

ORGANIC FERTILIZATION INFLUENCE ON GROWTH AND FRUITING PROCESSES OF THREE APPLE CULTIVARS GROWN IN THE MARACINENI-ARGES AREA

Mirela Florina Calinescu¹, Ivona Cristina Mazilu^{1,*}, Emil Chitu^{1,*}, Mihai Chivu¹, Florin Plaiasu¹

¹Research Institute for Fruit Growing, Marului 402, 117450, Maracineni, Arges, Romania



Abstract

The present paper studied the influence of organic biostimulators and fertilizers, administrated in three applications between 70-75 BBCH, on growth and fruiting processes of three apple cultivars grown in five and six years high-density orchards at the Research Institute for Fruit Growing, Maracineni, Arges (southern part of Romania). During 2020-2021, the increase of the trunk cross-sectional area registered an average of 5.25 cm² (0.02-21.19 cm²), and the fruit yield averaged 55.64 t/ha (0-166.98 t/ha). The mean values recorded for the fruit weight and pulp firmness, were 173.22 g (74.13-558.76) and 76.50 units Bareiss HPE-II-FFF (53.60-89.10), while the pH of the fruit juice and total soluble solids fluctuated around 3.55 (3.09-4.68) and 13.3 °Brix (9.45-18.20). Foliar treatment with Cifamin BK (1.5 l/plant) significantly increased fruit yield by 49.5% compared to the untreated variant. Fruit weight increased in all three fertilization treatments on 'Decosta Jonagold de Coster' and 'Red Braeburn'. Organic biostimulators and fertilizers improved pulp firmness on 'Golden Reinders Delicious', juice pH on 'Decosta Jonagold de Coster' and total soluble content on 'Red Braeburn'. The results of the study showed that, on the mineral nutrition background, Cifamin BK and Biohumus treatments in apple orchards improved fruit yield and quality.

Keywords: biostimulators, aminoacids, *Malus* spp., vermicompost.

1. INTRODUCTION

The apple tree is a perennial crop and it has specific nutrient requirements for growth and fruit development (Kurešová et al., 2019). The nutrient uptake depends on the soil properties and the cultural practices such as fertilization programs and soil management, but it is also influenced by the cultivar, rootstock dwarfism, sub-soil physical and chemical condition. Moreover, the expected yields and intended use of the fruit are sometimes additional factors in determining the nutrient input. According to Masunaga and Fong (2018) and Suman et al. (2017), Zn, B, Mn, Cu, Fe, and Mo deficiency are frequently reported related to horticultural crops. Among them, iron deficiency is mostly induced. Moreover, even trace elements found in soil in proper concentration, are not entirely available for the plant roots. Generally, soil nutrient availability depends on their concentration, interaction with other soil components (minerals, organic matter, microorganisms, etc), and chemical soil traits such as pH and redox potential (Masunaga and Fong 2018), and is also influenced by climatic conditions. Even on minerals-rich soils plants can use only a minor nutrient percent due to

the slow soil microbial activity or chemical processes. Nutrient removal through plant crops cannot be compensated if no fertilizer input is used (Chen, 2006). Fertilization can be ensured by applying nutrients to both soil and foliar. Also, synthetic fertilizers can be administered, as well as organic or biofertilizer. As a rule, among the fertilizers with soil application, the synthetic ones ensure quickly the necessary mineral elements of the trees (they are easily accessible), but their use is correlated with the risk of leaching, being easily entrained by irrigation water or precipitation. The potential for the destruction of micro-organisms in the soil (especially mycorrhizae) and leaf burns, when the application doses are excessive, also fall into the category of the same adverse effects. In this context, in soil fertilization practices, well established fertilizer dose is recommended to be used for a beneficial plant response (Hazra, 2016). An alternative is the application of natural fertilizers, compost, or manure to the soil, which has the remarkable property of gradual release of nutrients and does not pose a danger of contamination of the environment. According to Chatzistathis et al. (2021), organic fertilizers enhance soil organic C, cation exchange capacity, and microbiological activity, playing therefore a crucial role in improving soil health, and properties and promoting the sustainability of agroecosystems. Moreover, organic fertilizers may alleviate aridity (low fertility) stress and enhance the photosynthetic rate of plants (Baruah et al., 2016). However, such fertilizers have the disadvantage of a lag period, which is necessary for soil microorganisms to produce the mineralization of nutrients to forms accessible to trees. Among soil fertilizers, bio humus has more than simple nutritive role by improving soil structure. It also acts as a matrix that temporarily retains soil minerals and makes them gradually available to plants. The sequential release of nutrients provides the roots with an environment free of potentially toxic excesses and prevents their leakage into the surrounding environment (Hazra, 2016). Foliar application of nutrients provides an opportunity for supplying essential elements directly to the foliage, flowers, or fruits at times when a rapid response may be required. This method has the advantage of providing not only fast but also efficient nutrients and is a basic solution to correct any deficiencies. It is admitted that foliar fertilization cannot replace soil fertilization (Williams and Williams, 1986). However mineral nutrients, hormones and other active compounds can be delivered through this path. Higher yields and quality, diseases and insect resistance, drought tolerance were noted following foliar fertilization. Still, plant response is species specific and depends on fertilizer formula, treatments timing and the phenological stage of the plants (Williams and Williams, 1986). Moreover, in Takeuchi et al. (2008) study it was suggested that L-proline foliar application promoted the absorption of nitrogen from the fine roots, as well as the production of amino acids and the synthesis of chlorophyll in the leaves in cases where the soil nitrogen level was not in excess. Therefore a combined fertilization program (based on soil fertilization and foliar supplementation) is recommended. All fertilizer inputs should be delivered to ensure both yield quality-quantity traits and environment safety. Optimal nutrition plan can be achieved by using a combination of fertilizer types- chemical, organic or microorganism-based one (Chen, 2006). In this background, our paper aimed to study how bio-stimulants - based organic fertilization (with soil and foliar application) influenced the growth and fruiting processes of three apple cultivars.

