# THE EFFECT OF FOLIAR MICROELEMENTS FERTILIZERS ON THE NUTRITIONAL VALUE AND YIELD OF POTATO TUBERS (*SOLANUM TUBEROSUM* L.)

Ali Hulail Noaema, Barbara Sawicka
*University of Life Sciences in Lublin, Department of Plant Production Technology and Commodity Sciences, Poland;*
*E-mail:* ali.algayashe@gmail.com

**Abstract:** The analysis was based on a strict field experiment carried out in 2015-2016 in the conditions of central-eastern Poland (The Experimental Station, Uhnin in Province Lublin) (51°34 ', 23°02'E), on the fawn soil, slightly acidic. The experiment was performed in randomized blocks, in triplicate. In the study was evaluated the effect of foliar micronutrient fertilizer on yield and some characteristics of quality of potato variety Satina. Were tested four fertilization variants: three technologies foliar fertilization and control object, without foliar fertilization. Technologies foliar fertilization had had a significant effect on the dry matter content and vitamin C in potato tubers. Only foliar fertilization formulations using: Potato Micro Forte (2 $dm \cdot ha^{-1}$) + Suplofol Mono Zn ( $dm \cdot ha^{-1}$) + magnesium sulphate (5 $kg \cdot ha^{-1}$) per 400 dm water on 1 hectare significantly decreased content dry matter in potato tubers. In the case of vitamin C, all technologies foliar fertilization significantly decreased vitamin C content in tubers of this species. The total yield of tubers, the commercial yield of tubers and the content and yield of starch does not depend significantly on the technology of foliar fertilization. Meteorological conditions in the years of the study had a decisive influence on the so-tuber yield and productivity of dry matter and starch and dry matter content, starch and vitamin C in fresh mass of potato tubers.
**Key words**: potatoes; foliar fertilizers; nutritional value; dry mass, vitamin C, starch, yield of tubers

## 1. INTRODUCTION

One of the most popular food crops in the world after rice, wheat, it is the Potato, *Solanum tuberosum* L., and it seemed to be the most consumption of vegetables in Europe and in many other countries [1]. Additionally, the potato is represented as healthy, edible and pro-health plan. Potato tuber could be a basic element of the everyday diet in several countries. Consumption in the United States of potatoes averages 63 kg per capita. Between 34 vegetables and fruits commonly consumed, the potato is the third largest source of antioxidants, while In Most countries of Europe potato consumption ranges from 34 to 96 kg per capita, and per capita annually in Poland is 80 kg [2]. The potato tubers content of about 20% of solid substances and 80% water, but these values vary by several percentage points depending on the cultivar [3]. Potato tubers as well contain 13-37% dry matter and 0.7-4.6% proteins. Furthermore, vitamin C and different vitamins, minerals and phenolic substances are available [4]. Micronutrients are the fundamental supplements for the product to better yield. There is a critical relationship between the last tuber yield and the aggregate nitrogen focuses in the clears out [5]. Enhance the better yield production and induce resistance to various diseases and insect pests including nematodes by foliar applications of nutritional fertilization [6, 7]. Demonstrated that Fertilizer application has important effects on the quality and yield of potato [8]. Foliar fertilization potential plays an important role in the production of potatoes [9]. More studies that are recent have confirmed that N applications can increase total yield and marketable tuber yield [10, 11]. It is proposed that the delays in the application of N foliar spraying can take advantage of potatoes to an agricultural season long and reduce environmental losses of N. The foliar application of phosphorus led to a rise in the yield. The application of potassium increases the size of tubers [12]. The foliar application of potassium was increased potato tuber yield. The study to determine the effects of foliar fertilizers used in the form of spraying on the productivity and value of the tubers potatoes. In the research hypothesis, it was assumed that macro- and microelements contained in foliar fertilizers will affect the intensity of process of photosynthesis and transpiration in the field conditions, which in consequence may affect the yield and quality of potato tubers.

## 2. MATERIAL AND METHODS

The field experiment was conducted in the years 2014-2015 in ZDOO Uhnin (province Lublin). They conducted those using randomized blocks, in a subsidiary, split-plot, with 3 replications. The experimental design included four levels of foliar fertilization. I. Fertilization with the first spraying against potato late blight (Micro Forte potatoes - 1 dm. $ha^{-1}$; Suplofol Mono Mn - 1 dm· $ha^{-1}$; Suplofol Mono B - 1 dm· $ha^{-1}$; Magnesium sulphate - 5 kg· $ha^{-1}$; II. Additional fertilization of another fight blight, no later than prior to flowering: Potato Micro Forte - 2 dm· $ha^{-1}$, Suplofol Mono Mn - 1 dm· $ha^{-1}$, Magnesium sulphate - 5 kg · $ha^{-1}$; III. Fertilization after the end of flowering: Suplofol Makro K200 - 5 dm· $ha^{-1}$; Magnesium sulphate - 5 kg .$ha^{-1}$; Urea - 5 kg·$ha^{-1}$.

