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YIELD AND FRUIT QUALITY OF SOME PLUM CULTIVARSIN ECOLOGICAL SYSTEM

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ABSTRACT

The aim of this study was to assess the yield and fruits quality of plum produced in ecological system.In 2019-2020 periods the influence of different fertilizers (Biohumus, Macys BC 28 and Cifamin BK) on yield and fruits quality at three plum cultivars ('Centenar', 'Tita' and 'Stanley') was carried out in a demonstrative plot from Research Institute for Fruit Growing Piteşti, Romania. Biohumus was applied to the soil in increasing dosesfrom 0.5 l/tree (respectively 415 l/ha), 0.7 l/tree (respectively 585 l/ha) to 0.9 l / tree (respectively 750 l/ha) in two moments: in spring before the start of vegetation and in autumn after the fall of the leaves.Macys BC 28 and Cifamin BK fertilizers were applied foliar in doses of 2 l/ha, respectively 1 l/ha, in two moments: after flowering and in the young fruit phase.As results of the investigations we found that: the highest fruit yield was obtained at 'Centenar' (47.36 kg/tree) and 'Stanley' (41.00 kg/tree) cultivars in fertilization variant 3 (Biohumus – 0,9 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application);the best results regarding the fruits weight were also obtained in the 3rd fertilization variant (Biohumus – 0,9 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application), among the varieties being noted the 'Tita'cv. with an average fruit weight of 59. 14 g; the fruits soluble solid content was higher in the case of the fertilized variants than in the unfertilized variant and the fruits aciditywas higher in the case of the unfertilized variant than in the fertilized variants.

Keywords: plum, cultivar, fertilizers, yield, fruits quality.

INTRODUCTION

In the last decade, demand for ecological products by European consumer's increased (Amarante et al., 2008, Cuevas et al., 2015).
Consumers have started to look for safer and better controlled foods produced in more environmentally friendly. Ecological produced foods are widely believed to satisfy the above demands, leading to lower environmental impacts and higher nutritive values.
European Union guidelines' regarding ecological management practices exclude the use of synthetic pesticides and fertilizers, allowing the use of animal and green manures, compost, sulfur and copper products, botanical insecticides, traps and other biological control methods (Holb et al., 2003, Peck et al., 2006, Jonsson, 2007, Amarante et al., 2008).
Ecological plum production is still quite limited in most countries (including Romania), due mainly to the inadequate control of pests, diseases and weeds with organic alternatives. Regarding fertilization, in ecological system we can use compost, green fertilizers, manures

or other fertilizers certified for biological application (Yadav et al., 2000, Hristova et al., 2017).
Ecological agriculture has the potential to reduce the impacts of agriculture on humans and ecosystems, but it has been claimed that organic production system are less efficient, fruits production being lower than in the conventional production system (McArtney and Walker, 2004;Talamini do Amarante et al., 2008; Malezieux et al., 2018).
The major reason to choose organically grown fruits, besides the concern for environmental issues, is the improvement of fruits quality. Several articles show that ecological fruits have a higher content in micronutrients, phenolic compounds, vitamins etc. (Young et al., 2005, Raigon et al., 2010, Cuevas et al., 2015).
The aim of this paper was to evaluate yield and some important quality parameters of three plum cultivars from orchards managed under ecological system.