2. MATERIALS AND METHODS

Vegetal material

The study was conducted at the Research Institute for Fruit Growing Pitesti-Maracineni, Arges county, Romania (44° 53' N, 24° 51' E), from 2020 to 2021, in the experimental apple plot of the Orchard Technology Department. The apple trees were planted in 2017 in a superintensive orchard at 3×1 m apart (3,333 trees/ha). The orchard soil management system is based on inter-rows cultivation with grasses and herbicide treatments along the tree rows. A completely randomized factorial design experiment with two factors was set up to study the organic fertilizer influence on the growth and fruiting processes of three apple cultivars, in which the first experimental factor, A, was the fertilization, with four levels:

a1=unfertilized,

a2=Cifamin BK 1.5 l/ha, foliar application,

a3= Megafol 0.2%, foliar application,

a4= Biohumus 2 l/tree, soil application, and the second factor, B, was the cultivar, with three levels:

b1= 'Decosta Jonagold de Coster',

b2= 'Golden Reinders Delicious',

b3='Red Braeburn', resulting in 12 treatments, four replicates, and a total number of experimental units of 48.

Soil fertilization was performed in a single application, in the first week of May. Foliar treatments were administrated in three stages, between 70-75 BBCH at 7 days apart. All treatments were applied on a mineral fertigation background established with SmartFertilizer Management Software (SMART! PLUS), based on the future crop yield, and soil and leaf diagnosis.

Fertilizers presentation

Biohumus (vermicompost) is an organic fertilizer, microbiological pure, a mixture of manure and biological waste produced by earthworms. Biohumus contains the necessary set of macro and micro nutrients, enzymes, soil antibiotics, vitamins, growth hormones and humic substances. Cifamin BK is a foliar applicate fertilizer, very rich in organic compounds with a biostimulant action on vegetal physiology, particularly indicated for improving fruit size. The product contains amino acids such as arginine, proline, hydroxyl-proline, lysine, tryptophan, arginine and glycine. These are precursors of auxins and polyamines which favour cell division and extension ensuring a high number of cells in young fruits, improve plant stress resistance and stimulate photosynthetic activity. It also contains microelements like boron, manganese, and zinc. Seaweed *Macrocystis* extracts supply polysaccharides, enzymes, and betaine, thus sustaining and complementing the action of amino acids. According to the producer, Cifamin BK contains 8% total nitrogen, 8% organic nitrogen, 20% organic carbon (of biological origin), 0.01% water-soluble boron, 0.1% water-soluble manganese and 0.01% water-soluble zinc.

Megafol is a combination of foliar fertilizer and a bio-stimulant that not only nourishes the crops but also protects them from stress. Megafol includes a complex of proteins, amino acids, vitamins and other growth factors. Overall, Megafol contains 1% organic nitrogen, 1% urea nitrogen, 4.5% water-soluble potassium oxide, 10% organic carbon, 0.022% water soluble iron, 0.022% chelated iron, 0.026% water soluble magnesium, 0.026% chelated magnesium.

Methods

Vegetative growth and fruit yield study

The fertilizer influence on vegetative growth was assessed by trunk cross-sectional area (TCSA) and the annual increase of trunk cross-sectional area calculation (based on TCSA in the spring and autumn). Fruit yield data were obtained by weighing all fruits per tree at the harvest moment.

Fruit quality study

The harvest maturity date was determined by starch content test and organoleptic evaluation and samples of 30 fruits in four replicates per each treatment \times cultivar (A \times B combination) were randomly chosen. Fruit quality was assessed by determination of fruit weight (by weighing, with an Kern electronic laboratory balance), pulp firmness (using the Bareiss HPE-II-FFF undisturbed penetrometer), pH of fresh juice extracted from the fruit (with the Horiba LAQUA pH / ORP / COND Meter D74, equipped with the Horiba pH sensor 0030/0040) and the total soluble content (TSS), (with the Kern electronic refractometer). The obtained results were compared with the data of the control variants, in which no fertilizers were applied.

Data analysis

The data were analysed using two-way ANOVA with IBM SPSS 28 software and MS Office Excel 2010. Duncan's Multiple Range Test was used to determine the significant differences ($P < 0.05$).

