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Influence of nanofertilizers on the yield and quality of broccoli hybrids in the conditions of the Western Forest-Steppe of Ukraine

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Purpose. To study the features of the productivity formation of broccoli hybrids depending on the methods of application of "5 element" nanofertilizer in the conditions of the Western Forest-Steppe of Ukraine. **Methods.** Field, laboratory, statistical. **Results.** With the introduction of "5 element" nanofertilizer, the head diameter of the 'Batavia F_1' hybrid increased from 16.6 (var. 2) to 18.3 cm (var. 8), while in the control this indicator was 15.9 cm. The biggest head diameter in the hybrid 'Orantes F_1' 18.9 and 18.7 cm was noted with foliar feeding with "5 element" nanofertilizer in the phase of 4–6 leaves + beginning of head formation + 10–12 days after the beginning of head formation and in the phase of the beginning of head formation + 10–12 days after the beginning of head formation. Accordingly, in the aforementioned variants, the head mass was 901 and 863 g, which is higher than the control (without treatment) by 166 and 128 g, or 22.3 and 17.4%.The highest yield of the 'Batavia F_1' hybrid was obtained in 8 and 7 variants of the experiment – 33.5 and 31.9 t/ha, respectively, the yield increase was 5.2 and 3.6 t/ha, or 18.4 and 12.7%. In the hybrid 'Orantes F_1' the highest yield (37.1 t/ha) was recorded when applying the "5 element" nanofertilizer in the 8th variant of the experiment, which is 6.6 t/ha higher than the control, or 21.6%. Compared to the 'Batavia F_1' hybrid, the yield in this variant of the 'Orantes F_1' hybrid was 3.6 t/ha, or 9.7%. The diameter and weight of the head, as well as the yield of the hybrid 'Orantes F_1' were larger compared to the hybrid 'Batavia F_1', due to its biological characteristics. A strong correlation (r = 0.97 and 0.96) was revealed between the yield and the diameter of the broccoli head in the 'Batavia F_1' and 'Orantes F_1' hybrids. The quality indicators of broccoli (dry matter, sum of sugars and vitamin C) in the 'Orantes F_1' hybrid were higher compared to the 'Batavia F_1' hybrid. A tendency towards a decrease in the concentration of nitrates in the heads of broccoli with an increase in the number of treatments with nanofertilizer "5 element" was revealed. The concentration of nitrates in the 'Orantes F_1' hybrid was lower in all variants of the experiment in comparison with the 'Batavia F_1' hybrid. The concentration of nitrates in the heads of broccoli in all variants of the experiment did not exceed TLV (400 mg/kg wet weight). **Conclusions.** With an increase in the number of foliar treatments with "5 element" nanofertilizer, the yield increased and the quality of broccoli hybrids improved. It was revealed that the yield of the 'Orantes F_1' hybrid in all variants of the experiment was higher in comparison with the 'Batavia F_1' hybrid. When applying nanofertilizer "5 element" in three stages – foliar feeding in the phase of 4–6 leaves + beginning of head formation + 10–12 days after the beginning of head formation – we got the highest yield of broccoli in the hybrid 'Orantes F_1' – 37.1 t/ha, an increase over the control variant (without fertilizers) was 6.6 t/ha, or 21.6%. The 'Batavia F_1' hybrid had a yield of 33.5 t/ha, an increase over the control variant – 5.2 t/ha, or 18.4%.

Keywords: *broccoli; hybrid; nanofertilizer "5 element"; yield; qualitative indicators.*

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Introduction

Of all the species of cabbage on the market, broccoli is most in demand due to its nutritional value and medicinal properties, in particular in the fight against cancer. Iodine contained in broccoli in organic form improves the functioning of the thyroid gland [1]. Broccoli is demanding on nutrients supply in the

soil, which is associated with a small size of the root system, a large habit of the ground part and a high removal of nutrients per unit of production. However, it must be borne in mind that the genetic potential of a hybrid can be realized through the creation of optimal growing conditions, taking into account its biological characteristics, requirements for some elements of agricultural technology, as well as for the fertilization system. An increase in yield by 40–70% can be achieved due to technology and the use of various types of fertilizers and plant protection products, and by 30–50% – thanks to selection [2].