MATERIALS AND METHODS

The experimental field was established in 2009at RIFG Piteşti – Mărăcineni. Three plum cultivars grafted on 'Myrobalan C5' rootstock were planted in a spacing of 4 m between the rows and 3 m between trees, according to the following experimental scheme: Factor A – cultivar, with three graduation (a1-'Centenar',a2-'Tita' and a3-'Stanley'); Factor B – fertilization variant, with four graduations (b1-Biohumus – 0,5 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application; b2 - Biohumus – 0,7 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application; b3 – Biohumus – 0,9 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application; b4 – 'Unfertilized').
Biohumus is a 100% organic fertilizer, produced with the help of earthworms, which stimulates the yield, growth and health of trees.In the plum demonstration plot, soil fertilization with Biohumuswas carried out in increasing doses, from 0.5 l/tree (respectively 415 l/ha), 0.7 l/tree (respectively 585 l/ha) to 0.9 l / tree (respectively 750 l/ha) in 2019 – 2020 in two moments: in spring before the start of vegetation and in autumn after the fall of the leaves.
Macys BC 28 is a fertilizer based100% on the algae*Macrocystisintegrifolia*, which stimulates root development, vegetative growth, flowering and fruiting, in also the fruits size and quality.Macys BC 28 fertilizer was applied foliar in 2019 – 2020 in doses of 2l/ha, in two moments: after flowering and in the young fruit phase.
Cifamin BK is a special fertilizer based also on the algae *Macrocystisintegrifolia*, very rich in organic components, indicated for improving the size and fruits quality, keeping fruit and firmness unaltered, ensuring optimal shelf-life.Cifamin BKfertilizer was also applied foliar in 2019 – 2020 in doses of 1 l/ha, also in two moments: after flowering and in the young fruit phase.
Foliar fertilizers, Macys BC 28 and Cifamin BK were dissolved in 500 l water.
The experiment was carried out in a randomized block design, in 3 replications with 3 trees per plot.
In 2019 - 2020 periods, the following measurements were carried out: fruits yield in kg/tree; mean fruits weight in g; soluble solids content of fruits with a digital refractometer in % Brix; malic acidcontent of fruitsin % or g/100 g fresh matter with the device Minititrator Hanna Instrument 84532; fruits firmness was measured with non-destructive penetrometer Qualitest HPE equipped with a plunger of diameter 0.10 cm.
The results of the experiment were analyzed statistically using Duncan's multiple range test at a 0.05% significance level.

RESULTS AND DISCUSSIONS

The influence of factor A (cultivar) on fruits yield

Regarding the fruitsyield, in kg/tree, it can be observed that, on average, on the 4 fertilization variants, the 'Centenar'cv. registered the highest fruit production (39.20 kg/tree) significantly exceeding the 'Stanley' and 'Tita'cvs. (with 6.68 kg/tree in the case of 'Stanley' cv. and with 10.48 kg/tree in case of 'Tita' cv.). Also, fruit yield on the 'Stanley'cv. compared to the 'Tita'cv. was significantly higher by 3.8 kg/tree (Table 1).

The influence of factor B(fertilization variants) on fruits yield

On average, on the three cultivars studied, between the fertilized and unfertilized variants there are significant differences.The fruits production per tree increased with increasing Biohumus doses (from 31.82 kg/tree in V1 to 39.58 kg/tree in V3). Thus, the fertilization variant 3 determined a higher fruit production than the other variants, respectively 39.58 kg/tree, exceeding the fruits production obtained in V1 with 7.76 kg/tree, with 7.62 kg/tree inV2 and with 9.03 kg/tree in unfertilized variant (Table 1).

In conclusion, the highest fruits production was obtained on 'Centenar' (39.58 kg/tree) and 'Stanley'cvs. in fertilization variant 3 - Biohumus – 0,9 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application.

Even if it is not the subject of this paper, in order to see if the ecological fertilization is efficient, the fruit production obtained at the three varieties in ecological system was compared with the one obtained in conventional system. We find that yields in ecological systems were on average 10 to 20% lower than those in conventional orchard, results obtained by other authors like McArtney and Walker (2004), Amarante et al. (2008), Malezieux et al. (2018).

Table 1. Influence of the fertilizers on the yield (kg/tree)

No.	Cultivar	Fertilization variant				
		V1	V2	V3	V4	Average
1	Centenar	37.05	37.31	47.36	35.07	**39.20 a**
2	Tita	29.87	27.69	30.39	26.94	**28.72 c**
3	Stanley	28.56	30.89	41.00	29.63	**32.52 b**
	Average	**31.82 b**	**31.96 b**	**39.58 a**	**30.55 b**	

Duncan multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P>0.05).

