EFFECTS OF GROWING FACTORS ON THE FORMATION OF BIOACTIVE COMPOUNDS IN CELERY (*APIUM GRAVEOLENS* L. CONVAR. *RAPACEUM*)

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The polyphenolic compounds of several plant products are not known, nor are the biotic and abiotic factors that influence their evaluation. Thus we have very few data about the effects of growing factors in case of root vegetables – for example soil type, light intensity, growing method (on open field, under glass, in soil or without soil cultivation). Our experiment were aimed to prove the effects of genotypes and growing method (direction of rows) on the enrichment of polyphenol, flavonoid and vitamin C content. In the experiments it was established that varieties reacted differently on to the incidence of light originated from the direction of rows. Polyphenol, flavonoid and dry material content of *Prágai óriás* were higher at North-South row directions, which originated from the favourable light luminous influence without fail. Variety *Neon* produced better results in nutritional values of leaves at South West row directions. The opposite was found for the polyphenol, flavonoid and dry matter contents of tubers. In this direction the sunshine from South warmed up the bed in which the tubers were developing. This factor was favourable for their production. The results of our experiments showed differences between the genotypes regarding their sensitivity, that is, the intensity of light that differed in the rows of different direction influenced the formation of secondary metabolites. Results proved that celery leaves contain more bioactive compounds (total polyphenols, flavonoids, vitamin C) than tubers. The difference in polyphenol content was threefold and six fold in flavonoid content. Vitamin C content in the tubers was 30 percent of the amount that was measured in leaves at very similar dry material content. Our data document the nutritional importance of celery leaves and emphasize the selection of the growing method to the needs of varieties to produce good quality vegetables for our foods.

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Introduction

Researchers deal with evaluation of oxidative stress. Data support the fact that optimal quantity of vegetable, fruits and red vine in the diet has real effect on the human health, possibly due to the effect of polyphenols.[1] They are the most abundant antioxidants in the diet. If the total intake is as high as 1 g day^{-1}, they would be 10 times more efficient than vitamin C and 100 times more than carotenoids and vitamin E.[2,3,4] Several bioactive compounds have polyphenol structure. They are mainly products of secondary metabolites of plants which can protect against ultraviolet radiation and pathogenic attacks. Polyphenols contain several aromatic rings and hydroxyl groups. Distinctions are made between the following groups – phenolic acids, flavonoids, stilbens and lignin.[3]

Papers usually communicate mainly the total polyphenol content and very rarely the different components. Regarding the polyphenol content of apple, researchers have found values between 0.1 to 5 g per kg fresh fruits nearly in every variety. Only few varieties with higher acid content showed higher total polyphenol content (10 g kg^{-1}).[5,6]

Higher polyphenol content can be found in cabbage, celery, onion and parsley.[7,8] The highest polyphenol content [>250 mg gallic acid equivalent (GAE)/100g fresh product] was measured in artichokes, parsley and brussels sprouts, while the lowest in melon (*cv. Cantaloupe*). In the celery this content was 84.7 mg GAE in 100 g fresh product.[9]

Widely known is the fact that the synthesis of polyphenols is influenced by light intensity and the ripenness of the product.[10]

The amount and composition of total polyphenols are determined by the plant species, the variety (genotype), the soil composition, the growing conditions, ripening and the post harvest conditions.[11]

Stress conditions during the vegetation period, like temperature alterations, UV exposure and different pathogen attacks, can highly influence the synthesis of secondary assimilation products.[12]

It is very difficult to determine the reaction of plant family to environmental and growing factors. We have to pay attention to preparing the product for processing, because the deep peeling causes an increase in the loss of bioactive materials as these components are immediately under the skin of the product. Deep peeling can decrease the polyphenol content of the processed product.