3. RESULTS AND DISCUSSIONS

Table 1 presents the statistical descriptors of fruit and yielding processes of the three apple cultivars. As can be observed, the annual increase of trunk cross-sectional area varied from 0.02 to 21.19 cm², with an average of 5.25 cm². Fruit yield varied between 0 and 166.98 t/ha and averaged 55.64 t/ha.

Table 1. Statistical descriptors for the annual increase of trunk cross sectional (TCSA) and fruit yield

		Annual TCSA increase (cm ²)	Fruit yield (t/ha)
N	Valid	480	480
	Missing	0	0
Mean		5.25	55.64
Median		3.86	54.10
Mode		1.12 ^a	8.67
Std. Deviation		3.95	38.44
Range		21.17	166.98
Minimum		0.02	0.00
Maximum		21.19	166.98

a. Multiple modes exist. The smallest value is shown

The influence of fertilization treatments on the growth and yielding processes of three apple cultivars, 'Decosta Jonagold de Coster', 'Red Braeburn', and 'Golden Reinders Delicious' was presented in Table 2. On average, the annual increase of trunk cross-sectional area (TCSA) fluctuated non-significantly between 11.01 cm², under Cifamin BK treatment and 11.66 cm² when Megafol was applied. Fruit yield registered a significant variation from untreated, Megafol and Biohumus variants to Cifamin BK fertilization (Table 2). The highest fruit production, 73.42 t/ha, was obtained for Cifamin BK treatment of the 'Red Braeburn' cultivar, corresponding to a 49.5% increase over the untreated variant (49.11 t/ha).

Table 2. Effect of fertilization treatment on cultivar levels over the annual increase of trunk cross sectional and fruit yield

	Annual increase of TCSA (cm ²)				Fruit yield (t/ha)			
	'Decosta Jonagold de Coster'	'Red Braeburn'	'Golden Reinders Delicious'	Fertilizer effect	'Decosta Jonagold de Coster'	'Red Braeburn'	'Golden Reinders Delicious'	Fertilizer effect
Unfertilized	11.16 ^{ab*}	11.72 ^{ab}	11.26 ^a	11.32 ^a	55.62 ^a	49.11 ^c	50.65 ^b	52.36 ^b
Cifamin BK 1.5 l/ha	10.51 ^b	12.11 ^{ab}	10.96 ^a	11.01 ^a	53.89 ^a	73.42 ^a	66.44 ^a	62.82 ^a
Megafol 0.2%	11.42 ^{ab}	12.36 ^a	11.45 ^a	11.66 ^a	55.12 ^a	52.37 ^{bc}	55.89 ^b	54.74 ^b
Biohumus 2 l/tree	12.05 ^a	10.68 ^b	11.63 ^a	11.56 ^a	45.19 ^b	59.71 ^b	55.72 ^b	52.56 ^b

*according to Duncan Multiple Range Test ($p \leq 0.05$)

As figure 1 presents, the correlation between fruit yield and the annual increase of trunk cross-sectional area represented for all three cultivars, depending on fertilization treatment was generally significantly negative, linear for unfertilized variant, Megafol and Biohumus, and polynomial grade 2 for Cifamin. As both processes - growth and production - are fed from the same source of carbohydrates, production being a priority when production decreased, the tree growth increased almost proportionally for unfertilized variants, Megafol and Biohumus. In the area of very small increases, caused by an overload of fruit on the tree, the highest yields were obtained when applying Cifamin BK (averages around 100 t/ha), followed by Megafol with average yields of just over 80t/ha. In the other variants, average yields below 80 t/ha were obtained. When the annual increases of TCSA had average values (5-10 cm²), the average productions of the 4 variants were approximately equal, being comprised, according to the straight lines and the regression curve between 30 and 60 t/ha. In the area of the lowest fruit production (below 20 t/ha), the average increases on the experimental variants were over 12 cm², up to about 17 cm². In the absence of a sufficient number of fruits (trees in the year without fruit, or with very little fruits), the largest average increases of annual TCSA (18-20 cm²) were also recorded in the version treated with Cifamin, proofing that the trees had a plus of carbohydrates (assimilated) that they used mainly for the growth processes in TCSA.

For the 'Decosta Jonagold de Coster' cultivar (Figure 2), the correlation between vegetative growth and fruit yield was negative, significant, and polynomial for all the treatments. In the field of small growth (between 1 and 5 cm²) the highest yields were obtained when applying Cifamin BK (yields over 100 t/ha), followed by Megafol and Biohumus, with average yields just under 100 t/h. When the annual increases of SSTS had average values (5-10 cm²), the average productions of Cifamin BK and Biohumus variants were similar and under-average, being comprised, according to the straight lines and regression curve between 20 and 55 t/ha. Superior yields in conditions of average annual increase were obtained in the non-fertilized and the fertilized variant with Megafol, respectively 30-70 t/ha. For the lowest fruit production (under 20 t/ha), increases of up to 14.5 cm² were recorded for all variants except Cifamin BK, in which the TTSS increase exceeded 20 cm².