The influence of factor A (cultivar) on fruitsweight

The highest value of fruits weight was recorded onthe 'Tita'cv., which significantly exceeded the average fruit weight of the 'Centenar'cv. by 20 g and the 'Stanley' cv. by 18.84 g (Table 2).

The influence of factor B (fertilization variants) on fruitsweight

The fruit weight was influenced by the fertilization variants at all cultivars studied. It can be seen from Table 2 that in the four different formula fertilization treatments, variant 3 has the best effect, and the average fruit weight per fruit is the largest reaching 48.96 g on average, being very significant differences between V3 and unfertilized variant.

The highest fruitsweight was obtained on 'Tita' cv. (64.47 g) in fertilization variant 3 - Biohumus – 0,9 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + CifaminBK – 1 l/ha, foliar application (Table 2).

Table 2. Influence of the fertilizers on the fruits weight (g)

No.	Cultivar	Fertilization variant				
		V1	V2	V3	V4	Average
1	Centenar	39.53	38.53	40.67	37.70	**39.11 b**
2	Tita	57.23	60.97	64.47	53.90	**59.14 a**
3	Stanley	38.67	42.20	41.73	38.60	**40.30 b**
	Average	**45.14 bc**	**47.23 ab**	**48.96 a**	**43.40 c**	

Duncan multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P>0.05).

The influence of factor A (cultivar) on fruitssoluble solids content

A more significant difference was found in fruits soluble solids content. The results obtained are ranged from 16.15% Brix at 'Tita' cv. and 12.22% Brix at 'Stanley' cv., between cultivars being significantly difference (Table 3).

The influence of factor B (fertilization variants) on fruits soluble solids content

The three different fertilization variants have a greater influence on the fruits quality of the all plum cultivars studied, compared with unfertilized variant.

The highest values were found in all three fertilization variants (over 14% Brix), while in the unfertilized variant the content of fruits in soluble solids content was much lower (12.68% Brix).

In case of this trait, the best results were obtained on 'Tita' cv. in fertilization variant 1 - Biohumus – 0,5 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application.

Table 3. Influence of the fertilizers on the fruits soluble solids content (% Brix)

No.	Cultivar	Fertilization variant				
		V1	V2	V3	V4	Average
1	Centenar	13.27	14.54	14.60	12.37	**13.70 b**
2	Tita	17.27	17.23	15.63	14.47	**16.15 a**
3	Stanley	12.49	11.52	13.67	11.20	**12.22 c**
	Average	**14.34 a**	**14.43 a**	**14.63 a**	**12.68 b**	

Duncan multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P>0.05).

The influence of factor A (cultivar) on content of fruits in malic acid

The highest content of fruits in malic acid was recorded 'Tita'cv. (0.53 g/100 g fresh matter), which significantly exceeded the 'Centenar'cv. by 0.17 g/100 g fresh matter and the 'Stanley' cv. by 0.24 g/100 g fresh matter (Table 4).

The influence of factor B (fertilization variants) on content of fruits in malic acid

The content of fruits in malic acid ranged from 0.47% in unfertilized variant to 0.36%in variant 2 (Biohumus – 0,7 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application). In all fertilization variants the fruits acidity was lower than in unfertilized variant (Table 4). The same results obtained Hristova et al. (2017) at plum cultivar 'Tegera'. Amarante et al. (2008) came to the conclusion that apple fruits from organic orchard had lower titratable acidity than fruit from conventional orchard.

The highest malic acid content was recorded on 'Tita' cv. in fertilization variant 1 - Biohumus – 0,5 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application.

Table 4. Influence of the fertilizers on the content of fruits in malic acid (g/100 g fresh matter)

No.	Cultivar	Fertilization variant				
		V1	V2	V3	V4	Average
1	Centenar	0.27	0.34	0.29	0.54	**0.36 b**
2	Tita	0.63	0.47	0.55	0.49	**0.53 a**
3	Stanley	0.26	0.27	0.26	0.39	**0.29 c**
	Average	**0.39 b**	**0.36 b**	**0.37 b**	**0.47 a**	

Duncan multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P>0.05).