The use of modern growth regulators, chelated water-soluble organomineral fertilizers with trace elements in the form of foliar fertilization helps to increase yields by 15–30% and significantly improves the quality of agricultural products [3]. Trace elements are part of enzymes that catalyze biochemical processes, increasing their activity. Thus, they stimulate the growth of plants and accelerate their development, have a positive effect on their resistance to adverse environmental conditions (drought, temperature changes, etc.), help resist diseases and pests. Lack of micronutrients causes reduced yields, deterioration of product quality, stress in plants, which cause a number of diseases, and sometimes their death [4]. The yield of broccoli in Ukraine is still low and depends on a number of factors. Starting organomineral fertilizers in conditions of moisture deficiency, which is often manifested in recent years, do not promote intensive growth and development of a plant, because the process of their solubility and assimilation does not take place. Therefore, the use of biological resources of a variety or hybrid fully requires additional foliar application of macro-and micronutrients, which allows to increase the yield and quality of broccoli [5].

Thus, it is important to study the effectiveness of foliar application of micro- and nanofertilizers to increase the efficiency of growing and obtaining environmentally friendly products of broccoli on dark gray podzolic soils of the Western Forest-Steppe of Ukraine.

The purpose of the research is to study the peculiarities of the formation of broccoli hybrids productivity depending on the methods of application of nanofertilizer «5 element» in the Western Forest-Steppe of Ukraine.

Materials and methods

Research studies on the effect of nanofertilizers «5 element» on the yield and quality of broccoli were conducted in the research field of the Department of Horticulture and Vegetable growing named after prof. I. P. Gulko of Lviv National Agrarian University during 2019–2020.

Early-maturing broccoli hybrids of foreign breeding 'Batavia F_1' (Bejo Zaden) and 'Orantes F_1' (Rijk Zwaan), included in the State Register of Plant Varieties Suitable for Distribution in Ukraine were sown [6].

The studies were performed according to the given methods [7–9]. A new water-soluble nanofertilizer «5 element» was used in the experiments. Chemical composition of nanofertilizer (active substance), g/100 g: $ZnSO_4$ – 0.00027–0.0015%, $MgSO_4$ – 0.00019–0.002, $MnSO_4$ – 0.0081–0.0025, $FeSO_4$ – 0.00014–0.0015, $CuSO_4$ – 0.00074–0.002, $CoSO_4$ – 0.00005–0.0005, brassinolide grade 0.1SP – 1–1.5, sucrose 98.49–98.9978, the total content of salts of trace elements in the granules is not less than – 0.000001900 mg. The fertilizer is included in the State Register of Pesticides and Agrochemicals Permitted for Use in Ukraine.

The scheme of the experiment contained the following variants: 1) control (without treatment); 2) feeding in the phase of 4–6 leaves (after seedlings rooting); 3) feeding in the beginning of head formation; 4) feeding in 10–12 days after head formation; 5) feeding in the phase of 4–6 leaves + the beginning of head formation; 6) feeding in the phase of 4–6 leaves + 10–12 days after the beginning of head formation; 7) feeding in the phase of the beginning of head formation + 10–12 days after the beginning of head formation; 8) feeding in the phase of 4–6 leaves + the beginning of head formation + 10–12 days after the beginning of head formation.

The predecessor of broccoli was potatoes. As a background for cultivation, a new complex mineral fertilizer Nitroamofoska-M in the norm of + $N_{54}P_{108}K_{132}$ kg/ha was applied and ammonium nitrate at the rate of N_{60} kg/ha. Broccoli cassette seedlings were planted in a permanent place at the age of 25 days, when the plants formed 3–4 true leaves in the third decade of April in prepared soil. Planting scheme – 60 × 40 cm (41.6 thousand/ha of plants).