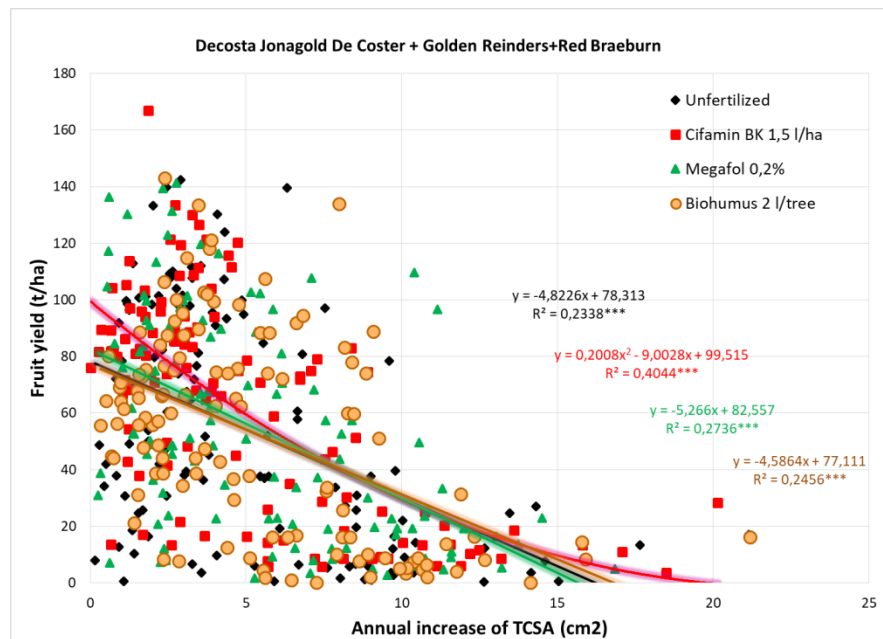


Figure 1. The correlation between fruit yield and the annual increase of trunk cross sectional area of all three apple cultivars on every fertilizer treatment

In the absence of adequate fruit production (trees in the year without fruit, or with very little fruit), the highest average increases (18-20 cm²) were also registered for Cifamin BK treatments. In the case of the 'Red Braeburn' cultivar (Figure 3), it is observed, first of all, that it has low vegetative growth, below 9 cm², compared to the others. Also, the correlations between the increase in trunk thickness and fruit production are polynomial, except for the untreated variant, in which the correlation is linear and positive, but they are not statistically assured. The highest yield (68-90 t/ha) was obtained in the Cifamin BK-treated variant, especially for low STT increases. There is a limitation of vegetative growth in the non-fertilized version (less than 7 cm²). For all treatment, at 'Red Braeburn', the photoassimilates were directed towards both vegetative growth and fruit yield. For the 'Golden Reinders Delicious' cultivar (Figure 4), the correlation between growth and fruiting processes is significantly negative and polynomial for all fertilization variants, except for Biohumus. For this cultivar, fruit production is mainly distributed in the area of vegetative growth below 10 cm². Thus, the highest fruit productions were obtained in terms of reducing the increase in trunk thickness (0-5 cm²) in Cifamin BK treatment (slightly over 100 t/ha), followed very closely by the non-fertilized variant and the Megafol. In the field of above-average growth, fruit production falls below 20 t/ha for fertilized varieties and is close to 0 for non-fertilized. At the same time, there is a limitation of vegetative growth, even in the absence of fruiting in the non-fertilized version, and an increase in vegetative growth, in low fruiting, superior to bio humus, followed by Cifamin BK.

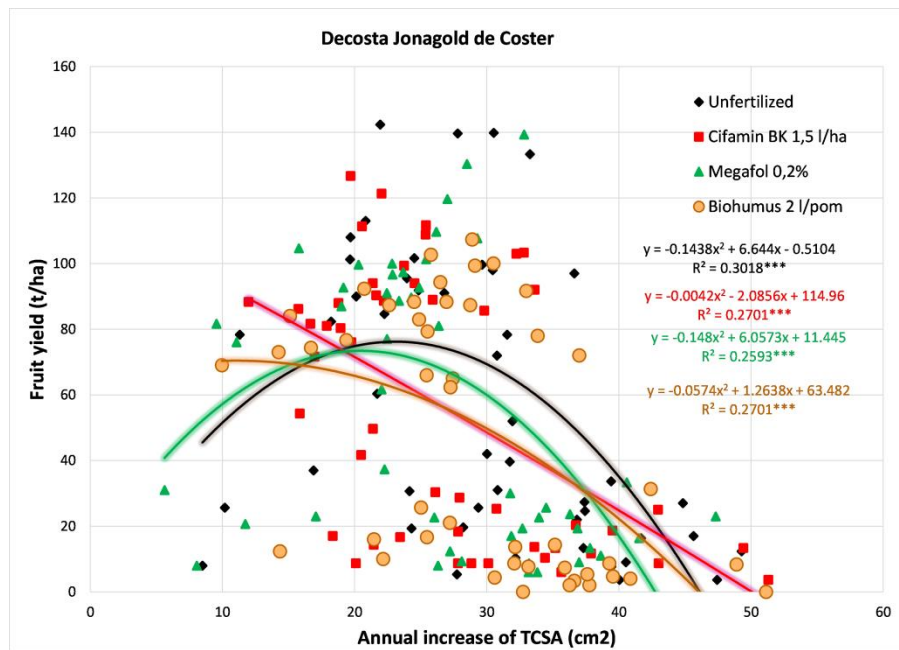


Figure 2. The correlation between fruit yield and the annual increase of trunk cross sectional area of 'Decosta Jonagold' apple cultivar on each fertilizer treatment

