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THE INFLUENCE OF FOLIAR FERTILIZATION WITH HUMIC ACIDS ON THE PRODUCTION OF WHITE CABBAGE

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ABSTRACT

The main purpose of the study was to test the effect of some fertilizers based on humic acids on autumn cabbage, Bucharest F_1 in the ecological conditions of the South-West of Romania. The foliar products applied were formulated and obtained by ICPA Bucharest. The biological material was represented by the Bucharest F_1 hybrid. The experience included three variants: V_1-untreated, V_2-foliar fertilization with Deceneu and V_3 foliar fertilization with Humifert Plus. In order to achieve the proposed objectives, biometric determinations have been carried out on the eatable organs: height and diameter of the head, the shape index and the degree of stuffi, but also the quantity and quality of the cabbage production. Application of fertilizers led to increased production at the fertilized variants, significant differences were at the variant with the Deceneu product, 132.5 kg/ha and a good accumulation of ascorbic acid, 35.78 mg/100g fresh matter, when applying Humifert Plus.

INTRODUCTION

In Romania the white cabbage (*Brassica oleracea* L., Var. *Capitata* f. *Alba* D.C. - *Brassicaceae* family) is widespread in all areas except for the high mountain regions. Very favorable regions are represented by the meadows of the rivers in the hilly area of Transylvania, Moldova, but also in the Plain area in the southern and western parts of the country (especially for extra-time crops from the solariums and early field crops).

Due to the antioxidant, anti-inflammatory and antibacterial properties, cabbage has a widespread use in traditional medicine in relieving symptoms associated with gastrointestinal disorders. Fresh cabbage prepared as a separate juice or mixed with other vegetables such as carrots and celery is often included in many weight loss diets (Samec 2011), diets that improve the bioavailable iron content as well as alternative therapies for incurable diseases (Maritess et al., 2005). Also, some studies highlight the cabbage potential to alleviate oxidative stress and inflammation (Sami Rokayya, 2013).

In order to obtain superior production and quality, a special importance is given to the root and foliar application of fertilizers. Foliar fertilization is an additional nutrition with macro and micronutrients and is applied to supplement nutrients under conditions of production limitation when there is deficiency or blockage of nutrients in the soil. Stressors (for example, the unfavorable soil properties) affecting young plants or crops during growth and development may affect the safety of the crop. Without preventive aid (fertilization) applied foliar or on the soil, the plant has no capacity for regeneration (Bonciu and Iancu, 2014).

Fertilizers containing humic substances can be combined in different proportions with nutritive elements as well as with other organic natural or synthetic substances (Parvan et al., 2013).

Humic fertilizers contain a series of essential elements in the form of humates extracted from coal mass in complex NPK-type matrices which, after their incorporation in the soil, ensure the assimilation of the nutrient ions contained and intensify the nutrition process (Cioroianu et al., 2009).

Many studies conducted both in the open field and in the laboratory have provided experimental evidence on the beneficial action of humic substances (HS) on plant growth and mineral nutrition, as well as on improving soil fertility. In recent years, research has focused on the use of humic acids as foliar fertilizers in various crops, carrots, tomatoes (Dinu et al, 2012), tomatoes, vines and sunflower (Parvan et al 2013), sugar beet, maize and sunflower (Sirbu et al., 2016).

Dinu et al., 2013 studied in tomatoes the effect of foliar fertilization with simple humic acids (HA), in combination humic acids + polyphenolic extract of *Vitis vinifera* seed (ESVv) and humic acids + polyphenolic extract of *Vitis vinifera* seed + boron (B). These treatments had positive effect on plant growth both in height and in diameter of base stem and also on the leaf growth. The ESVv application determine a retardant character of tomato plants and HA+ESVv+B determine very good vegetative growth compared with the control. The foliar application with HA+ESVv has positively influenced the fruit weight.

Ahn, T. et al., (2005) reported that fertilization with humic acid influences the total carbohydrate content and causes the growth of pepper production.

In other studies, polyphenol extracts from seeds of *Vitis vinifera* were used along with humic acids, and the germination of tomato seeds was found (Dinu et al., 2014). In this respect, the main purpose of the study was to test the effect of some organic and mineral fertilizers, based on humic acids, on the autumn cabbage crop, Bucharest F1 in the South-West Romania pedoclimatic conditions.

MATERIALS AND METHODS

The experience was established in the didactical field of the Faculty of Agriculture of University of Craiova, Romania (44° 19' North latitude and 23° 48' East longitude) in 2015. The soil is a reddish typical preluvosoil (Dodocioiu et al. 2009). The biological material was represented by the Bucharest F1 hybrid. This hybrid has a vegetation period of 80-85 days and is recommended for summer/autumn culture. The experience included three variants: V1-untreated, V2- foliar fertilization with Deceneu and V3- foliar fertilization with Humifert Plus and placed in randomized blocks in 3 repetitions. The foliar products applied were formulated and obtained by ICPA Bucharest (Table 1).