The estimated area of the plot was 18 m^2. The experiment was laid out in three repetitions, the placement of variants was systematic. The soil of the experimental field is dark gray podzolic light loam, characterized by average humus content (2.2–2.3%), weak-acid reaction of the soil solution (pH 6.5), content (in the 0–20 cm upper horizon) of easily hydrolyzed nitrogen was 83–85 mg/kg, mobile phosphorus 92–96, exchangeable potassium – 96–98 mg/kg, magnesium – 0.55–0.68 mg-eq/100 g, mobile sulfur –

2.13–2.35 mg/kg, manganese – 10.44–12.58 mg/kg, zinc – 1.47–1.69 mg/kg, cobalt – 0.60–0.67 mg/kg, copper – 0.16–0.19 mg/kg.

Broccoli growing technology is generally accepted for the conditions of the Western Forest-Steppe of Ukraine. Phenological observations, biometric measurements and records were performed in accordance with generally accepted methods in vegetable growing. Broccoli was harvested from each plot selectively with the onset of technical maturity (I–II decade of July) and determined the diameter and average weight of heads. In the collected heads of broccoli, biochemical parameters were determined. Dry matter was determined by thermogravimetric method – drying to constant weight, the amount of sugars – by Bertrand method, ascorbic acid (vitamin C) – by Murry method, nitrate content – by ionometric method [10].

The experiments were carried out in accordance with the methods of research in vegetable and melon growing [11]. Statistical processing of the obtained research results was performed by analysis of variance method using computer software Excel and Statistica 10.0.

Results and discussion

One of the main economic and valuable indicators that confirm the advantage of a particular agro-technical measure is the yield of the commodity part and its quality indicators. In the studies, the quality of the yield of broccoli hybrids was determined by the average head diameter and average weight of the head (Tables 1 and 2).

It was found that the application of nanofertilizer «5 element» increased head diameter of the hybrid 'Batavia F_1' from 16.6 (var. 2) to 18.3 cm (var. 8), while in the control this figure was 15.9 cm. 'Batavia F_1' exhibited the largest head weight (813 g) in the 8th variant with three foliar fertilization with nanofertilizer in the phase of 4–6 leaves + the beginning of head formation + 10–12 days after the beginning of head formation. Slightly lower mean weight of heads (769 and 763 g) was obtained in 7th and 5th variants of the experiment. In the control variant, mean weight of the head was 682 g, which was less than in 8 variant by 131 g, or 16.1% (Table 1).

Table 1

Yield of broccoli hybrid 'Batavia F_1' depending on the application of nanofertilizer «5 element» (average for 2019–2020)

Variant	Head diameter, cm	Head weight, g	Yield, t/ha	Increase to control	
				t/ha	%
1) Control – without treatment	15.9	682	28.3	–	–
2) Feeding in a phase of 4–6 leaves	16.6	697	28.9	0.6	2.1
3) Feeding in the beginning of head formation phase	17.3	736	30.5	2.2	7.7
4) Feeding in 10–12 days after head formation	16.8	721	29.7	1.4	4.9
5) Feeding in phase 4–6 leaves + the beginning of head formation	17.7	763	31.6	3.3	11.7
6) Feeding in phase 4–6 leaves + 10–12 days after the beginning of head formation	17.5	745	30.8	2.5	8.8
7) Feeding in the beginning of head formation phase + 10–12 days after the beginning of head formation	17.9	769	31.9	3.6	12.7
8) Feeding in phase 4–6 leaves + the beginning of head formation + 10–12 days after beginning of head formation	18.3	813	33.5	5.2	18.4
$LSD_{0.05}$	3.1	15.4	4.2	–	–

The average head weight and diameter are closely related to the yield. The use of nanofertilizer «5 element» in the form of foliar feeding in different phases of the growing season of broccoli hybrid 'Batavia F_1' increases the yield from 0.6 t/ha, or 2.1% (var. 2) to 5.2 t/ha, or 18,4% (var. 8), compared with the control without treatment. The high yield of broccoli hybrid 'Batavia F_1' was obtained in 7th and 5th variants of the experiment, respectively 31.9 and 31.6 t/ha, the increase in yield was 3.6 and 3.3 t/ha, respectively, or 12.7 and 11.7%.