In the experiment, they applied to the soil solid NPK fertilization in the amount of (80 kg N, 34.9 kg P and 99.6 kg K·$ha^{-1}$) tillage was carried out in accordance with good agricultural practice. Chemical plant protection in the fight: weeds, Colorado potato beetle, and late blight, as well as the dose, timing of application and the choice of products, were in line with the recommendations of the IOR-PIB. Potato harvest was conducted in physiological maturity. Were determined total yield and Marketable yield. At the time of harvest, tuber yield was determined; its structure and tuber samples were taken to determine the quality. The contents of the individual elements of the chemical composition of potato tubers were determined by the following methods: dry matter - drying method, the starch content by polarimetrically, vitamin C - according to Tillmans. The test results were calculated statistically by analysis of variance and descriptive statistics. The Data collected were subjected to analysis of variance (ANOVA) using the GLM procedure of SAS [13]. Mean separation was performed using the Tukey's Studentized range (HSD) procedure at a 5% probability level.

Meteorological conditions in the years of studies were varied. The year 2015 can be described as optimal in terms of water requirements of potato and 2016 - as dry, in the period June - August (table 1).

Table 1. Classification of the vegetation period of potato by hydrothermal coefficient of Sielininov

| Year | Month | Rainfall (mm) | Mean of air temperature (ºC) | Hydrothermal coefficients of Sielianinov |
|---|---|---|---|---|
| 2015 | April | 63,7 | 10,0 | 2,1 |
| | May | 119,0 | 13,4 | 2,9 |
| | June | 52,9 | 16,0 | 1,1 |
| | Juni | 164,2 | 19,6 | 2,7 |
| | August | 67,9 | 17,4 | 1,3 |
| | September | 31,3 | 14,9 | 0,7 |
| 2016 | April | 28,2 | 8,3 | 1,1 |
| | May | 80,5 | 14,5 | 1,8 |
| | June | 26,2 | 15,7 | 0,6 |
| | Juni | 63,1 | 20,1 | 1,0 |
| | August | 10,6 | 20,5 | 0,2 |
| | September | 108,0 | 15,3 | 2,4 |

Source: own data by Meteorological Station in Uhnin. The following ranges of values for the ratio Sielianinov: extremely dry k ≤ 0.4; very dry - 0.4 <k ≤ 0.7; dry - 0.7 <k ≤ 1.0; fairly dry - 1.0 <k ≤ 1.3; optimal - 1.3 <k ≤ 1.6; quite humid - 1.6 <k ≤ 2.0; wet - 2.0 <k ≤ 2.5; very humid - 2.5 <k ≤ 3.0; extremely humid - k> 3.0

The values of hydrothermal coefficients of Sielianinov was calculated according to the formula:

$$K = \frac{P}{0{,}1\sum t}, \text{ where:}$$

P – The sum of monthly precipitation,

Σt – monthly total air temperature.

## 3. RESULTS AND DISCUSSIONS

The results showed in the table (2) that the techniques of foliar fertilization had no significant impact on the total yield. The season of 2016 had a significant impact on the total yield of tubers; it registered (54.968 t.$ha^{-1}$) table (3). Perhaps the significant impact of the different weather conditions between the seasonal agricultural years where conditions were bad steps rainfall in 2015 while greatly improved in 2016, which led to improved production and comparison between the two agricultural seasons. These findings (there was not any effect for the techniques of foliar fertilization) are consistent with other authors have shown that yields of crops grown either with mineral or organic fertilizer can be equivalent to one another [14]. Equivalent yields were obtained regardless of the kind of fertilizer [15].