Cooking has also negative effects on the polyphenol content. Researchers stated that the quercetin loss can be as high as 75-80 % in the onion and tomato, after 15 min cooking.[13]

As these compounds have great importance in prevention, the presence of polyphenols and flavonoids would be desirable beside that of vitamins, minerals and fibre content on the products. To resolve this problem we would like to present some data of our experiments about important root vegetables such as celery, because its leaf and tuber are equally important products in food the industry and in cooking too.

The enrichment of this component is influenced by the growing method, the direction of rows, since the length of sunny periods can influence the synthesis of bioactive molecules.

The data provides information on growing methods, as well as on choices of variety, and can also support the favourable dietary effects of celery leaves.

Experimental

Experiments were performed in the experiment garden of the Debrecen University. Raised beds were formed; the soil type was calcareous chernozem. In the two factorial experiments (growing method and varieties) random plot arrangement was used in four repetitions. Varieties *Prágai óriás* and *Neon* were sowed in North-South (N-S) and East–West (E-W) row directions on a plot of 2 m x 1 m size.

Beds were 15 cm high with four rows. Cultivation method – soil loosening, nutrient supply, mechanical and chemical weed control and plant protection – were selected for the varieties. Drip irrigation was used for the uniform water supply. Harvest was done on 8th October. Measurements were performed on 10-10 plants, and samples were prepared for the chemical analysis.

Total polyphenols in mg GAE/100 g fresh product were determined by Folin Ciocalteu colorimetric method, results were given in gallic acid equivalent value. Flavonoid content was determined using colorimetric method,[14] results were given in catechin equivalent value. Vitamin C content was determined by redox titration using iodine solution. Dry material content was measured by drying in oven at 105 °C.

Results and discussion

The light luminous influences of leaves were determined by the direction of rows. In our experiment in the tween-row production as a result of wide row spacing the sunlight reached the loft from side direction too. In case of N-S rows the loft could get light from west and east, too. When the raw direction was E-W, the light was less from the North, while too much from the South. In our experiment these effects on the formation of bioactive compounds in the leaves and the tubers were analysed.

The formation of bioactive compounds in leaves

By examining the reaction of species to the row direction, we can get information about the demand of genotypes to form the best quality that is to accumulate the bioactive components in great amount.

Data are shown in Figure 1. We can establish that N-S row direction was favourable for the accumulation of polyphenols and flavonoids in case of *Pallagi óriás.*

