Plant Growth, Yield and Quality of Potato Crop in Relation to Potassium Fertilization

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Abstract: The present work evaluated the effect of soil (S) and foliage (F) applied potassium on the growth, yield, and quality of potato plants. Potassium was added in soil at the recommended rate for all the treatments combining mineral fertilizers with K-feldspar and biofertilizers, while foliar spraying included the application of potassium citrate (PC), potassium silicate (PS), and monopotassium phosphate (MP). The obtained results showed that plant height was highest following treatment with 100% mineral potassium fertilizer under the foliar application of MP, while the content of P, K, and total carbohydrates in leaves also increased with the same fertilization treatment. On the other hand, the highest values for number of stems and fresh and dry weight per plant, as well as the highest nitrogen content in leaves, were obtained after the addition of mineral potassium fertilizer and the foliar spraying of PC, regardless of the growing season. Yield parameters were positively affected by the combination of mineral potassium fertilizers (100% or 80% K2SO4 + 20% K-feldspar + biofertilizer) and the foliar spraying of MP, while the total nitrogen, protein, amino acids, potassium, phosphorus, and starch content of tubers were positively affected by the same mineral fertilizer treatments combined with foliar spraying of MP or CP. In conclusion, the application of mineral potassium fertilizer with foliar spraying of MP or CP increased most of the plant growth- and tuber chemical composition-related parameters. These results highlight the importance of potassium fertilizer regimes for achieving high tuber yields and improving the quality of tubers in a sustainable and cost-effective manner.

Keywords: K-feldspar; mineral composition; total sugars; yield; starch; Solanum tuberosum L.; tuber yield; biofertilizers

1. Introduction

Potato (Solanum tuberosum L.) is one of most important food crops and can be used in human nutrition as a low-cost energy source. Additionally, it is an affordable food with significant content of starch, minerals, vitamin C and B, and amino acids and is highly appreciated worldwide [1]. According to the FAO, potato is a very important vegetable crop throughout the world, while in Africa total production in 2019 was 26.5 million tons harvested from approximately 1.76 million hectares [2].
Potassium (K) is an important macro nutrient for vegetable crops, including potato, because plant requirements for K are higher than any other macro nutrient after nitrogen [3,4]. The function of K in photosynthesis is well known and can improve photosynthate translocation, enzyme activities, and the synthesis of proteins, carbohydrates, and fats, and is responsible for higher crop productivity [5]. Moreover, K is highly involved in potato plant growth and development [6,7], and can assist plants in adapting to biotic and abiotic stressors such as pathogens, drought, and extreme temperatures [8].

Using natural sources of potassium can be a cost-effective practice to provide plants with adequate K and can also substitute for expensive chemical fertilizers [9]. The main source of K for plants grown under natural conditions comes from the weathering of K minerals, e.g., K-feldspar, K-mica, and illite [10]. Many researchers have reported that K-feldspar can be considered as a slow-releasing fertilizer and affordable source of K [11]. Feldspar is a natural potash mineral that contains 10.50% to 11.25% of K₂O and can be used as an effective application to minimize the inputs of chemical potassium fertilizers in crop production [10,12]. Moreover, according to the literature, the combination of potassium sulfate and K-feldspar may improve starch content and macro nutrient uptake (N, P, and K) in tubers and shoots and increase potato yield [13–15].

Another agricultural practice is the use of potassium-solubilizing bacteria (KSB) as bio-fertilizers, i.e., silicate-dissolving bacteria have been suggested as a sustainable solution to enhance plant growth, chemical constituents, root growth, flowering, productivity, and quality through the increase of potassium availability [12]. Moreover, KSB play a vital role in the formation of soil humus and the recycling of other minerals tied up in the soil organic matter [10,16]. Furthermore, they can enable solubilization from rock-K mineral powder such as feldspar through the production and excretion of organic acids or chelate silicon ions that transfer K into solution [17]. On the other hand, inoculation with potassium-solubilizing bacteria combined with either potassium sulfate or K-feldspar can provide a faster and continuous supply of K for enhanced plant growth, yield, and final product quality [15].

Considering the importance of potassium availability for potato crop cultivation, the purpose of this work was to study the effects of supplementing potassium fertilizers through direct soil application and via foliar spraying in the presence of biofertilizers and K-feldspar on the growth, productivity, and chemical composition of the potato plant cultivar (cv.) Lady Rosetta. The main aim of the present study was to evaluate the potential of reducing K chemical fertilizer inputs through the use of alternative potassium sources and biofertilizers without affecting the quality of the final product. For this purpose, a two-year field experiment was carried out where potassium was applied: (a) directly to soil in the form of inorganic mineral potassium sulfate and K-feldspar in the presence of biofertilizer containing potassium-solubilizing bacteria, and (b) via foliar spraying in the forms of potassium silicate, potassium citrate, and monopotassium sulfate. Considering that the aim of the present study was to evaluate the possibility of partial substitution for mineral K fertilizers with alternative sources, a zero K application was therefore not considered as an experimental treatment because it would conceal any significant differences among the tested treatments.

2. Materials and Methods
2.1. Field Experiment Conditions
A field trial was carried out at the experimental farm of the Faculty of Agriculture, Benha University, Egypt for two consecutive winter seasons (2017/2018 and 2018/2019). The average values of temperature, precipitation, and relative humidity during the experimental periods ranged between 18–30 °C, 1.6–5.7 mm, and 53–68%, respectively. Pest control was conducted according to the recommendations of the Ministry of Agriculture for the commercial production of potato under Egyptian conditions. K requirements of potato plants (cv. Lady Rosetta) were covered up to the recommended dose (RD) for all the tested treatments, which included the direct soil application (S) of mineral potassium fertilizer
(100% K$_2$SO$_4$) without biofertilizers and the application of 40%, 60%, and 80% of the RD with mineral fertilizer combined with K-feldspar and biofertilizers (60%, 40%, and 20%, respectively). Moreover, the foliar spraying (F) treatments of K included the application of potassium citrate (PC), potassium silicate (PS), and monopotassium phosphate (MP). One month before starting the field experiments, soil samples were collected at a depth of 0–30 cm for physical and chemical determinations. Physicochemical properties of the soil are shown in Table 1. Physical and chemical parameters were determined according to Jackson [18] and Gupta [19], respectively.

| Particle Size Distribution (%) | Texture | Chemical Properties |
|-------------------------------|---------|---------------------|
| Fine Sand | Coarse Sand | Clay | Silt | pH | EC | Available N | Available P | Available K | OM |
| 4.08 | 8.51 | 56.17 | 31.24 | Clay | 7.8 | 0.85 | 22.2 | 12.5 | 61.9 | g kg$^{-1}$ |