Based on the correlation analysis, a very strong correlation was revealed ($r = 0.97$) and the coefficient of determination $R^2 = 0.94$ was obtained between the yield and the diameter of the broccoli head of the 'Batavia F_1' hybrid with foliar application of nanofertilizer «5 element» (Fig. 1).

The diameter and weight of the head, as well as the yield of the hybrid 'Orantes F_1' were higher compared to the hybrid 'Batavia F_1', due to its biological features. The largest diameters of the head – 18.9 and 18.7 cm – were noted by foliar feeding with nanofertilizer «5 element»

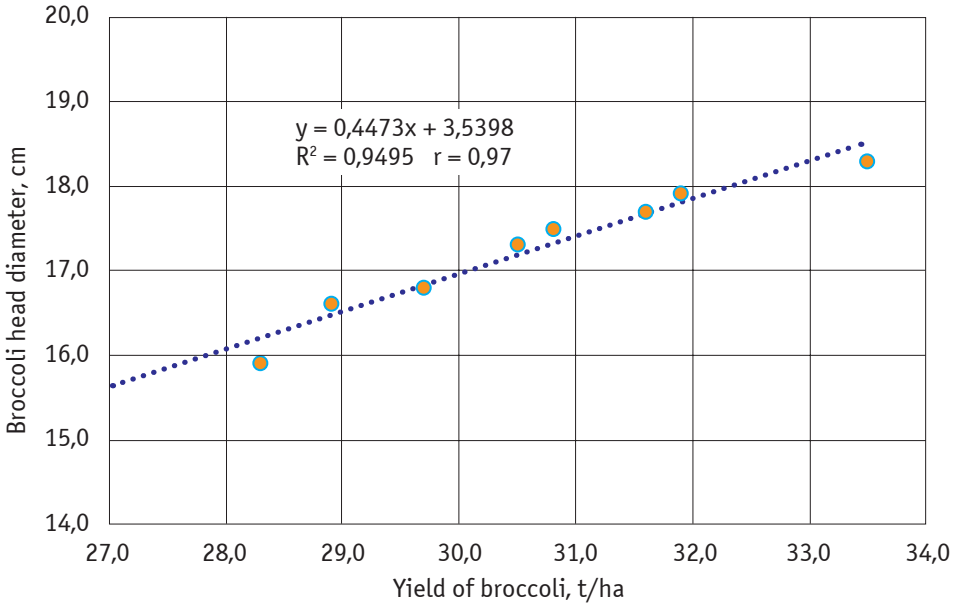

Fig. 1. Correlation between yield and diameter of broccoli heads of the hybrid 'Batavia F_1' for «5 element» nanofertilizer application

in the phase of 4–6 leaves + the beginning of head formation + 10–12 days after the beginning of head formation and in the phase of the beginning of head formation + 10–12 days after the beginning of head formation. Respectively, in the above-mentioned variants, the weight of the heads was 901 and 863 g, which is more than in the control (without treatment) by 166 and 128 g, or 22.3 and 17.4% (Table 2).

The highest yield of broccoli (37.1 t/ha) in the hybrid 'Orantes F_1' was noted for the application of nanofertilizer «5 element» in the 8th variant of the experiment, which is higher than in control by 6.6 t/ha, or 21.6%. Compared with the 'Batavia F_1' hybrid, the yield of this variant in the hybrid 'Orantes F_1' was higher by 3.6 t/ha, or 9.7%.

High yield of broccoli in the hybrid 'Orantes F_1' – 35.7 and 35.1 t/ha was obtained by foliar fertilization of nanofertilizer «5 element» in the phase of the beginning of head formation + 10–12 days after the beginning of head formation (var. 7) and in phase of 4–6 leaves + the beginning of head formation (var. 5), while for fertilization in the phase of 4–6 leaves (var. 2) it was 31.3 t/ha.