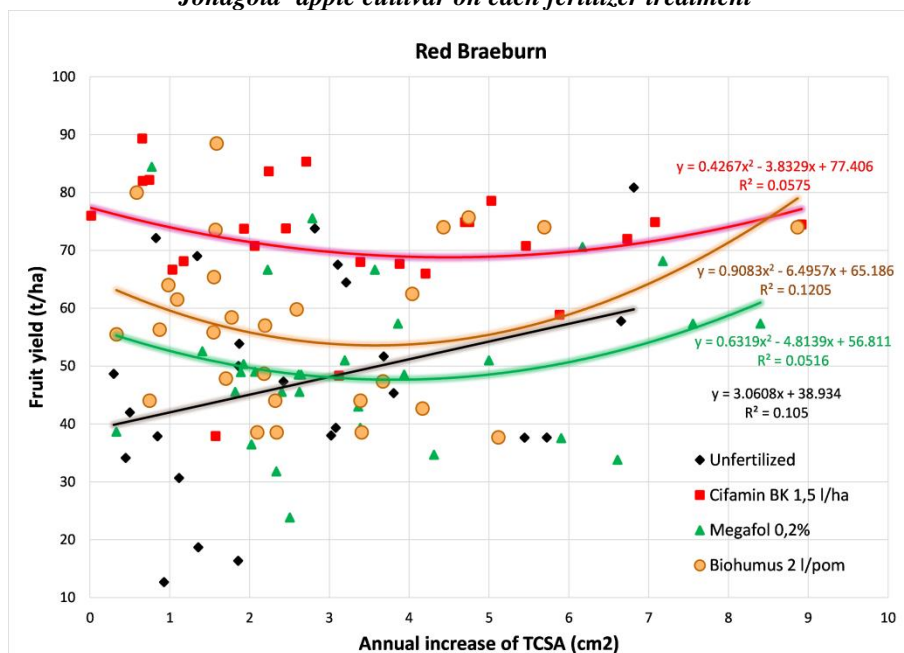


Figure 3. The correlation between fruit yield and the annual increase of trunk cross sectional area of 'Red Braeburn' apple cultivar on each fertilizer treatment

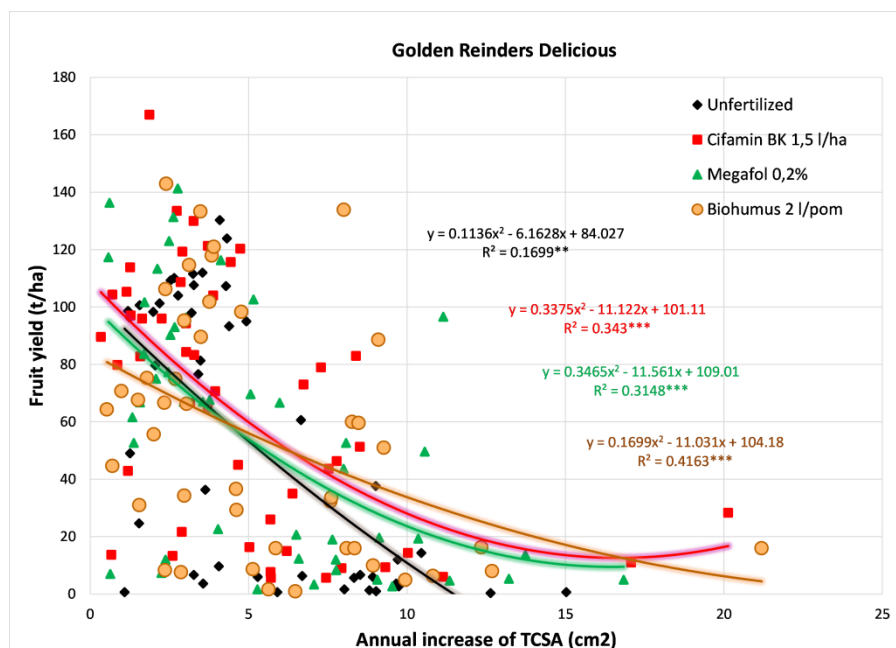


Figure 4. The correlation between fruit yield and the annual increase of trunk cross sectional area of 'Golden Reinders' apple cultivar on each fertilizer treatment

The statistical descriptors of fruit quality data are presented in Table 3. For the three studied cultivars, fruit weight fluctuated between 74.13 and 558.76 g, averaging 173.22 g. Pulp firmness, juice pH, and total soluble solids (TSS) averaged respectively 76.50 HPE-FFF Bareiss units (53.60-89.10, 3.55 (3.09-4.68), and 13.30°Brix (9.45-18.20). Among fruit quality indicators, fruit weight fluctuated significantly when organic fertilizers were applied (Table 4). Fruit weight increased in all three fertilization treatments on 'Decosta Jonagold de Coster' and 'Red Braeburn', although no significant effect was registered for 'Golden Reinders Delicious'. The highest fruit weight increase, by 9.1%, was obtained from 'Red Braeburn' treated with Megafol. A non-significant fluctuation of pulp firmness from 76.11 to 76.86 HPE-FFF Bareiss units was registered. Fertilizer treatments resulted in a different effect on fruit firmness depending on the cultivar (Table 4). Therefore, a reduced firmness was registered on 'Decosta Jonagold de Coster', for Megafol and Cifamin BK (by 2.1-3.8%), and on 'Red Braeburn' for Megafol treatment (by 2.3%). Though, the same fertilization treatment (Megafol) improved fruit firmness, by 2.5%, on 'Golden Reinders Delicious'.