Potato tubers were planted on 20 and 22 October in the first and second season, respectively. Four ridges of 4 m in length and 80 cm in width with an area of 12.8 m$^2$, were allocated for each experimental plot, and potato tubers were planted 30 cm apart (53.3 plants/plot or 41,640 plants ha$^{-1}$). All agricultural practices required for the production of potatoes were carried out in compliance with the recommendations of the Ministry of Agriculture of Egypt. The recommended rates of mineral NPK fertilizers for potato plants were 357 kg N ha$^{-1}$ (in the form of ammonium nitrate; 33% N), 143 kg P$_2$O$_5$ ha$^{-1}$ (in the form of calcium superphosphate; 16% P$_2$O$_5$) and 229 kg K$_2$O ha$^{-1}$ (in the form of potassium sulfate; 48% K$_2$O). N fertilizer was added with in-season applications at three equal doses of 119 kg N ha$^{-1}$ starting after complete sprouting (21 days after planting) and two more times at two-week intervals between applications. Mineral P was added during soil preparation as base dressing. Mineral K fertilizer was divided into three equal doses starting two months after planting and two more times at two-week intervals. Irrigation was performed with a sprinkler irrigation system providing a total amount of 12 $\times$ 10$^6$ mm of water per ha.

2.2. Experimental Design and Treatments

The experiment was carried out according to a complete randomized block (CRB) design using two experimental factors (direct soil application (S) and foliar spraying (F) of K) with four levels each (see below). The experiment included 16 treatments replicated three times, accounting for 48 experimental plots in total.

2.2.1. Soil Addition of Potassium Fertilizers (S)

The experimental treatments of direct soil additions of K were as follows:

1. 100% mineral K fertilizer: the recommended dose of mineral K (229 kg K$_2$O ha$^{-1}$ in the form of potassium sulfate, 48% K$_2$O) (S1).
2. 80% mineral K fertilizer + 415 kg K-feldspar ha$^{-1}$, which was equivalent to 20% of the recommended dose of mineral K + biofertilizer (S2).
3. 60% mineral K fertilizer + 830 kg K-feldspar ha$^{-1}$, which was equivalent to 40% of the recommended dose of mineral K + biofertilizer (S3).
4. 40% mineral K fertilizer + 1245 kg K-feldspar ha$^{-1}$, which was equivalent to 60% of the recommended dose of mineral K + biofertilizer (S4).

The abovementioned amounts of K-feldspar and biofertilizer were added to the soil during soil preparation as base dressing in both growing seasons. The chemical composition of K-feldspar is presented in Table 2.
Table 2. Chemical composition of K-feldspar used in the experiment during the 2018 and 2019 growing seasons.

| Components | SiO₂ | Al₂O₃ | K₂O | MgO | Na₂O | pH | EC (dS m⁻¹) | P₂O₅ | CaO | Cl | TiO₂ | MnO |
|------------|------|-------|-----|-----|------|----|-------------|------|-----|----|------|-----|
| SiO₂       | 63.35% |      |     |     |      |    |             |      |     |    |      |     |
| Al₂O₃      | 16.14% |      |     |     |      |    |             |      |     |    |      |     |
| K₂O        | 11.0%  |      |     |     |      |    |             |      |     |    |      |     |
| MgO        | 7.11%  |      |     |     |      |    |             |      |     |    |      |     |
| Na₂O       | 1.83%  |      |     |     |      |    |             |      |     |    |      |     |
| pH         | 8.21   |      |     |     |      |    |             |      |     |    |      |     |
| EC (dS m⁻¹) | 0.52 |      |     |     |      |    |             |      |     |    |      |     |

2.2.2. Foliar Spraying of Potassium Sources (F)

The experimental treatments of foliar application of K additions were as follows:

1. Control treatment (C): foliar spraying with tap water.
2. Potassium citrate (K₃C₆H₅O₇; 38% K₂O) (PC): applied at 2.64 g L⁻¹ to provide 1000 mg kg⁻¹ of K.
3. Potassium silicate (K₂SiO₃; 10% K₂O) (PS): applied at 10 g L⁻¹ to provide 1000 mg kg⁻¹ of K.
4. Monopotassium phosphate (KH₂PO₄; 34% K₂O) (MP): applied at 2.94 g L⁻¹ to provide 1000 mg kg⁻¹ of K.

The spraying solution of potassium was applied to completely cover the plant foliage until drip. Potato plants were subjected to foliar spraying with the aforementioned treatments four times at two-week intervals, starting 45 days after planting time in both seasons.

2.2.3. Biofertilizer Application

Silicate-dissolving bacteria (SDB) (Bacillus circulans) were obtained from the Department of Microbiology, Agricultural Research Center, Giza. One mL of solution contained 10⁷ viable cells of SDB and was added three times via irrigation at a rate of 10 L ha⁻¹ at two-week intervals, starting on 20 and 22 November (one month after planting) in the first and second growing seasons, respectively. All soil fertilization treatments received the same doses of biofertilizers, except for the S1 treatment, which received all the recommended rate in the form of mineral fertilizer.

2.3. Plant Parameters

Vegetative growth parameters of potato plants were estimated at 80 days after planting. Representative samples of three plants from each experimental plot (12 plants in total for each treatment) were taken for measuring the vegetative growth parameters as follows: plant height (cm), number of stems per plant, and fresh and dry weight (g) per plant. Batch samples of leaves for each treatment were used for the determination of total carbohydrates, nitrogen, phosphorus, and potassium content (%) according to the methods previously described by Chaplin and Kennedy [20], Page et al. [21], John [22], and Cottenie et al. [23], respectively. The number of tubers per plant, the average tuber weight (g), and the total yield (ton ha⁻¹) were also determined. Samples of tubers were collected at harvest time (120 days after planting) and dried in an electric oven to constant weight at 70 °C for dry weight determination. Moreover, the digested dry matter of each sample was used for the chemical analyses of minerals (N, P, K), total protein, total amino acids, total starch, and total sugars. Total nitrogen was determined using the Micro-Kjeldahl method. Total protein was calculated in the digested dry matter of tuber samples by multiplying the total nitrogen content by the factor of 6.25 as described by A.O.A.C. [24]. Phosphorus was determined colorimetrically with the UV spectrophotometer UVMini-1240 (Shimadzu Corporation, Kyoto, Japan), through molybdate reactive P method while maintaining the ammonium molybdenum concentration at 10 g L⁻¹ as described by John [22] and Page et al. [21]. Total potassium was determined using a flame photometer (Model: 400 FP) according to...
A.O.A.C. [25]. Total amino acid content was measured with the UV spectrophotometer using reduced ninhydrin with the amino group method in 0.25 g of the digested dry matter of potato tubers [24]. Starch was determined in the dried samples of tuber according to the method of Luff-Schoorl, which applies the acid hydrolysis of starch and titration by sodium thiosulfate as described in the A.O.A.C. methods [25]. Total sugar content was determined by the phenol-sulfuric acid method according to Chaplin and Kennedy [20] using a UV spectrophotometer (UVMini-1240, Shimadzu Corporation, Kyoto, Japan).