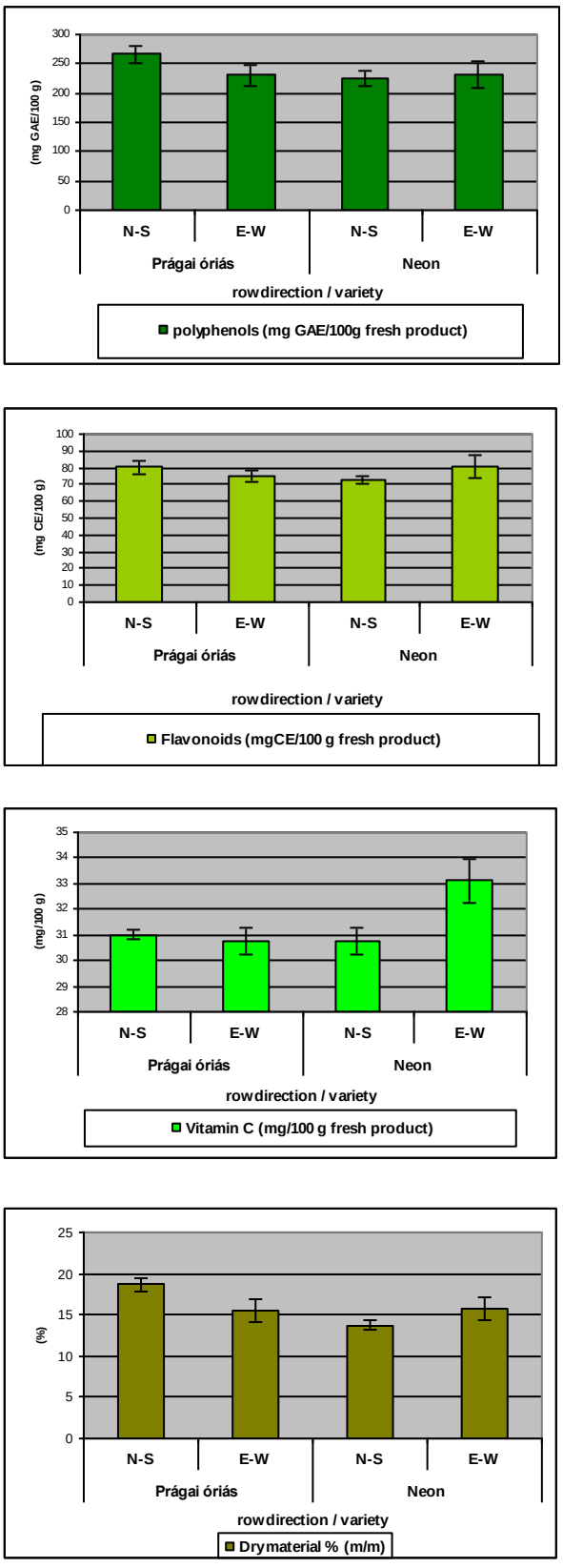
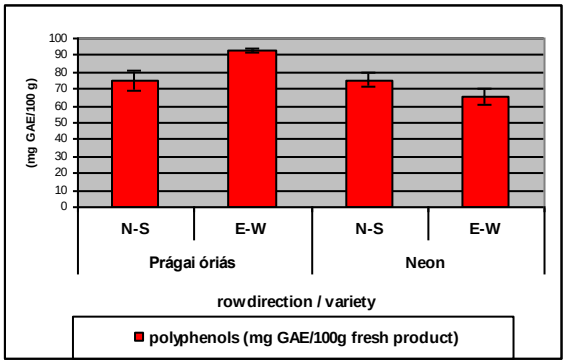
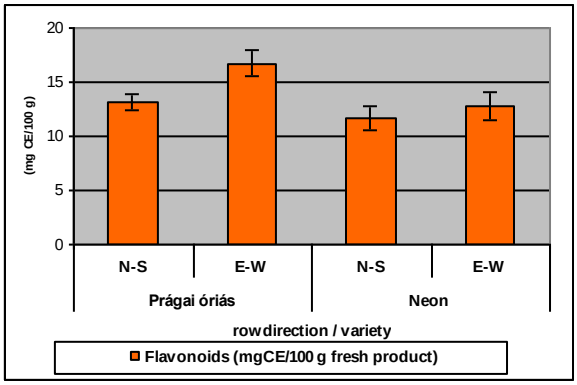
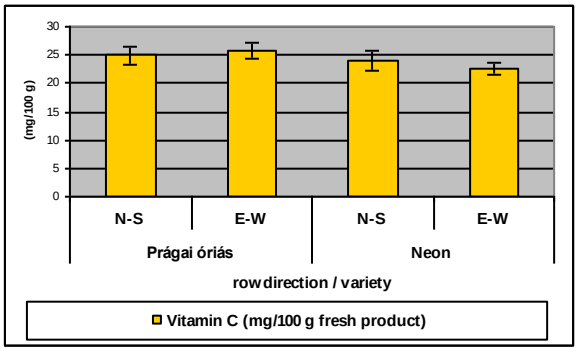


Figure 1. Bioactive compounds of celery loft with different row direction, Debrecen, 2013.

On the other hand, best results were found at E-W row direction in variety *Nero* for flavonoids, but there was no significant difference in the amount of total phenolic compounds.