Correlation analysis showed a very strong correlation (r = 0.96) with a coefficient of determination R^2 = 0.93 between yield and head diameter of broccoli hybrid 'Orantes F_1' with foliar application of nanofertilizer «5 element» (Fig. 2).

So, when using «5 element» nanofertilizer, a similar tendency to an increase in the yield of broccoli was observed in the 'Batavia F_1' and 'Orantes F_1' hybrids according to the variants of the experiment with the approximation probability R^2 = 0.88. However, the greatest

Table 2

Yield of broccoli hybrid 'Orantes F_1' depending on the application of nanofertilizer «5 element» (average for 2019–2020)

Variant	Head diameter, cm	Head weight, g	Yield, t/ha	Increase to control	
				t/ha	%
1) Control – without treatment	16.3	735	30.5	0	–
2) Feeding in a phase of 4–6 leaves	17.2	754	31.3	0.8	2.6
3) Feeding in the beginning of head formation phase	17.8	796	32.9	2.4	7.9
4) Feeding in 10–12 days after head formation	17.5	771	32.2	1.5	5.6
5) Feeding in phase 4–6 leaves + the beginning of head formation	18.3	845	35.1	4.6	15.1
6) Feeding in phase 4–6 leaves + 10–12 days after the beginning of head formation	17.9	812	33.6	3.1	10.2
7) Feeding in the beginning of head formation phase + 10–12 days after the beginning of head formation	18.7	863	35.7	5.2	17.0
8) Feeding in phase 4–6 leaves + the beginning of head formation + 10–12 days after beginning of head formation	18.9	901	37.1	6.6	21.6
$LSD_{0.05}$	3.5	17.6	5.0	–	–

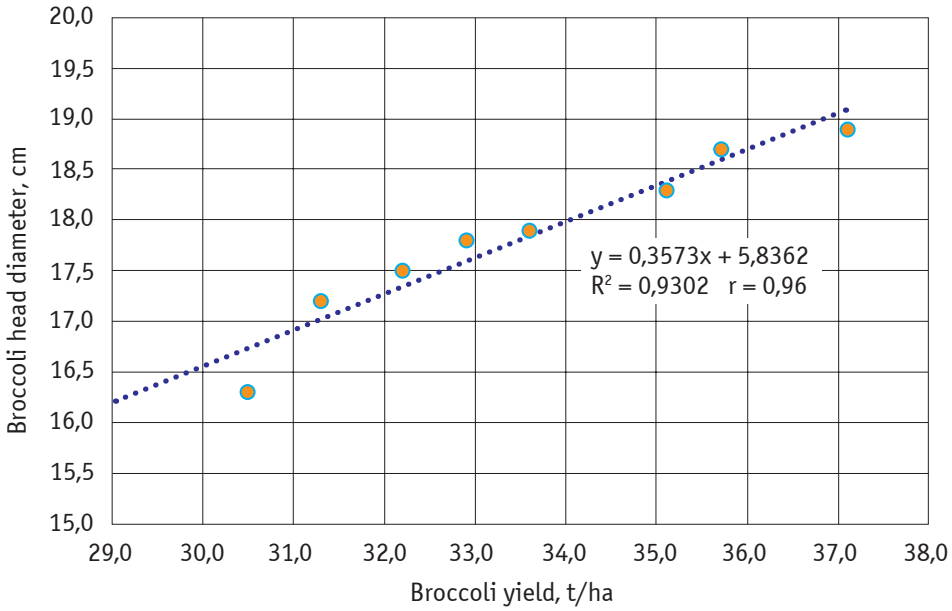

Fig. 2. Correlation between yield and diameter of broccoli heads of the hybrid 'Orantes F_1' for «5 element» nanofertilizer application

agronomic efficiency in increasing the yield was found with foliar feeding with «5 element» nanofertilizer in the phase of 4–6 leaves + beginning of head formation + 10–12 days after the beginning of head formation (Fig. 3).

The use of «5 element» nanofertilizer increased dry matter content, amount of sugars and vitamin C in the heads of broccoli 'Batavia F_1' and 'Orantes F_1' hybrids. But the content of nitrates decreased with an increase in the number of foliar treatments with nanofertilizer «5 element» (Tables 3 and 4).