2.4. Statistical Analysis

All data obtained in both seasons of the study were subjected to a two-way analysis of variance (ANOVA) using the M-stat v.4 program for Windows (Informer Technologies, Inc., Los Angeles, CA, USA). For mean comparisons, the least significant difference (LSD) test was used at $p = 0.05$. Correlation analyses of the qualitative parameters were carried out using Pearson’s correlation coefficient ($R$) at $p = 0.05$.

3. Results and Discussion

3.1. The Effect of Potassium Application on Plant Vegetative Growth Parameters

The statistical analysis of the results showed a significant interaction between the tested factors (soil addition (S) and foliar spraying (F)) for all the tested parameters except total sugar content, where no significant effects were observed for either the interaction or the single effects of both factors. The ANOVA tables are presented in the Supplementary Materials. Therefore, the results are presented and discussed according to the two-way ANOVA analysis. The results in Table 3 present the effect of potassium application on the tested parameters related to plant vegetative growth. The addition of K$_2$SO$_4$ fertilizer through the soil (S1) resulted in better plant growth compared to the rest of the soil-added treatments, although no significant differences were observed between S1 and S2 treatments in the case of plant height in the 2nd growing season and plant dry weight in the 1st growing season. In contrast, the addition of increasing amounts of K-feldspar + biofertilizer (S3 and S4 treatments) had no beneficial effect on any of the tested plant growth parameters for both growing seasons. Regarding the effect of foliar applications, plant height was beneficially affected by monopotassium phosphate (MP) in the 1st growing season, whereas no significant differences were observed among the treatments in the second growing season. On the other hand, both the addition of MP and potassium citrate (PC) resulted in the highest number of stems per plant and plant dry weight regardless of the growing season, while only PC treatment was more beneficial for plant fresh weight than the rest of the treatments. The combined effect of soil and foliar application of potassium showed a varied response depending on the tested parameter. Therefore, plant height increased when MP was combined with the S1 or S2 treatment in both growing seasons, although a similar response was observed in the case of S1 × PC treatment in the 2nd growing season. The number of stems was positively affected by foliar applications of potassium, regardless of the soil addition treatments, except for the case of S3 × PS and S4 × PS, where no significant differences from the control treatment of leaf application (C) were recorded. In the case of plant fresh weight, direct applications of the full dose of K$_2$SO$_4$ in soil (S1) combined with PC and MP foliar treatments were the best combinations, while for the 1st growing season the addition of 80% K$_2$SO$_4$ + 20% K-feldspar + biofertilizer and PC treatment showed similar results. Finally, plant dry weight showed a varied response with no specific trends in the 1st growing season, whereas in the 2nd growing period the foliar application of potassium citrate combined with either the S1 or the S2 treatments presented the highest values. According to the literature, the addition of feldspar acidified with organic acids resulted in improved plant growth in pea plants [26]; however, that was not the case in our study. Moreover, the use of biofertilizers containing potassium solubilizing bacteria is considered an eco-friendly approach to activate potassium bound in soil particles and increase its availability for plant uptake [16,27]. This contradiction with the results of our study indicates that the practice of adding biofertilizers had no significant effect on most of the
tested growth parameters when plant requirements were covered mostly through mineral fertilizers (S1 and S2 treatments) and/or foliar applications of potassium. According to the literature, increasing potassium application rates at 139 kg ha\(^{-1}\) and 183 kg ha\(^{-1}\) resulted in taller plants and increased total leaf area and chlorophyll content, respectively, suggesting that plant growth and crop performance are regulated by potassium availability in soil [4]. Similarly to our study, the application of potassium solely in the form of mineral fertilizers (100% potassium sulfate) resulted in better plant growth indices compared to feldspar rock (100%) or 100% feldspar rock + potassium-releasing bacteria (PRB), while the best results were obtained when most of the potassium requirements were covered through mineral fertilizers (50–75%) and the rest via the application of feldspar rock (25–50%) and PRB [28]. Similarly, Lallawmkima et al. [29] suggested that the best plant performance was recorded when macronutrient requirements were partially fulfilled through the addition of mineral fertilizers plus the addition of biofertilizers. In the study by Abd El-Gawad [30], it was also suggested that the foliar spraying of potato plants with potassium silicate significantly improved vegetative growth because potato is a highly demanding crop with regard to potassium, and the foliar addition of this macronutrient increases its availability and benefits the translocation of assimilates and protein synthesis as well as membrane polarization, ion homeostasis, enzyme activity, and osmotic regulation [8,31]. Moreover, the results of Abdel-Salam and Shams [15] were in the same line, highlighting the positive effect of combining various sources of potassium on potato plant growth, while Shunka et al. [32] indicated the interaction of potassium application with other macronutrients such as nitrogen. Finally, Zelelew et al. [33] reported a variable response to potassium fertilization depending on the potato cultivar, while Soratto et al. [34] and Kumar et al. [35] highlighted the importance of application timing and potassium source for crop response to potassium fertilization. In contrast, Ali et al. [36] reported a positive effect on the growth of potato plants treated with feldspar-K and potassium-solubilizing bacteria; however, the results of that study are not comparable to the present work because different treatments were applied. Therefore, despite the lack of positive effects from the increasing K-feldspar and biofertilizer applications in our study, it is worth considering the long-term beneficial effects that such a practice may have on soil fertility status through the increase of potassium solubilization and the decrease of inorganic mineral fertilizer inputs.