The foliar fertilizations were applied in 2 treatments, at 0.5% concentration.

The culture was set up by the seedling produced on the furrows in the field at end of May and the planting took place in the second decade of July. Planting distances were 80 cm between rows and 30 cm between plants/row. In the experiment, crop-specific field technology was applied. Prior to the establishment, basic fertilization with complex fertilizer 20-20-20, 200 kg/ha was performed.

In order to achieve the proposed objectives, biometric determinations were made on the edible organs: height, diameter and shape index, as well as the degree of stuffing and production was determined by weighing on experimental plots, harvesting taking place when the majority of cabbage reached the specific size of each hybrid. The main biochemical components were determined: The total soluble solids (TSS %), sugar, vitamin C, titratable acidity.

Table 1.

The composition of the applied foliare fertilizers

Crt. No.	Phiso-chemical characteristics	DECENEU	HUMIFERT PLUS
		Concentration (g/dm^3)	Concentration (g/dm^3)
1	Total nitrogen	220	170
2	Phosphorus, P_2O_5	45	35
3	Potassium K2O	45	40
4	Iron, Fe	0,2	0,4
5	Copper, Cu	0,1	0,2
6	Zinc, Zn	0,1	0,2
7	Magnesium, Mg	0,2	0,3
8	Manganese, Mn	0,1	0,2
9	Boron, B	0,2	0,3
10	Sulfur, SO_3	10	25
11	Organic substances, of which: compusi humici	10	15
12	pH, unitati de pH	7,1	6,7
13	Densitate, g/cm^3	1,22 – 1,24	1,21

The total soluble solids was determined using a digital refractometer (Kruss Optronic DR 301-95) at 20°C; The titratable acid content (acidity) was determined by titration with 0.1N sodium hydroxide (NaOH) and expressed as % citric acid; Reducing sugars (%) were extracted in distilled water (1:50 w/V) and assayed colorimetric with 3,5 dinitrosalicylic acid using glucose as standard. Ascorbic acid was extracted in 3% metaphosphoric acid (1:50 w/V) and determined by using redox titration with 2,6-dichloroindophenol (Babeanu et al., 2016).

The results were statistically interpreted by variance analysis and means compared by Duncan's multiple range test (p <5%).

RESULTS AND DISSCUTIONS

For the assessment of morphological and productivity characteristics, some determinations were made to highlight the behavior of cabbage plants under the influence of applied foliar treatments. The average data obtained are presented in Table 2 and attests the positive effect of these treatments with organo-mineral products on the growth and development parameters of white cabbage plants.

Thus, the average height of the cabage was 17 cm in the untreated variant and in the foliar fertilized variants it ranged between 17.85 cm (V3-Humifert Plus) and 20.12 cm (V2-Deceneu fertilization). Variability of the cabage diameter may vary from 10 cm to over 40 cm, but the most common values are about 25-30 cm. In the variants of white cabbage studied, the diameter recorded the highest value in V2-fertilization with Deceneu of 23.17 cm. Rajhans et al. (2014) showed significant increases in cabage diameter (14.41 cm), weight (1.49 kg/plant) and productive yield (54.38 tonnes/ha) when applied 100 % RDF + *Pseudomonas fluorescens* and humic acid in cabbage culture.

Also, in the present study, the shape index showed close values between variants, from 0.81 to 0.86, indicating the spherical shape.

Table 2.

Influence of foliar fertilization products on some morphological and productivity characteristics of cabbage (average values)

Hibrid	Characters				
	Height of the cabbage (cm)	Cabbage diameter (cm)	Shape index	Average weight (kg)	Degree of stuffing
V1-untreated	17,0ns	20,75b	0,81	2,02b	Good
V2-Deceneu	20,12ns	23,17a	0,86	3,23a	Very good
V3-Humifert Plus	17,85ns	21,0b	0,85	2,04b	Very good
LSD 0.05	4,51	1,83	-	0,28	-

ns – no significant for p ≤0.05, Values in the same column followed by different superscript letters are significantly different

Crop harvesting was performed gradually, as the cabbage showed a good and very good degree of stuffing, recording the values on variants. Thus, the average of cabbage weight, an important element for productivity, recorded the lowest value in the untreated variant of 2.02 kg and the highest value in the variant fertilized with the Deceneu foliar product of 3.23 kg. Regarding the production obtained at the control variant, it was 82 t/ha and in variant 2, 132.5 t/ha, foliar fertilization with Deceneu, and in variant 3, foliar fertilization with Humifert Plus, 93.6 t/ha.

It is found that in all variants where plants were treated with products based on humic acids, were obtained superior yields compared to the untreated control. The best variant of foliar fertilization was also variant 2, foliar fertilization with Deceneu, being significantly positive (Table 3). The values obtained are similar to those obtained in a white cabbage crop study on the influence of planting density, yields of up to 126.53 t / ha (Apahidean A.S. et al., 2013).