Table 2. Effect of foliar fertilization on total and commercial yield and yield of dry matter and starch [$t.ha^{-1}$] (Mean 2015-2016)

| Fertilization | Total yield of tubers | Marketable yield | Yield of dry mass | Yield of starch |
|---|---|---|---|---|
| I | 48.349a | 47.422a | 11.218a | 6.532a |
| II | 45.666a | 44.863a | 9.838b | 6.610a |
| III | 49.303a | 48.144a | 10.433a | 7.037a |
| IV | 46.822a | 45.932a | 11.086a | 6.956a |
| Mean | 47.535 | 46.59 | 10.644 | 6.784 |
| $HSD_{0.05}$ | ns* | ns | 1.08 | ns |

*ns – not significant at $p_{0.05}$

I. Fertilization with the first spraying against potato late blight (Micro Forte potatoes - 1 $dm \cdot ha^{-1}$; Suplofol Mono Mn - 1 $dm \cdot ha^{-1}$; Suplofol Mono B - 1 $dm \cdot ha^{-1}$; Magnesium sulphate - 5 $kg \cdot ha^{-1}$; II. Additional fertilization of another fight blight, no later than prior to flowering: Potato Micro Forte - 2 $dm \cdot ha^{-1}$, Suplofol Mono Mn - 1 $dm \cdot ha^{-1}$, Magnesium sulphate - 5 $kg \cdot ha^{-1}$; III. Fertilization after the end of flowering: Suplofol Makro K200 - 5- $dm \cdot ha^{-1}$; Magnesium sulphate - 5 kg .$ha^{-1}$; Urea - 5 $kg \cdot ha^{-1}$.

Data in table 2 showed that the techniques of foliar fertilization had no significant effect on marketable yield. There was the season of 2016 had a significant impact on marketable yield, which gave (54.615 $t \cdot ha^{-1}$) (table 3). Perhaps due to the great disparity in the environmental conditions of the agriculture during the 2015-2016 as well as a result of the difference in the total yield of tubers [1].

Table 3. Effect of years on total and commercial yield and yield of dry matter and starch [$t \cdot ha^{-1}$] (Mean 2015-2016)

| Years | Total yield of tubers | Marketable yield | Yield of dry mass | Yield of starch |
|---|---|---|---|---|
| 2015 | 40.103b | 38.565b | 8.496b | 5.704a |
| 2016 | 54.968a | 54.615a | 12.792a | 7.864b |
| Mean | 47.535 | 46.59 | 10.644 | 6.784 |
| $HSD_{0.05}$ | 2.561 | 2.502 | 0.562 | 0.690 |

Ekspanations as in Table 2

The results of the table (2) that there had a significant impact of each of the techniques of foliar fertilization on the yield of dry mass. Also excelled fertilization technology I. with additional fertilization of another fight blight, no later than prior to flowering (Potato Micro Forte - 2 dm. $ha^{-1}$, Suplofol Mono Mn - 1 $dm \cdot ha^{-1}$, Magnesium sulphate - 5 kg. $ha^{-1}$) mathematically on techniques (III and IV) and excelled these three techniques significant impact effect on the yield of dry mass, and that the year 2016 had a significant impact too in table 3.

As Table 2 shows, foliar fertilization had no significant effect on yield of starch, in 2016, the highest starch content significantly different compared with the year 2015, during the entire experimental period; weather conditions had the greatest influence on the total yield of potato tubers and starch yield. Starch yield is the outcome of total potato yield and starch content. The highest starch yield (7.86 $t \cdot ha^{-1}$) was attained in 2016, while lowest (5.70 $t \cdot ha^{-1}$) – in 2015 (Table 3). An insignificant increase in starch yield was a note in this year, because, the growing season of 2015 did not support the development of potato tubers. Perhaps the grain size of the potato tubers, severed in 2016 had a significant impact on the content of starch. The Grain starch a diameter > 40 μm be considered desirable because the smallest granules (< 20 μm) could not be used for industrial purposes, on the other hand not fertilizer foliar applied on the size of the granules. According to Hasse [16], Hasse and Plate [17], Bogucka and Cwalina-Ambroziak [18] and Penston [19] the content of large starch grains is a varietal property. Haberland [20] reported that the fertilizer foliar did not affect the meaning of the potato starch. Jablonski [21] in the experiments with foliar fertilization was observed decreases in starch content of potatoes, and he showed the yield of starch by 0.5 $t \cdot ha^{-1}$, as a result of the application of the nutrifol, compared with observation without addressing foliar fertilizer.

The results reveal in table 4, that the techniques of foliar fertilization had a significant impact on the content of dry mass, starch and vitamin C. All variations of foliar fertilization were decreased as dry matter, starch content and vitamin C, as compared to the control object, without foliar application of fertilization. Similar results were obtained Bogucka and Cwalina-Ambroziak [18]. The authors explain the fact that the lack of impact of the effect of different doses of foliar fertilizers on the intensity of photosynthesis, but significant variation of transpiration. The results of the many studies pointed to influence positively on fertilizers foliar selection starch accumulation of potatoes. Boligłowa [22] found that starch content of potatoes and tubers increased significantly (by 0.7% to 2.5% in comparison with the control treatment because of the application of various foliar fertilizers.