The dry matter content in the 'Batavia F_1' hybrid varied from 9.7% with foliar feeding in the phase of 4–6 leaves to 10.6% with three single feeding in the phase of 4–6 leaves + beginning of head formation + 10–12 days after beginning of head formation. A slightly higher content of dry matter in the heads of broccoli was noted in the hybrid 'Orantes F_1' – from 10.4% (control) to 12.3% (variant 8).

The highest content of total sugars (3.9 and 3.8%) in the heads of broccoli of the 'Batavia F_1' hybrid was found in 8 and 5 variants of the experiment. Somewhat less – 3.5% – in the variant of foliar feeding with nanofertilizers in the phase of the beginning of head forma-

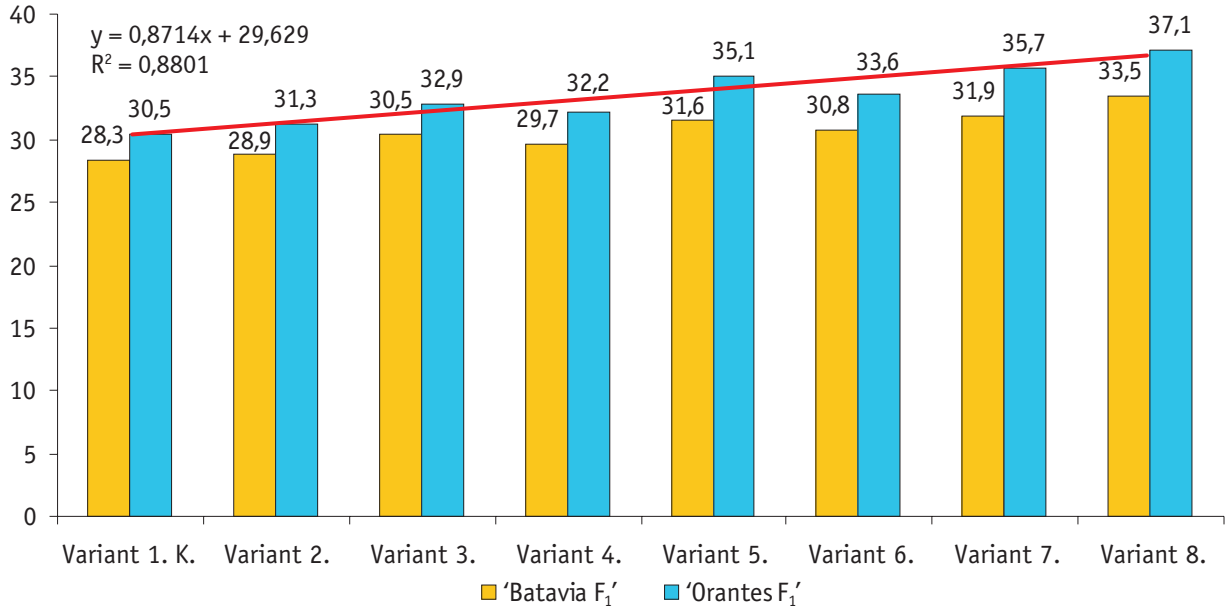

Fig. 3. Productivity of broccoli 'Batavia F_1' and 'Orantes F_1' hybrids with the introduction of the «5 element» nanofertilizer

tion + 10–12 days after the beginning of head formation (variant 7). It should be noted that the 'Orantes F_1' hybrid had this indicator higher in all variants of the experiment in comparison with the 'Batavia F_1' hybrid, however, the trend for variants remained.

