See Table 1 for study sites. [2] The research was not carried out in a given year.

Study Sites [1]	Soil WRB (World Reference Base)	Year	pH	N	P	K
				(g/kg)	(mg/kg)	
I	Fluvic Cambisols	2016	8.0	1.01	234.3	315.0
		2017	— [2]	—	—	—
		2019	8.1	1.60	212.3	145.0
		2020	7.7	0.50	265.1	165.0
II	Fluvic Cambisols	2016	—	—	—	—
		2017	7.3	1.25	200.6	180.0
		2019	7.6	1.76	192.2	135.0
		2020	7.0	0.64	132.3	170.0
III	Podzols	2016	7.6	1.24	47.8	145.0
		2017	7.5	0.93	31.2	40.0
		2019	7.2	1.01	99.9	55.0
		2020	7.5	0.78	154.9	350.0
IV	Fluvic Cambisols	2016	—	—	—	—
		2017	7.3	0.40	122.1	65.0
		2019	7.3	0.48	154.2	35.0
		2020	7.0	0.13	155.6	65.0
V	Eutric/Endocalcaric Cambisols	2016	7.1	1.44	136.5	350.0
		2017	—	—	—	—
		2019	7.6	1.71	100.6	55.0
		2020	6.8	1.86	177.2	200.0

Table A2. Chemical compositions in the straw of *A. spica-venti*: [1] See Table 1 for study sites. [2] The research was not carried out in a given year.

Study Sites [1]	Year	N	P	K
		% Dry Matter		
I	2016	1.18	0.09	0.93
	2017	— [2]	—	—
	2019	0.67	0.25	1.42
	2020	0.75	0.18	1.54
II	2016	—	—	—
	2017	0.49	0.54	0.74
	2019	1.27	0.18	1.83
	2020	0.51	0.15	1.75
III	2016	0.96	0.04	1.17
	2017	0.44	0.56	0.75
	2019	0.93	0.13	1.73
	2020	0.56	0.19	1.70
IV	2016	—	—	—
	2017	0.63	0.57	0.78
	2019	0.58	0.17	1.30
	2020	0.47	0.18	1.67
V	2016	0.40	0.09	1.01
	2017	—	—	—
	2019	1.00	0.20	2.11
	2020	0.60	0.16	1.47

Table A3. Selected morphological features of *A. spica-venti* associated with culms in particular years of research: [1] See Table 1 for study sites. [2] Statistical analysis performed for different locations in a given year (vertical analysis, superscript) the same letter means that results are not statistically different at the $\alpha \leq 0.05$ level, according to Tukey's HSD test; others are. [3] The research was not carried out in a given year.

Study Sites [1]	Culm Length (cm)				Number of Nodes per Culm (no.)			
	2016	2017	2019	2020	2016	2017	2019	2020
I	73.31 c [2]	—	111.34 a	100.51 b	4.54 b	—	4.86 a	4.46 a
II	— [3]	94.42 b	80.89 c	112.11 a	—	5.29 a	4.51 ab	4.49 a
III	99.40 b	113.74 a	104.71 a	91.86 c	5.14 a	5.17 ab	4.46 ab	4.69 a
IV	—	113.11 a	93.00 b	100.34 b	—	4.86 b	4.31 b	4.60 a
V	129.00 a	—	112.50 a	114.23 a	5.20 a	—	4.20 b	4.54 a

Table A4. Selected morphological features of *A. spica-venti* associated with panicles in particular years of research: [1] See Table 1 for study sites. [2] Statistical analysis performed for different locations in a given year (vertical analysis, superscript) the same letter means that results are not statistically different at the $\alpha \leq 0.05$ level, according to Tukey's HSD test; others are. [3] The research was not carried out in a given year.

Study Sites [1]	Panicles Length (cm)				Number of Panicle Storeys (no.)			
	2016	2017	2019	2020	2016	2017	2019	2020
I	19.65 b [2]	—	28.14 b	30.17 a	10.11 a	—	5.83 ab	8.80 ab
II	— [3]	26.54 c	25.29 b	28.74 a	—	8.37 a	5.25 b	9.71 a
III	21.40 b	33.89 a	26.29 b	31.26 a	9.05 b	7.68 a	6.46 a	8.45 b
IV	—	30.20 b	25.51 b	25.09 b	—	7.65 a	5.43 b	7.91 b
V	24.17 a	—	31.77 a	29.14 a	8.11 c	—	5.71 b	6.22 c

Table A5. The mass of 35 plants of *A. spica-venti* depending on the study sites: [1] See Table 1 for study sites. [2] The research was not carried out in a given year.

Study Sites [1]	Years of Research			
	2016	2017	2019	2020
I	44.2	—	40.65	38.2
II	— [2]	51.32	31.16	48.9
III	42.2	33.59	52.23	36.3
IV	—	30.19	26.42	46.9
V	40.9	—	71.87	51.9

Table A6. Selected values of the Pearson (r) correlation coefficient at $\alpha = 0.05$ between the studied habitat, the chemical composition and selected morphological features of *A. spica-venti*. [1] The Pearson correlation coefficient (r) was not calculated.

Pearson (r)		pH	Soil			Straw			Culm Length	Panicle Length	No. Nodes per Culm	Panicle Storeys No.	Dry Mass of 35 Plants
			N	P	K	N	P	K					
pH		x [1]	x	x	x	0.53	−0.01	−0.08	−0.43	−0.12	0.01	0.03	−0.15
Soil	N	x	x	x	x	0.37	x	x	0.12	−0.05	0.10	−0.43	0.38
	P	x	x	x	x	x	−0.15	x	−0.43	−0.21	−0.27	0.06	−0.08
	K	x	x	x	x	x	x	−0.13	−0.13	−0.29	0.24	0.50	−0.03
Straw	N	0.53	0.37	x	x	x	x	x	−0.59	−0.40	−0.42	−0.16	0.14
	P	−0.01	x	−0.15	x	x	x	x	0.17	0.55	0.44	−0.05	−0.20
	K	−0.08	x	x	−0.13	x	x	x	−0.05	0.18	−0.75	−0.37	0.42
culm length		−0.43	0.12	−0.43	−0.13	−0.59	0.17	−0.05	x	x	x	x	0.23
panicle length		−0.12	−0.05	−0.21	−0.29	−0.40	0.55	0.18	x	x	x	x	0.07
no. nodes per culm		0.01	0.10	−0.27	0.24	−0.42	0.44	−0.75	x	x	x	x	−0.23
panicle storeys no.		0.03	−0.43	0.06	0.50	−0.16	−0.05	−0.37	x	x	x	x	−0.01
mass of 35 plants		−0.15	0.38	−0.08	−0.03	0.14	−0.20	0.42	0.23	0.07	−0.23	−0.01	x

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