### Table 3. The effect of potassium fertilization with soil addition (S) or foliar spraying (F) on growth parameters of potato plants during the 2018 and 2019 growing seasons.

| Potassium Fertilizer Treatments | Plant Height (m) | Number of Stems/Plant | Plant Fresh Weight (kg) | Plant Dry Weight (kg) |
|-------------------------------|-----------------|----------------------|------------------------|----------------------|
| Soil Addition (S)             | 1st Season      | 2nd Season           | 1st Season             | 2nd Season           | 1st Season | 2nd Season | 1st Season | 2nd Season |
| 100% K\(_2\)SO\(_4\) (S1)    | 0.55            | 0.53                 | 4.31                   | 4.60                 | 0.23       | 0.23       | 0.03       | 0.04       |
| 80% K\(_2\)SO\(_4\)+20% K-feldspar+biofertilizer (S2) | 0.53            | 0.51                 | 4.07                   | 4.29                 | 0.21       | 0.21       | 0.03       | 0.03       |
| 60% K\(_2\)SO\(_4\)+40% K-feldspar+biofertilizer (S3) | 0.51            | 0.49                 | 3.82                   | 4.05                 | 0.19       | 0.19       | 0.03       | 0.03       |
| 40% K\(_2\)SO\(_4\)+60% K-feldspar+biofertilizer (S4) | 0.49            | 0.46                 | 3.50                   | 3.91                 | 0.17       | 0.12       | 0.03       | 0.03       |
| LSD at 0.05                   | 0.01            | 0.01                 | 0.62                   | 0.74                 | 0.01       | 0.01       | 0.004      | 0.004      |
| Control (C)                   | 0.49            | 47.8                 | 2.61                   | 2.80                 | 0.15       | 0.15       | 0.02       | 0.02       |
| Potassium citrate (PC)        | 0.53            | 47.8                 | 4.80                   | 5.09                 | 0.24       | 0.24       | 0.04       | 0.04       |
| Potassium silicate (PS)       | 0.51            | 47.8                 | 4.01                   | 4.24                 | 0.20       | 0.20       | 0.03       | 0.03       |
| Monopotassium phosphate (MP)  | 0.55            | 47.8                 | 4.29                   | 4.71                 | 0.21       | 0.22       | 0.03       | 0.04       |
| LSD at 0.05                   | 0.01            | 0.01                 | 0.62                   | 0.74                 | 0.01       | 0.01       | 0.001      | 0.001      |
Table 3. Cont.

| Potassium Fertilizer Treatments | Plant Height (m) | Number of Stems/Plant | Plant Fresh Weight (kg) | Plant Dry Weight (kg) |
|---------------------------------|------------------|-----------------------|------------------------|-----------------------|
|                                  | 1st Season       | 2nd Season            | 1st Season             | 2nd Season            | 1st Season | 2nd Season | 1st Season | 2nd Season |
| **Soil Addition (S)**            |                  |                       |                        |                        |            |            |            |            |
| 100% K₂SO₄ (S1)                  | Control (C)      | 0.53                  | 0.51                   | 2.86                   | 2.93        | 0.17       | 0.16       | 0.02       | 0.03       |
|                                 | Potassium citrate (PC) | 0.56   | 0.54                   | 5.24                   | 5.62        | 0.27       | 0.28       | 0.04       | 0.05       |
|                                 | Potassium silicate (PS) | 0.54   | 0.51                   | 4.31                   | 4.71        | 0.22       | 0.23       | 0.03       | 0.04       |
|                                 | Monopotassium phosphate (MP) | 0.59   | 0.56                   | 4.86                   | 5.14        | 0.25       | 0.26       | 0.04       | 0.04       |
| **80% K₂SO₄ +20% K-feldspar+biofertilizer (S2)** | Control (C) | 0.49                  | 0.49                   | 2.64                   | 2.81        | 0.15       | 0.15       | 0.02       | 0.02       |
|                                 | Potassium citrate (PC) | 0.54   | 0.52                   | 5.03                   | 5.21        | 0.25       | 0.25       | 0.04       | 0.04       |
|                                 | Potassium silicate (PS) | 0.53   | 0.51                   | 4.16                   | 4.23        | 0.21       | 0.20       | 0.03       | 0.03       |
|                                 | Monopotassium phosphate (MP) | 0.57   | 0.55                   | 4.47                   | 4.92        | 0.22       | 0.23       | 0.03       | 0.04       |
| **60% K₂SO₄ +40% K-feldspar+biofertilizer (S3)** | Control (C) | 0.49                  | 0.46                   | 2.53                   | 2.72        | 0.146      | 0.14       | 0.02       | 0.02       |
|                                 | Potassium citrate (PC) | 0.51   | 0.49                   | 4.82                   | 4.93        | 0.232      | 0.23       | 0.03       | 0.03       |
|                                 | Potassium silicate (PS) | 0.51   | 0.49                   | 3.91                   | 3.92        | 0.19       | 0.18       | 0.03       | 0.03       |
|                                 | Monopotassium phosphate (MP) | 0.53   | 0.520                  | 4.02                   | 4.61        | 0.19       | 0.22       | 0.03       | 0.03       |
| **40% K₂SO₄ +60% K-feldspar+biofertilizer (S4)** | Control (C) | 0.46                  | 0.45                   | 2.42                   | 2.74        | 0.14       | 0.14       | 0.02       | 0.02       |
|                                 | Potassium citrate (PC) | 0.49   | 0.46                   | 4.12                   | 4.60        | 0.19       | 0.211      | 0.03       | 0.03       |
|                                 | Potassium silicate (PS) | 0.48   | 0.45                   | 3.64                   | 4.12        | 0.18       | 0.19       | 0.03       | 0.03       |
|                                 | Monopotassium phosphate (MP) | 0.51   | 0.49                   | 3.82                   | 4.18        | 0.18       | 0.19       | 0.03       | 0.03       |
| LSD at 0.05                     | 0.02             | 0.03                   | 1.24                   | 1.48        | 0.02       | 0.03       | 0.001      | 0.001      |

Comparison of means for each growing period was performed with the least significant difference (LSD) test at p = 0.05.

3.2. The Effect of Potassium Application on the Chemical Composition of Leaves

The results in Table 4 present the effect of potassium application on the chemical composition of leaves. Covering plant potassium requirements via soil addition of mineral fertilizers (S1 treatment) or the combination of mineral fertilizers (80%) + K-feldspar (20%) and biofertilizers (S2 treatment) resulted in the highest content of macronutrients and total carbohydrates in the leaves of potato plants, regardless of the growing season. The only exception was observed in the case of nitrogen content in the 1st growing season, where the S1 treatment increased nitrogen content significantly compared to the rest of the fertilization treatments. A varied effect was recorded regarding the foliar application of potassium, depending on the potassium source and the growing season. Monopotassium phosphate (MP) was among the best-performing treatments for most of the tested parameters, especially in the case of potassium and total carbohydrate content. The combinatory effect of soil and foliar application of potassium also showed a varied response; although in most cases the application of S1 and S2 treatments combined with potassium citrate (PC) and monopotassium phosphate (MP) were the best-performing treatments. In particular, the highest phosphorus, potassium, and total carbohydrate content was recorded for the S1 × MP treatment, whereas the application of S1 × PC treatment resulted in the highest nitrogen content. According to the literature, the combination of soil and foliar application of potassium ensures its improved availability throughout the vegetative growth, especially at 30–45 days after emergence, when the highest potassium content was recorded in plant tissues [37]. Similarly, El-Sayed et al. [38] reported that partial substitution for mineral
fertilizers with compost and biofertilizers may affect macronutrient content in potato leaves at 75 days after planting. The findings of our study indicate that covering most of the plant potassium requirements with inorganic mineral fertilizers (e.g., S1 and S2 treatments) as well as via the foliar spraying of monopotassium phosphate and potassium citrate may increase K uptake by plants due to better availability and consequently improve biosynthetic processes and carbohydrate assimilation.