Table 4. Effect of foliar fertilization on the content of dry mass, starch and vitamin C (Mean 2015-2016)

| Fertilization | Dry mass (%) | Starch (%) | Vitamin C ($mg \cdot 100\ g^{-1}$ fresh mass) |
|---|---|---|---|
| I | 22.81b | 13.40d | 16.526ab |
| II | 21.53c | 14.52b | 15.324b |
| III | 21.27c | 14.33c | 19.528ab |
| IV | 23.29a | 14.83a | 23.071a |
| Mean | 22.23 | 14.27 | 18.612 |
| $HSD_{0.05}$ | 0.318 | 0.104 | 7.046 |

*ns – not significant at $p_{0.05}$

The meteorological conditions in the years of study significantly modified both the dry matter content, the content of starch and vitamin C in fresh weight of tubers (table 5). Significantly higher dry matter content, starch and vitamin C in potato tubers were obtained in a dry 2016 than optimal in terms of rainfall, 2015. The impact of weather conditions on the chemical composition of tubers also was observed by other authors [22, 16-20, 21-3, 18-19].

Table 5. Effect of years on the content of dry mass, starch and vitamin C (Mean 2015-2016)

| Years | Dry mass (%) | Starch (%) | Vitamin C ($mg \cdot 100\ g^{-1}$ fresh mass) |
|---|---|---|---|
| 2015 | 21.19b | 14.23b | 12.536b |
| 2016 | 23.27a | 14.30a | 24.689a |
| Mean | 22.23 | 14.27 | 18.612 |
| $HSD_{0.05}$ | 0.166 | 0.054 | 3.677 |

*ns – not significant at $p_{0.05}$

In our study, the weather conditions substantially differentiate, so the content and yield of dry matter and starch. The highest content, as well as the yield of dry matter and starch obtained in a very dry July and August, while the lowest content of dry matter and starch obtained in the wet conditions. The impact of meteorological conditions on the content of dry matter and starch in potato tubers proved Boligłowa [22], Westermann [18], Pszczółkowski and Sawicka [23] Kołodziejczyk [24], Jablonski [21], Trawczynski [25], Zarzecka et al. [26] Barascu et al. [27] Rymuza et al. [28]. According to them, excessive rainfall, and their deficiency during the growing season (especially during the formation of tubers) reduce dry matter and starch content in potato tubers. According to Yusuph et al. [29] on the accumulation of dry matter and starch in potato tubers also affected by temperature, especially in the final period of the growing season. Trawczynski [25] in the case of varieties of very early and early watching the highest starch content and dry matter in a year in which periods of warm and dry lasted from June until the end of July, while Jablonski [21] in the varieties of starchy starch highest value recorded in the year with a lower total rainfall in the months of August and September. Kolodziejczyk [24] the highest content of dry matter and starch obtained in with the largest, the average air temperature from May to September. Trawczynski [25] was observed, that turn both excess and a shortage of rainfall during the June-August reduce the starch content. Boligłowa [22] the highest starch content was given in the warm and dry, while Zolnowski [30] - in which the highest amount of precipitation. Bogucka and Cwalina-Ambroziak [18] noted a higher starch content in years, where in July there was high precipitation, but August and September were dry. According to Trawczynski [25] years of research, the variation of the total starch content accounted for 40.2%, and the studies Kolodziejczyk [24] - 18.7%. In the case of dry weight was determined by the weather content of 32.4% according to Kolodziejczyk [24] of 37.9%. The structure of variance components, carried out by Sawicka [31] showed 22.5% and 39.9% of years in the phenotypic variability, starch, and dry matter. Studies of Zimnoch-Guzowska and Flis [32] have shown that vitamin C content does not affect the genotype, but environmental conditions. Warm and dry weather during the growing season favors the accumulation of vitamin C, which is confirmed by testing their own and other authors [22, 26, 24, 32]. Trawczynski [33] point out that the uneven distribution and shortage of rainfall and air temperature too high in the final period of the growing season will decrease the content of vitamin C. The dominant source of variability of this component of tubers by Sawicka et al. [31], are the environmental conditions, and their participation the phenotypic variation is 45.0%.

Similarly says Trawczynski [33], which estimates that the vitamin C content is determined by environmental conditions in 41.2%.

## 4. CONCLUSIONS

1) The application foliar fertilizers with trace elements contributed to the reduction in dry weight of starch and vitamin C in potato tubers did not affect significantly the yield of tubers and marketable yield of tubers, dry matter, and starch.

2) The growing season also appears to have significantly affected on the yield of dry mass, and content of the dry mass, vitamin C, and starch.

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