Table 3

Influence of «5 element» nanofertilizer on the biochemical composition of broccoli hybrid 'Batavia F_1' (average for 2019–2020)

Variant	Dry matter, %	Sugars content, %	Vitamin C, mg/100 g	Nitrates, mg/kg of raw mass
1) Control – without treatment	9.6	3.0	79.2	277
2) Feeding in a phase of 4–6 leaves	9.7	3.2	80.3	275
3) Feeding in the beginning of head formation phase	9.8	3.3	81.1	264
4) Feeding in 10–12 days after head formation	9.6	3.2	80.7	270
5) Feeding in phase 4–6 leaves + the beginning of head formation	10.3	3.8	82.9	249
6) Feeding in phase 4–6 leaves + 10–12 days after the beginning of head formation	10.1	3.4	83.3	263
7) Feeding in the beginning of head formation phase + 10–12 days after the beginning of head formation	10.4	3.5	83.5	251
8) Feeding in phase 4–6 leaves + the beginning of head formation + 10–12 days after beginning of head formation	10.6	3.9	84.4	245
$LSD_{0.05}$	0.6	0.3	3.1	17.8

An important indicator of the quality of broccoli is the content of ascorbic acid. In the 'Batavia F_1' hybrid this indicator varied from 80.3 to 84.4 mg/100 g, while in the control it was 79.2 mg/100 g. In the 'Orantes F_1' hybrid, vitamin C content was high in all variants of the experimentm, compared to the 'Batavia F_1' hybrid due to its biological characteristics. The highest content of ascorbic acid (88.3 mg/100 g) in the heads of the 'Orantes F_1' hybrid was revealed when feeding with a nanofertilizer in the phase of 4–6 leaves + beginning of head formation + 10–12 days after the beginning of head formation (variant 8), which is 5.2 mg/100 g more in comparison with variant 2. In the control variant (without feeding) this indicator was the lowest (82.4 mg/100 g).

Table 4

Influence of «5 element» nanofertilizer on the biochemical composition of broccoli cabbage, hybrid 'Orantes F_1' (average for 2019–2020)

Variant	Dry matter, %	Sugars content, %	Vitamin C, mg/100 g	Nitrates, mg/kg raw mass
1) Control – without treatment	10.1	3.8	82.4	261
2) Feeding in a phase of 4–6 leaves	10.4	3.9	83.1	256
3) Feeding in the beginning of head formation phase	10.5	4.2	84.5	254
4) Feeding in 10–12 days after head formation	10.2	3.8	84.2	252
5) Feeding in phase 4–6 leaves + the beginning of head formation	11.7	4.8	85.7	244
6) Feeding in phase 4–6 leaves + 10–12 days after the beginning of head formation	11.4	4.3	85.6	250
7) Feeding in the beginning of head formation phase + 10–12 days after the beginning of head formation	12.0	4.9	86.8	239
8) Feeding in phase 4–6 leaves + the beginning of head formation + 10–12 days after beginning of head formation	12.3	5.1	88.3	238
$LSD_{0.05}$	0.7	0.5	3.9	16.1

The environmental safety of broccoli is characterized by such an important indicator as the content of nitrates. The studies revealed a tendency towards a decrease in the concentration of nitrates in broccoli heads with an increase in the number of treatments with «5 element». However, we note that the content of nitrates in the hybrid 'Orantes F_1' was lower in all variants compared to the hybrid 'Batavia F_1'. The highest content of nitrates in the studied hybrids was found in the control variant (277 and 261 mg/kg raw mass). It was determined that the content of nitrates in the heads of broccoli cabbage in all variants of the experiment did not exceed TLV (400 mg/kg raw mass).

Conclusions

With an increase in the number of foliar treatments with nanofertilizer «5 element», the yield increased and the quality of broccoli

hybrids improved. It was revealed that the yield of the 'Orantes F_1' hybrid in all variants of the experiment was higher, in comparison with the 'Batavia F_1' hybrid.

When applying nanofertilizer «5 element» in three stages – foliar feeding in the phase of 4–6 leaves + beginning of head formation + 10–12 days after the beginning of head formation – we got the highest yield of broccoli in the hybrid 'Orantes F_1' – 37.1 t/ha, the increase in comparison to the control (without fertilizers) was 6.6 t/ha, or 21.6%. The 'Batavia F_1' hybrid had a yield of 33.5 t/ha, an increase in comparison to the control was 5.2 t/ha, or 18.4%.