Table 4. The effect of potassium fertilization with soil addition (S) or foliar spraying (F) on the chemical composition of potato leaves during the 2018 and 2019 growing seasons (results are expressed on a dry weight basis).

| Potassium Fertilizer Treatments | Nitrogen (%) | Phosphorus (%) | Potassium (%) | Total Carbohydrates (%) |
|--------------------------------|--------------|----------------|---------------|-------------------------|
|                                 | 1st Season   | 2nd Season     | 1st Season    | 2nd Season             | 1st Season | 2nd Season | 1st Season | 2nd Season |
| 100% K2SO4 (S1)                | 1.57         | 1.71           | 0.14          | 0.14                   | 1.72       | 1.62       | 17.2       | 16.2       |
| 80% K2SO4+20% K-feldspar+biofertilizer (S2) | 1.45         | 1.61           | 0.14          | 0.13                   | 1.64       | 1.55       | 16.2       | 15.1       |
| 60% K2SO4+40% K-feldspar+ biofertilizer (S3) | 1.38         | 1.41           | 0.13          | 0.12                   | 1.51       | 1.40       | 14.8       | 13.9       |
| 40% K2SO4+60% K-feldspar+ biofertilizer (S4) | 1.28         | 1.38           | 0.12          | 0.12                   | 1.46       | 1.36       | 14.3       | 13.1       |
| LSD at 0.05                     | 0.11         | 0.13           | 0.01          | 0.01                   | 0.12       | 0.14       | 1.32       | 1.10       |
| Control (C)                     | 1.25         | 1.33           | 0.12          | 0.12                   | 1.46       | 1.32       | 13.97      | 13.5       |
| Potassium citrate (PC)          | 1.58         | 1.74           | 0.13          | 0.13                   | 1.60       | 1.52       | 15.7       | 14.7       |
| Potassium silicate (PS)         | 1.37         | 1.44           | 0.13          | 0.13                   | 1.49       | 1.48       | 15.2       | 14.1       |
| LSD at 0.05                     | 0.11         | 0.13           | 0.01          | 0.01                   | 0.12       | 0.14       | 1.32       | 1.10       |
| Control (C)                     | 1.34         | 1.51           | 0.14          | 0.13                   | 1.56       | 1.41       | 15.8       | 14.3       |
| Potassium citrate (PC)          | 1.82         | 1.94           | 0.15          | 0.14                   | 1.73       | 1.67       | 17.3       | 16.8       |
| Potassium silicate (PS)         | 1.53         | 1.62           | 0.14          | 0.13                   | 1.62       | 1.58       | 16.1       | 15.3       |
| LSD at 0.05                     | 0.11         | 0.13           | 0.01          | 0.01                   | 0.12       | 0.14       | 1.32       | 1.10       |
| Control (C)                     | 1.62         | 1.75           | 0.15          | 0.15                   | 1.97       | 1.85       | 19.7       | 18.4       |
| Potassium citrate (PC)          | 1.64         | 1.81           | 0.14          | 0.13                   | 1.68       | 1.60       | 16.1       | 15.0       |
| Potassium silicate (PS)         | 1.41         | 1.47           | 0.13          | 0.13                   | 1.57       | 1.59       | 16.3       | 14.8       |
| LSD at 0.05                     | 0.11         | 0.13           | 0.01          | 0.01                   | 0.12       | 0.14       | 1.32       | 1.10       |
| Control (C)                     | 1.49         | 1.76           | 0.14          | 0.14                   | 1.82       | 1.71       | 18.2       | 16.9       |
| Potassium citrate (PC)          | 1.51         | 1.64           | 0.13          | 0.13                   | 1.52       | 1.42       | 15.2       | 13.9       |
| Potassium silicate (PS)         | 1.30         | 1.32           | 0.13          | 0.12                   | 1.38       | 1.42       | 14.2       | 13.1       |
| LSD at 0.05                     | 0.22         | 0.26           | 0.02          | 0.02                   | 0.24       | 0.28       | 2.64       | 2.20       |

Comparison of means for each growing period was performed with the least significant difference (LSD) test at $p = 0.05$.

3.3. The Effect of Potassium Application on Yield Parameters

Soil addition of potassium through mineral fertilizers (S1 treatment) or the combination of mineral fertilizers (80%) + K-feldspar (20%) and biofertilizers (S2 treatment) had positive effects on the tested yield parameters, namely, the number of tubers per plant, the average tuber weight, and the total yield per ha for both growing seasons (Table 5). On the other hand, among all sources of foliar applied K, monopotassium phosphate (MP) had the highest positive effects, regardless of the growing season, although no significant
differences were observed from the potassium citrate (PC) treatment in the case of the number of tubers per plant and the average tuber weight in the 1st growing season. Moreover, the combined effect of soil application of S1 and S2 treatments with the foliar spraying of MP resulted in the highest yield parameters, while no significant difference was observed from PC treatment in the case of the number of tubers per plant (2nd growing season) and the average tuber weight (both seasons). The observed trends for the yield parameters are in accordance with the effect of the applied treatments on plant growth parameters, thus indicating that the improvement in plant growth was associated in this particular study with yield increasing through the formation of more and larger tubers. Several reports in the literature highlighted the importance of potassium fertilization in order to obtain high tuber yields. Scherer et al. [39] conducted a long-term experiment studying the effect of potassium availability on various crops and suggested that potassium deprivation may result in a detrimental decline in potato tuber yield. Moreover, Davenport and Bentley [40] and Kumar et al. [35] highlighted the importance of application time and fertilizer form of potassium for obtaining high tuber yields, especially in the case of in-season K applications. The beneficial effects of potassium fertilization on potato yield parameters are associated with numerous physiological processes such as osmotic regulation, ionic balance, and stomatal and enzymatic activity that directly affect plant growth and consequently tuber formation and yield [3]. In addition, the combined application of mineral fertilizers with biofertilizers containing Azotobacter and potassium-solubilizing bacteria may also increase plant growth and tuber yield [29,41].