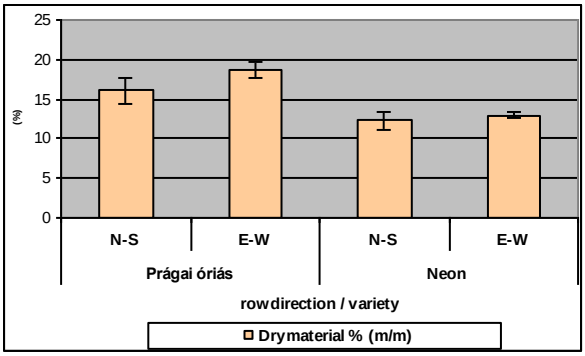


Figure 2. Bioactive compounds of celery tubers at different row directions, Debrecen, 2013.

As regards to vitamin C, very high amount was found in *Nero* at E-W row direction, but the vitamin content was similar in both varieties at N-S row direction (30 mg in 100 g). Dry material content was higher in *Pallagi óriás* at N-W direction, while E-W proved to be favourable for *Nero*.

Formation of bioactive compounds in the tubers

As opposed to the loft, the S-W row directions resulted in the formation of most bioactive compounds in case of *Pallagi óriás* (Figure 2). The opposite effect was detected in variety *Neon* in the formation of flavonoids. In N-E rows more total phenolic compounds were measured than in South-East rows. Regarding flavonoid formation there was no significant difference, nor in vitamin C content.

The same tendency was found in dry material formation, the S-W direction was favourable for *Pallagi óriás*, but there was no difference in the variety *Neon*. Comparing the leafage and tubers we can say that the green parts of the plants are more abundant in bioactive compounds (Figure 3)

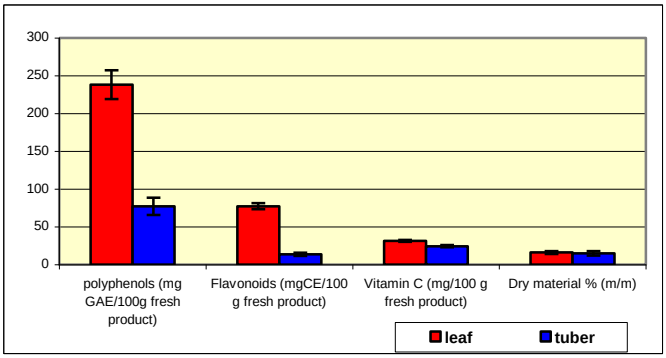


Figure 3. Comparison of nutritional values of leafage and tubers as a function of treatments and varieties, Debrecen, 2013.

Threefold difference was detected for polyphenols while the ratio was 7-8 times more for flavonoids. The leaf is more abundant in vitamin C than tubers (31.40 and 24.31 mg in 100 g), while the dry material contents were fairly similar. On the basis of data it can be established that celery leafage is very rich in bioactive compounds. This makes it important to keep in mind the state of health of celery so that it would be useable at the time of harvesting in autumn.Differences in leafage features as a function of treatment and varieties are presented in Figure 4.

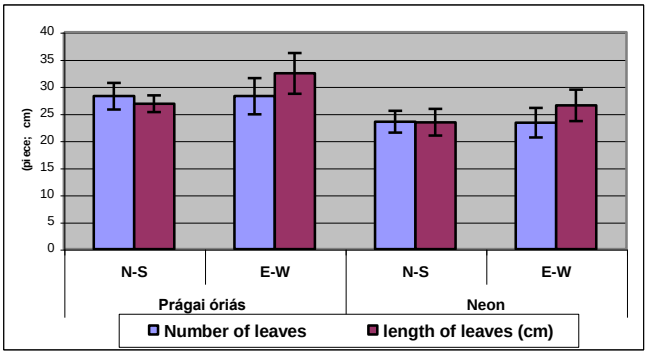


Figure 4. Leafage features at difference row directions, Debrecen, 2013.

Conclusion

It was found that variety *Prágai óriás* has more leaves and long stems than *Neon*. Leaves were longer in S-W row directions than at N-S. The differences were proved statistically.

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