Organic fertilization did not show a main effect on juice pH (Table 5). Between cultivars, only for 'Decosta Jonagold de Coster' was registered a significant pH increase (by 1.7%) compared to the untreated variant, related to Megafol and Cifamin BK treatments. As Table 5 presents, on average, TSS increased significantly between 12.96 (untreated variant) and 13.46°Brix (Cifamin BK). Among the three cultivars, the only significant effect of fertilization was registered for 'Red Braeburn' and resulted in a similar TSS increase in all fertilized variants (by 3.9-5.4%).

Table 3. Statistical descriptors for fruit quality indicators (fruit weight, pulp firmness, juice pH and TSS)

		Fruit weight (g)	Pulp firmness (HPE-FFF Bareiss units)	Juice pH	TSS (°Brix)
N	Valid	2880	960	960	960
	Missing	0	1922	1920	1921
Mean		173.22	76.50	3.55	13.30
Median		161.30	76.20	3.55	13.15
Mode		129.60 ^a	76.60 ^a	3.50	12.30
Std. Deviation		51.33	6.30	0.18	1.47
Range		484.63	35.50	1.59	8.75
Minimum		74.13	53.60	3.09	9.45
Maximum		558.76	89.10	4.68	18.20

a. Multiple modes exist. The smallest value is shown

Table 4. Effect of fertilization treatment on cultivar levels over fruit weight and pulp firmness

	Fruit weight (g)				Pulp firmness (HPE-FFF Bareiss units)			
	'Decosta Jonagold de Coster'	'Red Braeburn'	'Golden Reinders Delicious'	Fertilizer effect	'Decosta Jonagold de Coster'	'Red Braeburn'	'Golden Reinders Delicious'	Fertilizer effect
Unfertilized	205.33 ^{b*}	137.50 ^c	157.15 ^a	166.66 ^b	75.04 ^a	83.57 ^a	71.93 ^b	76.86 ^a
Cifamin BK 1.5 l/ha	219.13 ^a	144.46 ^b	157.16 ^a	173.59 ^a	72.21 ^b	83.38 ^a	72.74 ^{ab}	76.11 ^a
Megafof 0.2%	221.57 ^a	150.00 ^a	157.79 ^a	176.45 ^a	73.45 ^b	81.66 ^b	73.70 ^a	76.28 ^a
Biohumus 2 l/tree	223.17 ^a	146.01 ^b	159.40 ^a	176.19 ^a	73.65 ^{ab}	83.34 ^a	73.29 ^{ab}	76.76 ^a

*according to Duncan Multiple Range Test ($p \leq 0.05$)

Table 5. Effect of fertilization treatment on cultivar levels over the juice pH and total soluble solids

	Juice pH				TSS (°Brix)			
	'Decosta Jonagold de Coster'	'Red Braeburn'	'Golden Reinders Delicious'	Fertilizer effect	'Decosta Jonagold de Coster'	'Red Braeburn'	'Golden Reinders Delicious'	Fertilizer effect
Unfertilized	3.54 ^{b*}	3.43 ^a	3.68 ^{ab}	3.55 ^a	13.06 ^a	12.65 ^b	13.16 ^a	12.96 ^b
Cifamin BK 1.5 l/ha	3.60 ^a	3.40 ^a	3.70 ^a	3.57 ^a	13.37 ^a	13.36 ^a	13.66 ^a	13.46 ^a
Megafof 0.2%	3.59 ^a	3.39 ^a	3.64 ^b	3.54 ^a	13.41 ^a	13.16 ^a	13.63 ^a	13.40 ^a
Biohumus 2 l/tree	3.57 ^{ab}	3.42 ^a	3.64 ^b	3.54 ^a	13.39 ^a	13.25 ^a	13.45 ^a	13.36 ^a

*according to Duncan Multiple Range Test ($p \leq 0.05$)

The intensity of the correlations between the fruit quality indicators, presented in Table 6, indicates that the fruit weight increased as the pulp firmness decreased ($r=-0.511^{ooo}$) and the pH and total soluble content increased ($r=0.223^{***}$, $r=0.375^{***}$). A negative correlation between firmness and both pH and TSS ($r=-0.642^{ooo}$, $r=-0.332^{ooo}$) was also highlighted.