In contrast, Dkhil et al. [42] reported that increasing potassium sulfate rates improved plant growth parameters without significantly affecting yield (number of tubers per plant and tuber yield). However, this contradiction should be attributed to the growing conditions, because in that study plants were grown under semi-arid conditions that could affect tuber formation and eventually total yield. Moreover, Abd El-Gawad [30] suggested that the foliar application of potassium silicate may alleviate drought stress effects, which highlights the assessment that better availability of potassium through foliar spraying may ensure high yields even under arid or semi-arid conditions. The fact that in our study the high rates of mineral fertilizer (S1 and S2 treatments) resulted in the highest tuber yield could be explained by the fulfillment of crop K requirements through the soil-added rates (229 kg K₂O ha⁻¹), which exceeded the model-based suggested rates (100 kg K₂O ha⁻¹ [4]). However, the additional application of MP and PC through foliar spraying resulted in significantly higher yield than the rest of the treatments, indicating that the improved potassium availability during the growing period is critical for achieving high tuber yields.

Table 5. The effect of potassium fertilization with soil addition (S) or foliar spraying (F) on the yield parameters of potato tubers during the 2018 and 2019 growing seasons.

| Potassium Fertilizer Treatments | Foliar Spraying (F) | Number of T tubers/Plant | Average Tuber Weight (kg) | Total Tuber Yield kg ha⁻¹ |
|---------------------------------|--------------------|--------------------------|---------------------------|--------------------------|
|                                 | 1st Season         | 2nd Season               | 1st Season                | 2nd Season               |
| 100% K₂SO₄ (S1)                 | 10.9               | 9.64                     | 0.07                      | 0.07                     | 33750                      | 29370                      |
| 80% K₂SO₄+20% K-feldspar+biofertilizer (S2) | 10.6               | 9.57                     | 0.07                      | 0.07                     | 32,690                      | 29,280                      |
| 60% K₂SO₄+40% K-feldspar+ biofertilizer (S3) | 9.26               | 8.49                     | 0.07                      | 0.07                     | 26,520                      | 23,043                      |
| 40% K₂SO₄+60% K-feldspar+ biofertilizer (S4) | 8.94               | 8.25                     | 0.06                      | 0.06                     | 23,130                      | 21,640                      |
| Control (C)                     | 9.04               | 8.32                     | 0.07                      | 0.07                     | 25,910                      | 22,770                      |
| PST at 0.05                     | 0.64               | 0.43                     | 0.001                     | 0.001                    | 1230                        | 1170                        |
| Potassium citrate (PC)          | 10.0               | 8.96                     | 0.07                      | 0.07                     | 29,820                      | 25,750                      |
| Potassium silicate (PS)         | 9.35               | 8.79                     | 0.07                      | 0.07                     | 26,760                      | 24,940                      |
| Monopotassium phosphate (MP)    | 10.6               | 9.88                     | 0.07                      | 0.07                     | 32,520                      | 29,800                      |
| PST at 0.05                     | 0.64               | 0.43                     | 0.001                     | 0.001                    | 1230                        | 1170                        |
### Table 5. Cont.

| Potassium Fertilizer Treatments | Number of Tubers/Plant | Average Tuber Weight (kg) | Total Tuber Yield kg ha⁻¹ |
|---------------------------------|------------------------|--------------------------|--------------------------|
|                                 | 1st Season  | 2nd Season  | 1st Season  | 2nd Season  | 1st Season  | 2nd Season  |
| **Soil Addition (S)**           |            |            |            |            |            |            |
| 100% K₂SO₄ (S1)                 |            |            |            |            |            |            |
| Control (C)                     | 9.68       | 9.09       | 0.07       | 0.07       | 29,080     | 26,320     |
| Potassium citrate (PC)          | 10.8       | 9.82       | 0.07       | 0.07       | 33,900     | 30,190     |
| Potassium silicate (PS)         | 10.2       | 9.03       | 0.07       | 0.07       | 31,250     | 26,930     |
| Monopotassium phosphate (MP)    | 12.2       | 10.6       | 0.08       | 0.08       | 40,070     | 34,040     |
| **80% K₂SO₄+20% K-feldspar+biofertilizer (S2)** |            |            |            |            |            |            |
| Control (C)                     | 9.61       | 8.91       | 0.07       | 0.07       | 29,310     | 26,090     |
| Potassium citrate (PC)          | 10.4       | 9.84       | 0.08       | 0.07       | 32,940     | 30,010     |
| Potassium silicate (PS)         | 10.1       | 9.12       | 0.07       | 0.07       | 30,020     | 27,510     |
| Monopotassium phosphate (MP)    | 11.8       | 10.4       | 0.08       | 0.08       | 38,510     | 33,520     |
| **60% K₂SO₄+40% K-feldspar+biofertilizer (S3)** |            |            |            |            |            |            |
| Control (C)                     | 8.54       | 7.71       | 0.07       | 0.06       | 24,410     | 20,230     |
| Potassium citrate (PC)          | 9.62       | 8.14       | 0.07       | 0.07       | 28,450     | 22,310     |
| Potassium silicate (PS)         | 8.91       | 8.80       | 0.07       | 0.07       | 25,280     | 23,860     |
| Monopotassium phosphate (MP)    | 9.36       | 9.31       | 0.07       | 0.07       | 27,960     | 27,340     |
| **40% K₂SO₄+60% K-feldspar+biofertilizer (S4)** |            |            |            |            |            |            |
| Control (C)                     | 8.32       | 7.58       | 0.06       | 0.06       | 21,280     | 18,980     |
| Potassium citrate (PC)          | 9.51       | 8.04       | 0.06       | 0.06       | 25,280     | 21,170     |
| Potassium silicate (PS)         | 8.21       | 8.24       | 0.06       | 0.06       | 21,700     | 21,620     |
| Monopotassium phosphate (MP)    | 9.14       | 9.16       | 0.06       | 0.06       | 24,820     | 24,800     |
| **LSD at 0.05**                 | 1.28       | 0.86       | 0.004      | 0.004      | 2460       | 2340       |

Comparison of means for each growing period was performed with the least significant difference (LSD) test at $p = 0.05$.