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Дидів О. Й.[1*], Дидів І. В.[1], Лещук Н. В.[2], Кузько В. Г.[3], Дидів А. І.[1] Вплив нанодобрива на врожайність і якість гібридів капусти броколі в умовах Західного Лісостепу України. *Plant Varieties Studying and Protection*. 2020. Т.16, № 4. С. 387–394. https://doi.org/10.21498/2518-1017.16.4.2020.224056

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Мета. Вивчити особливості формування продуктивності гібридів капусти броколі залежно від способів застосування нанодобрива «5 element» в умовах Західного Лісостепу України. **Методи.** Польовий, лабораторний, статистичний. **Результати.** За внесення нанодобрива «5 element» збільшувався діаметр головки в гібрида

'Batavia F_1' від 16,6 (вар. 2) до 18,3 см (вар. 8), тоді як на контролі цей показник становив 15,9 см. Найбільший діаметр головки в гібрида 'Orantes F_1' 18,9 та 18,7 см відзначено за позакореневого підживлення нанодобривом «5 element» у фазі 4–6 листків + початок формування головки + через 10–12 діб після початку формування головок та у фазі початок формування головок + через 10–12 діб після початку формування головок. Відповідно у вищезгаданих варіантах маса головок становила 901 та 863 г, що вище за контроль (без обробки) на 166 та 128 г, або 22,3 та 17,4%. Найвищу врожайність капусти броколі гібрида 'Batavia F_1' одержано у 8 та 7 варіантах досліду – 33,5 та 31,9 т/га відповідно, приріст урожаю становив відповідно 5,2 та 3,6 т/га, або 18,4 та 12,7%. У гібрида 'Orantes F_1' найбільшу врожайність (37,1 т/га) відзначено за внесення нанодобрива «5 element» у 8 варіанті досліду, що вище за контроль на 6,6 т/га, або 21,6%. Порівняно з гібридом 'Batavia F_1' урожайність на цьому варіанті у гібрида 'Orantes F_1' була більшою на 3,6 т/га, або 9,7%. Діаметр та маса головки, а також урожайність у гібрида 'Orantes F_1' були більшими, порівняно з гібридом 'Batavia F_1', що зумовлено його біологічними особливостями. Виявлено сильний кореляційний зв'язок (r = 0,97 та 0,96) між урожайністю та діаметром головки капусти броколі в гібридів 'Batavia F_1' та 'Orantes F_1'. Якісні показники капусти броколі (суха речовина, сума цукрів та вітамін С) у гібрида 'Orantes F_1' були вищими порівняно з гібридом 'Batavia F_1'. Виявлено тенденцію до зменшення концентрації нітратів у головках капусти броколі зі збільшенням кількості обробок нанодобривом «5 element». Концентрація нітратів у гібрида 'Orantes F_1' була меншою в усіх варіантах досліду, порівняно з гібридом 'Batavia F_1'. Уміст нітратного азоту в головках капусти броколі в усіх варіантах досліду не перевищував ГДК (400 мг/кг сирої маси). **Висновки.** Зі збільшенням кількості позакореневих обробок нанодобривом «5 element» підвищувалась урожайність та поліпшувалася якість продукції гібридів капусти броколі. Виявлено, що врожайність гібрида 'Orantes F_1' у всіх варіантах досліду була більша, порівняно з гібридом 'Batavia F_1'. За внесення нанодобрива «5 element» у три етапи – позакореневе підживлення у фазі 4–6 листків + початок формування головки + через 10–12 діб після початку формування головок – одержали найбільшу врожайність капусти броколі в гібрида 'Orantes F_1' – 37,1 т/га, приріст до контролю (без добрив) становив 6,6 т/га, або 21,6%. У гібрида 'Batavia F_1' урожайність становила 33,5 т/га, приріст до контролю – 5,2 т/га, або 18,4%.

Ключові слова: *капуста броколі; гібрид; нанодобриво «5 element»; урожайність; якісні показники*.

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