Table 6. Correlation matrix between fruit quality indicators

		Pulp firmness	Juice pH	TSS
Fruit weight	Pearson Correlation	-0.511 ^{ooo}	0.223 ^{***}	0.375 ^{***}
	Sig. (2-tailed)	0.000	0.000	0.000
Pulp firmness	Pearson Correlation	1.000	-0.642 ^{ooo}	-0.332 ^{ooo}
	Sig. (2-tailed)		0.000	0.000
Juice pH	Pearson Correlation		1.000	0.315 ^{***}
	Sig. (2-tailed)			0.000

**Correlation is significant at the 0.01 level (2-tailed);

***Correlation is significant at the 0.001 level (2-tailed).

All three fertilizers studied in the present experiment contained compounds belonging biostimulants group. According to Al-Juthery et al. (2020), the plant biostimulants currently accepted include extracts of seaweed, humic substances (humic acids and fulvic acids), chitin and chitosan derivatives, amino acids, protein hydrolysates, and microorganisms, and are classified as substances which have increased the positive effects on growth and productivity when applied to plants, improve resistance against biotic and abiotic stresses and increased post-harvest shelf life. Among them, seaweed extracts and humic acids are widely studied for their role in plant growth promotion (Al-Juthery et al., 2020). Moreover, seaweed extracts can also improve nutrient uptake by the roots (Crouch et al., 1990).

Frequently in literature similar results as ours regarding vegetative growth, fruit yield, and quality are reported. In the tryptophan and glycine foliar applications performed by Mosa et al. (2021) on 'Anna' apple trees' fruit yield, the vegetative growth (shoot length and diameter) and fruit quality (weight, TSS, firmness etc.) were significantly increased. Fruit yield, fruit weight increasing and fruit quality improving (higher TSS and lower acidity) on 'Generos', 'Redix', 'Golden Delicious' and 'Granny Smith' cultivars fertilized with commercial fertilizers containing aminoacids were also reported in Ilie et al. (2017; 2018) and Arabloo et al. (2017) experiments. Kai and Adhikari (2021) also reported a significant increase of fruits sugar content in organic fertilized variant compared to conventional chemical fertilizer treatment.

Soppelsa et al. (2018) tested on 'Jonathan' cultivar several biostimulants, including humic acids, macro and micro seaweed extracts, alfalfa protein hydrolysate, amino acids alone or in combination with zinc, B-group vitamins, chitosan and a commercial product containing silicon. Authors reported that the foliar application of macroseaweed extract was effective in stimulate tree growth potential, as shown by increasing leaf area (in both experimental years) and by a higher chlorophyll content and leaf photosynthetic rate (in the first experimental year). No fruit quality improvement was reported related to fertilization treatments.

The sugar and soluble solids content of the 'Kosui' Japanese pear fruit was increased by the foliar treatment with L-proline, but the fruit size and weight were not influenced (Takeuchi et al., 2007). The seaweed-based treatments had a positive effect on fruit yield, increased fruit weight and their sugar content but had no effect on fruit acidity in Tamás et al. (2019) study. The soil application of

vegetal amino acids, increased the trunk thickness and height for both 'Topaz' and 'Ariwa' cultivars grown in apple nurseries (Grzyb et al., 2012).

Contrarily, in other research, no differences in crop yield or fruit quality (fruit size, colour, fruit firmness, sugar content, acidity) were reported regardless biostimulant applications on apple cultivars ('Braeburn', 'Golden Delicious', 'Fuji') in high-density apple orchards (Thalheimer and Paoli, 2002). Similarly, in Malaguti et al. (2001) experiment, foliar sprays with seaweed extracts-based (brown algae, *Fucus* spp) did not affect fruit yield, fruit weight, and vegetative growth, in 'Mondial Gala' and 'Fuji' cultivars.

4. CONCLUSIONS

Overall, mineral fertigation supplemented with organic biostimulators and fertilizers improved both fruit yield and quality (in Cifamin and Biohumus treatments), while mineral fertigation supplemented with the foliar Megafol treatment, enhanced fruit quality. In particular, Cifamin BK increased fruit yield ('Red Braeburn' and 'Golden Reinders Delicious') and improved fruit quality: higher fruit weight ('Decosta Jonagold de Coster' and 'Red Braeburn'), TSS ('Red Braeburn'), and juice pH ('Decosta Jonagold'). Biohumus increased fruit yield ('Decosta Jonagold de Coster' and 'Red Braeburn') and improved fruit quality: higher fruit weight ('Decosta Jonagold de Coster' and 'Red Braeburn'), TSS ('Red Braeburn'), and juice pH ('Decosta Jonagold'). Megafol improved fruit quality: higher fruit weight ('Decosta Jonagold de Coster' and 'Red Braeburn'), TSS ('Red Braeburn'), pulp firmness ('Golden Reinders Delicious'), and juice pH ('Decosta Jonagold de Coster'). Our results showed that additional fertilizations based on both aminoacids-brown algae extract combination (Cifamin BK) and humic acids (Biohumus) stimulated quantitatively and qualitatively the production of fruit, while the combination of aminoacids and growth factors (Megafol) acted as a fruit quality enhancer. Finally, by selecting an adequate mineral and organic fertilization program could improve the economic efficiency of apple orchards.