### 3.4. The Effect of Potassium Application on Tuber Chemical Composition

The results regarding the effect of potassium application regimes on the chemical composition of tubers are presented in Table 6. A consistently positive impact of S1 and S2 treatments on quality parameters was observed for both growing seasons, while the foliar application of MP treatment (and in some cases the application of PC treatment) also had a beneficial effect on all the tested parameters. The combination of soil and foliar application of potassium showed a varied effect depending on the tested parameter and the growing season. In particular, the fulfillment of plant potassium requirements with 80% mineral fertilizers (S2 treatment) combined with monopotassium sulfate resulted in the highest overall content of nitrogen, phosphorus, protein, and amino acids in both growing seasons, without being significantly different from other combinations (e.g., S1 and S2 × PC and PS treatments, as well as the S1 × C in the case of total protein content). On the other hand, the highest potassium and total starch content was observed in the case of S1 × PC treatments, whereas no significant differences were recorded in total sugar content for any of the tested treatments. The findings of this study indicate that it is possible to improve tuber quality through simple and cost-effective cultivation practices such as targeted potassium fertilization. The correlation analysis for the qualitative parameters showed a significant positive response for most of the tested variables in both growing seasons, except for the case of total sugar content, which was not significantly correlated with P or K content in the first and second growing seasons, respectively (see Supplementary Materials Tables S1 and S2). According to the literature, potassium application rates are effective in regulating potato tuber quality, especially when considering the high requirements of the crop for this specific macronutrient [4,43]. Similarly to our study, Labib et al. [9] reported that covering crop potassium requirements with 50% K-feldspar and 50% potassium sulfate
resulted in the best performance in terms of vegetative growth and yield and specific
quality parameters (starch, sugars, and protein content), followed by the application of
100% potassium sulfate. However, the fact that the substitution of 50% potassium sulfate
with K-feldspar gave the best results in the study by Labib et al. [9] could be attributed
to the lower availability of potassium in the soil, compared to our study. Regarding the
effects on tuber quality, potassium availability is associated with the activation of starch
synthesis [3], a finding which is in agreement with our results, where the treatment that
gave the best results for potassium content (S2 \times PC) was also the best treatment for
starch content. Nitrogen content was also affected by the fertilization regime, especially
the combination of S1 \times MP treatments, which resulted in the highest content of this
macronutrient, while similar trends were observed for total protein and total amino acid
content. Increasing the availability of potassium in soil through increased application rates
may have beneficial effects on protein content because potassium enhances nitrogen uptake
from soil and up-regulates the synthesis of proteins and amino acids [3,8,44]. Therefore, it
can be suggested that regulation of the potassium fertilization regime may improve specific
quality parameters of potato tuber and can be a cost-effective cultivation practice aimed at
increasing the added value of this important vegetable crop.
Table 6. The effect of potassium fertilization with soil addition (S) or foliar spraying (F) on tuber chemical composition during the 2018 and 2019 growing seasons (results are expressed on a dry weight basis).