By appling in other crops products with humic acids, it produced high yield increases in the several crops in vegetation houses trials, i.e. 45.5% in the Dacia Pontica tomatoes and 49.2% in the Justin sunflower, as compared to the nonfertilized control. In field trials, as a result of the application of Folhum the yield increase was 14.4% in sunflower with basic fertilization N80, P2O5 80 kg/ha, as compared to the nonfertilized controls, and 34.9% in the grape vine plantation. The yield increase was 38.5% in the ADI 7 tomato hybrid grown in greenhouse with drip irrigation on a previously non-fertilized soil (Parvan et al, 2009). Some authors state that irrespective of the analysed index, variants organically fertilized are significantly superior to the control variant (Draghici et al, 2016).

The obtained results for the total soluble solids (TSS **%)** are shown in Table 2 and it was recorded a variation amplitude of 6.7% in the control variant and 10.2% in the fertilized variants. In case of fertilized variants the content of total soluble solids is increased but not significant. The results obtained for the content of reducing sugars vary with the applied treatment being recorded at 4.45% in the unfertilized control variant and between 5.88% and 6.13% in the fertilized variants. Other authors (Kalota and Chohura, 2015) reported for white cabbage 'Kalorama F1' treated with differentiated dose of nitrogen, an average total sugars content of 4.13% fw for the variant fertilized with 150 kg N•ha-1 and 4.11% fw for the variant fertilized with 300 kg N•ha-1.

Table 3.

Cabbage yield and its quality, depending on the experimental variants

Variant	Production (t/ha)	SDS (%)	Reducing sugars (%)	Ascorbic acid mg/100 g fw.	Acidity (% citric acid)
V1- untreated	82,00b	8,7ns	4,45b	34,12ns	0,200c
V2-Deceneu	132,5a	10,2ns	6,13a	33,73ns	0,208b
V3-Humifert Plus	93,6ab	10,2ns	5,88a	35,78ns	0,215a
LSD 0.05	47,89	1,90	0,48	8,08	0,02

ns – no significant for $p \leq 0.05$, Values in the same column followed by different superscript letters are significantly different

Ascorbic acid is the component with proven antioxidant activity that contributes to the beneficial effects of white rabbit. The content in vegetables of ascorbic acid may vary depending on environmental and stress factors such as light intensity, temperature, humidity conditions, air pollution, etc. (M. Duma, 2015). Ascorbic acid content in the present study varies with applied treatment and has values between 33.73 mg/100 g fw and 35.78 mg 100 g fw (Table 3). Compared with the untreated control, the content of ascorbic acid increased when the Humifert plus fertilizer was applied and decreased at the fertilized variant with Deceneu, but the values were insignificant. Other authors (Avramiuc M., 2014) reported values of ascorbic acid content of 34.7 mg% in white cabbage. Singh et al., 2007 studying phytochemical antioxidant content in 18 cabbage cultivars reported an ascorbic acid content ranging from 5.66-23.5 mg/100 g fw with an average of 9.65 mg/100g and Bahorun et al. (2004) reports 18.8 mg of ascorbic acid/100 g of fw for white cabbage.

Sady et al., 2010, demonstrates the apparent influence of the variation of the nitrogen source on ascorbic acid concentration in cabbage plants, the highest amount of AA was found in plants harvested in 2005-30.2 mg 100 g-1 f.m. and the lowest value of ascorbic acid was evaluated in cabbage in 2007-25.4 mg. In other studies, there was also a significantly higher content of ascorbic acid (34.51 mg/100 g) in white cabbage, after fertilization of 100% fertilizer with *Pseudomonas fluorescens* and humic acid (Rajhans et al. 2014).

Acidity is an important property in assessing the quality of foods as it contributes directly to the formation of taste, and for some products it is an indicator of their freshness. Thus, the acidity in the studied variants was 0.200% citric acid in the untreated control and in foliar fertilized variants the values were between 0.208% and 0.215% citric acid. The V3 Humifert Plus variant resulted in higher acidity (Table 3).

The results of this study are similar to those of Aminifard et al., 2012, but on pepper culture reporting increasing acidity and TSS in fruit with increasing levels of humic acids and there were no differences in vitamin C content. The control of sugar content, vitamins and other organic substances must be permanently made to promote high quality production. By differentiated fertilization it is possible to maintain the quality of the offal to the particular parameters of the species, variety or hybrid.

CONCLUSIONS

Foliar fertilizers based on humic acids have been complementary to soil fertilization. The differences between the variants determined by foliar fertilizers were due to their composition and, in particular, to the balance of the nutrients held. The Deceneu fertilizer applied extraradicularly led to significant increases in cabbage production and quality. The content in reducing carbohydrates and acidity recorded significant increases, while soluble dry substance and vitamin C did not increase significantly in fertilized variants with humic acids.

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