5. ACKNOWLEDGEMENTS

This paper was supported by a grant of the Academy of Agricultural and Forestry Sciences "Gheorghe Ionescu-Șișești" (AAFS) Bucharest, Romania, Thematic Plan - project number 3193/24.09.2018.

6. REFERENCES

- Al-Juthery, H.W., Drebee, H.A., Al-Khafaji, B.M., Hadi, R.F. (2020, August). Plant biostimulants, seaweeds extract as a model (article review). In *IOP Conference Series: Earth and Environmental Science* (Vol. 553, No. 1, p. 012015). IOP Publishing.
- Arabloo, M., Taheri, M., Yazdani, H., Shahmoradi, M. (2017). Effect of foliar application of amino acid and calcium chelate on some quality and quantity of Golden Delicious and Granny Smith, *Trakia Journal of Sciences*, 1, 14-19.
- Baruah, A., Baruah, K.K., Bhattacharyya, P. (2016). Comparative effectiveness of organic substitution in fertilizer schedule: Impacts on nitrous oxide emission, photosynthesis and crop productivity in a tropical summer rice paddy. *Water Air Soil Pollut*, 227, 410.
- Chatzistathis, T., Kavvadias, V., Sotiropoulos, T., Papadakis, I. E. (2021). Organic fertilization and tree orchards. *Agriculture*, 11(8), 692.
- Chen, J.H. (2006, October). The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. In *International workshop on sustained management of the soil-rhizosphere system for efficient crop production and fertilizer use*, Vol. 16, No. 20, 1-11. Land Development Department Bangkok Thailand.

- Crouch, I.J., Beckett, R.P., van Staden, J. (1990). Effect of seaweed concentrate on the growth and mineral nutrition of nutrient stressed lettuce. *Journal of Applied Phycology*, 2, s. 269-272.
- Grzyb, Z.S., Bielicki, P., Piotrowski, W., Paszt, L.S., Malusa, E. (2012). Effect of some organic fertilizers and amendments on the quality of maidens trees of two apple cultivars. Proc. 15th Intern. Konfer. on *Organic Fruit Growing*, Univ. oh Hohenheim, Germany, 410-414.
- Hazra, G. (2016). Different types of eco-friendly fertilizers: An overview. *Sustainability in Environment*, 1(1), 54.
- Ilie, A.V., Petrișor, C., Hoza, D. (2017). Influence of foliar application of amino acids to yield and quality attributes of apple. *Journal of Horticulture, Forestry and Biotechnology*, 21(3), 104-107.
- Ilie, A.V., Petrișor, C., Hoza, D. (2018). Effect of different amino acid foliar fertilizers on yield and fruit quality of 'Redix' apple cultivar. *Scientific Papers*, 101.
- Kai, T., Adhikari, D. (2021). Effect of organic and chemical fertilizer application on apple nutrient content and orchard soil condition. *Agriculture*, 11(4), 340.
- Kurešová, G., Menšík, L., Haberle, J., Svoboda, P., Raimanova, I. (2019). Influence of foliar micronutrients fertilization on nutritional status of apple trees. *Plant, Soil and Environment*, 65(6), 320-327.
- Malaguti, D., Rombolà, A.D., Gerin, M., Simoni, G., Tagliavini, M., Marangoni, B. (2001, September). Effect of seaweed extracts-based leaf sprays on the mineral status, yield and fruit quality of apple. In *International Symposium on Foliar Nutrition of Perennial Fruit Plants 594* (pp. 357-359).
- Masunaga, T., Fong, J.D.M. (2018). Strategies for increasing micronutrient availability in soil for plant uptake. In *Plant Micronutrient Use Efficiency* (pp. 195-208). Academic Press.
- Mosa, W.F., Ali, H.M., Abdelsalam, N.R. (2021). The utilization of tryptophan and glycine amino acids as safe alternatives to chemical fertilizers in apple orchards. *Environmental Science and Pollution Research*, 28(2), 1983-1991.
- Soppelsa, S., Kelderer, M., Casera, C., Bassi, M., Robatscher, P., Andreotti, C. (2018). Use of biostimulants for organic apple production: effects on tree growth, yield, and fruit quality at harvest and during storage. *Frontiers in plant science*, 1342.
- Suman, M., Sangma, P.D., Meghawal, D.R., Sahu, O. P. (2017). Effect of plant growth regulators on fruit crops. *Journal of Pharmacognosy and Phytochemistry*, 6(2), 331-337.
- Takeuchi, M., Arakawa, C., Kuwahara, Y., Gemma, H. (2007, May). Effects of L-proline foliar application on the quality of 'Kosui' Japanese pear. In *X International Pear Symposium 800* (pp. 549-554).
- Tamás, N.P., Ádám, C., Anita, S. (2019). Effects of algae products on nutrient uptake and fruit quality of apple. *Natural Resources and Sustainable Development*, 9.
- Thalheimer, M., Paoli, N. (2001, September). Effectiveness of various leaf-applied biostimulants on productivity and fruit quality of apple. In *International Symposium on Foliar Nutrition of Perennial Fruit Plants 594* (pp. 335-339).
- Williams, G., Williams, P. (1998). Plant therapy. *Plants & Gardens News*. Winter. p.2.