| Potassium Fertilizer Treatments | Nitrogen % | Phosphorus % | Potassium % | Total Starch % | Total Protein % | Total Sugars % | Total Amino Acids % |
|---------------------------------|------------|--------------|-------------|----------------|-----------------|---------------|-------------------|
| Soil Addition (S) | Foliar Spraying (F) | 1st Season | 2nd Season | 1st Season | 2nd Season | 1st Season | 2nd Season | 1st Season | 2nd Season | 1st Season | 2nd Season |
| 100% K₂SO₄ (S₁) | Control (C) | 2.83 | 2.72 | 0.312 | 0.309 | 2.70 | 2.77 | 13.8 | 14.3 | 17.69 | 17.0 | 0.85 | 0.83 | 0.78 | 0.71 |
| 80% K₂SO₄+20% K-feldspar+biofertilizer (S₂) | Potassium citrate (PC) | 2.73 | 2.65 | 0.299 | 0.308 | 2.69 | 2.81 | 14.0 | 14.4 | 17.1 | 16.6 | 0.85 | 0.82 | 0.77 | 0.67 |
| 60% K₂SO₄+40% K-feldspar+biofertilizer (S₃) | Potassium silicate (PS) | 2.49 | 2.45 | 0.281 | 0.268 | 2.44 | 2.98 | 12.7 | 12.8 | 15.6 | 15.3 | 0.82 | 0.79 | 0.56 | 0.45 |
| 40% K₂SO₄+60% K-feldspar+biofertilizer (S₄) | Monopotassium phosphate (MP) | 2.38 | 2.23 | 0.259 | 0.251 | 2.22 | 2.21 | 11.9 | 12.2 | 14.9 | 13.9 | 0.82 | 0.78 | 0.40 | 0.38 |
| LSD at 0.05 | | 0.13 | 0.12 | 0.014 | 0.019 | 0.12 | 0.08 | 0.72 | 0.81 | 0.92 | 0.76 | N.S | N.S | 0.12 | 0.13 |
| Control (C) | Potassium citrate (PC) | 2.46 | 2.41 | 0.288 | 0.258 | 2.40 | 2.48 | 12.43 | 12.6 | 15.4 | 15.1 | 0.82 | 0.76 | 0.54 | 0.42 |
| Potassium silicate (PS) | Potassium citrate (PC) | 2.66 | 2.49 | 0.294 | 0.283 | 2.64 | 2.68 | 14.0 | 14.1 | 16.6 | 15.6 | 0.85 | 0.81 | 0.67 | 0.61 |
| Monopotassium phosphate (MP) | Potassium silicate (PS) | 2.59 | 2.49 | 0.272 | 0.279 | 2.47 | 2.52 | 12.8 | 13.1 | 16.2 | 15.6 | 0.85 | 0.83 | 0.57 | 0.52 |
| LSD at 0.05 | | 0.13 | 0.12 | 0.014 | 0.019 | 0.12 | 0.08 | 0.72 | 0.81 | 0.92 | 0.76 | N.S | N.S | 0.12 | 0.13 |
| 100% K₂SO₄ (S₁) | Control (C) | 2.76 | 2.62 | 0.291 | 0.282 | 2.54 | 2.62 | 12.8 | 13.2 | 17.2 | 16.4 | 0.83 | 0.76 | 0.62 | 0.58 |
| Potassium citrate (PC) | Potassium citrate (PC) | 2.81 | 2.72 | 0.312 | 0.312 | 2.83 | 2.91 | 14.9 | 15.3 | 17.6 | 17.0 | 0.86 | 0.84 | 0.83 | 0.77 |
| Potassium silicate (PS) | Potassium silicate (PS) | 2.79 | 2.68 | 0.298 | 0.306 | 2.66 | 2.71 | 13.5 | 13.9 | 17.4 | 16.7 | 0.89 | 0.89 | 0.76 | 0.68 |
| Monopotassium phosphate (MP) | Monopotassium phosphate (MP) | 2.96 | 2.84 | 0.346 | 0.338 | 2.79 | 2.84 | 14.2 | 14.7 | 18.5 | 17.7 | 0.84 | 0.82 | 0.94 | 0.85 |
| 80% K₂SO₄+20% K-feldspar+biofertilizer (S₂) | Control (C) | 2.64 | 2.56 | 0.283 | 0.276 | 2.51 | 2.68 | 13.1 | 13.1 | 16.5 | 16.0 | 0.84 | 0.81 | 0.64 | 0.51 |
| Potassium citrate (PC) | Potassium citrate (PC) | 2.74 | 2.63 | 0.306 | 0.316 | 2.86 | 2.97 | 15.2 | 15.4 | 17.1 | 16.4 | 0.87 | 0.81 | 0.81 | 0.76 |
| Potassium silicate (PS) | Potassium silicate (PS) | 2.70 | 2.61 | 0.268 | 0.311 | 2.71 | 2.76 | 13.6 | 14.2 | 16.9 | 16.3 | 0.86 | 0.83 | 0.72 | 0.62 |
| Monopotassium phosphate (MP) | Monopotassium phosphate (MP) | 2.84 | 2.81 | 0.341 | 0.332 | 2.71 | 2.86 | 14.3 | 14.9 | 17.7 | 17.6 | 0.85 | 0.83 | 0.91 | 0.81 |
| Potassium Fertilizer Treatments | Nitrogen % | Phosphorus % | Potassium % | Total Starch % | Total Protein % | Total Sugars % | Total Amino Acids % |
|---------------------------------|------------|--------------|-------------|----------------|----------------|---------------|-------------------|
|                                 | 1st Season | 2nd Season   | 1st Season  | 2nd Season     | 1st Season     | 2nd Season    | 1st Season        | 2nd Season        | 1st Season | 2nd Season | 1st Season | 2nd Season |
| Soil Addition (S)               |            |              |            |                |                |               |                   |                   |            |            |            |            |
| 60% K$_2$SO$_4$+40% K-feldspar+ biofertilizer (S3) | Control (C) | 2.32 | 2.32 | 0.246 | 0.236 | 2.42 | 2.46 | 12.2 | 12.4 | 14.5 | 14.5 | 0.81 | 0.73 | 0.59 | 0.32 |
|                                | Potassium citrate (PC) | 2.52 | 2.41 | 0.294 | 0.261 | 2.52 | 2.58 | 13.8 | 13.2 | 15.7 | 15.1 | 0.84 | 0.83 | 0.58 | 0.50 |
|                                | Potassium silicate (PS) | 2.51 | 2.46 | 0.271 | 0.262 | 2.32 | 2.40 | 12.3 | 12.5 | 15.7 | 15.4 | 0.82 | 0.81 | 0.45 | 0.43 |
|                                | Monopotassium phosphate (MP) | 2.61 | 2.60 | 0.312 | 0.314 | 2.51 | 2.48 | 12.6 | 13.0 | 14.7 | 16.2 | 0.81 | 0.80 | 0.62 | 0.58 |
| 40% K$_2$SO$_4$+60% K-feldspar+ biofertilizer (S4) | Control (C) | 2.11 | 2.14 | 0.251 | 0.238 | 2.13 | 2.17 | 11.6 | 11.8 | 13.2 | 13.4 | 0.80 | 0.76 | 0.32 | 0.30 |
|                                | Potassium citrate (PC) | 2.56 | 2.20 | 0.262 | 0.243 | 2.35 | 2.26 | 12.1 | 12.4 | 16.0 | 13.7 | 0.82 | 0.78 | 0.46 | 0.42 |
|                                | Potassium silicate (PS) | 2.36 | 2.24 | 0.254 | 0.239 | 2.17 | 2.20 | 11.8 | 11.9 | 14.7 | 14.0 | 0.82 | 0.82 | 0.37 | 0.38 |
|                                | Monopotassium phosphate (MP) | 2.48 | 2.32 | 0.272 | 0.285 | 2.25 | 2.23 | 11.9 | 12.7 | 15.5 | 14.5 | 0.82 | 0.79 | 0.48 | 0.43 |
| LSD at 0.05                     | 0.13       | 0.24       | 0.030     | 0.040     | 0.24       | 0.16       | 1.44     | 1.62     | 1.84     | 1.52     | N.S   | N.S   | 0.24   | 0.26   |

Comparison of means for each growing period was performed with the least significant difference (LSD) test at $p = 0.05$. 

Table 6. Cont.
4. Conclusions

In conclusion, the findings of our study highlight the importance of potassium application in potato crops because the application regime (soil and/or foliar spraying) as well as the potassium form (potassium citrate, potassium silicate, and monopotassium phosphate) had a significant impact not only on plant growth and yield but, most importantly, also on the quality of the final product. Considering the low extractable K values in the studied soil, the fulfillment of potassium plant requirements via direct soil addition of mineral fertilizers (S1 and S2 treatments) combined with foliar spraying of monopotassium phosphate and potassium silicate were proved to be the most beneficial treatments for the tested vegetative, yield, and quality parameters. However, considering that the applied fertilization regime in the present study was based on the hypothesis that all the soil-added treatments received the same rates of potassium according to agricultural recommendations, further research is needed in order to identify possible variable effects of potassium form and application regime on plants where soil application of mineral potassium partially covers potato crop needs and the rest of the needed rates are supplied with in-season application in spraying forms or other forms of soil-added potassium and biofertilizers. Finally, it can be assumed that fertilizing potato plants with the combined treatment of soil-added potassium in mineral form (100% or 80% K$_2$SO$_4$ + 20% feldspar + biofertilizers) and foliar spraying with monopotassium phosphate or potassium citrate could play an important role in improving the growth, yield, quality, and chemical composition of potato plants. However, the effect of earlier application of potassium with higher amounts of K-feldspar should be considered in future studies, as well the application of K-feldspar in comparison with treatments at lower than the recommended rates, including a control treatment with no potassium added.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/agronomy11040675/s1, ANOVA tables; Table S1: Pearson’s correlation coefficient values between the qualitative parameters in year 2018. The asterisk (*) indicates significant correlation between the corresponding variables; Table S2: Pearson’s correlation coefficient values between the qualitative parameters in year 2019. The asterisk (*) indicates significant correlation between the corresponding variables.

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