The influence of factor A - cultivar on fruitsfirmness

Stanley' cv. had firmer fruits than 'Tita' cv. in all the fertilization variants, between these two cultivars being very significant differences.

The influence of factor B - fertilization variants on fruitsfirmness

The fruits of all cultivars studied had higher flesh firmness at harvest time in all fertilization variants than unfertilized variant (Table 5), results confirmed by other authors as well DeEll and Prange (1992), Reganold et al. (2001), Weibel et al. (2004), Peck et al. (2006) at apple. A significant difference is found between fertilization variant 1 and unfertilized variant (60.14 HPE units in V1 and 54.01 HPE units in V4) (Table 5). '

The 'Tita' cv. in fertilization variant 1 - Biohumus – 0,5 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + CifaminBK – 1 l/ha, foliar application, had the highest value of fruits firmness.

Table 5. Influence of the fertilizers on the fruits firmness (HPE units)

No.	Cultivar	Fertilization variant				
		V1	V2	V3	V4	Average
1	Centenar	62.22	62.53	54.68	61.07	**60.12 a**
2	Tita	51.22	48.88	53.68	48.68	**50.61 b**
3	Stanley	66.98	62.40	66.74	52.28	**62.10 a**
	Average	**60.14 a**	**57.94 ab**	**58.37 ab**	**54.01 b**	

Duncan multiple ranges test. Mean values followed by the same letter within a column are not significantly different (P>0.05).

There arevery significant correlations between: fruit weight and soluble solids content (Fig. 2); fruit weight and malic acid content; firmness and fruit weight (Fig. 3). There aredistinctly significant correlations between: yield and fruit weight (Fig. 1); fruit soluble solids content and firmness; fruit firmness and acid malic content; fruit soluble solids content and malic acid content. We find also significant correlations between: yield and fruit firmness; fruit weight and firmness; content of fruit in malic acid and yield (Table 6).

Table 6. Correlation coefficients r obtained between parameters studied

r	Yield (kg/tree)	Fruit weight (g)	SU (% Brix)	Firmness (units HPE)	Malic acid (g/100 g fresh matter)
Yield (kg/tree)	x	-0.4630**	-0.1233	0.3829*	-0.2766
Fruit weight (g)	-0.4441**	x	0.7824***	-0.4107*	0.7175***
SU (% Brix)	-0.0632	0.7228***	x	-0.4418**	0.5067**
Firmness (units HPE)	0.2510	-0.5996***	-0.4418**	x	-0.5066**
Malic acid (g/100 g fresh matter)	-0.4129*	0.6504***	0.5067**	-0.5066**	x

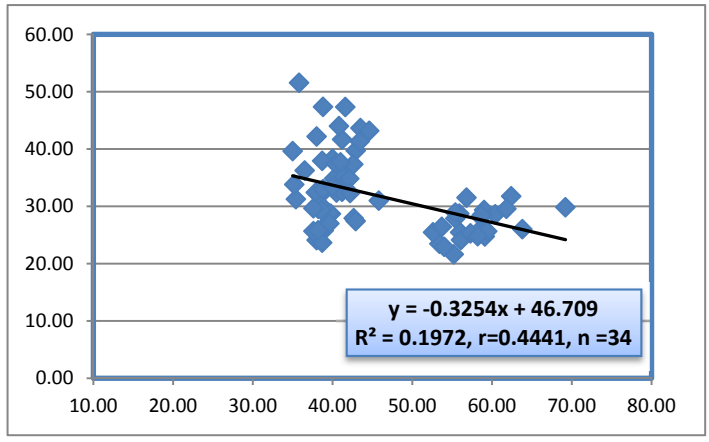

Figure 1. Significant correlation between fruit weight (g) and yield (kg/tree)

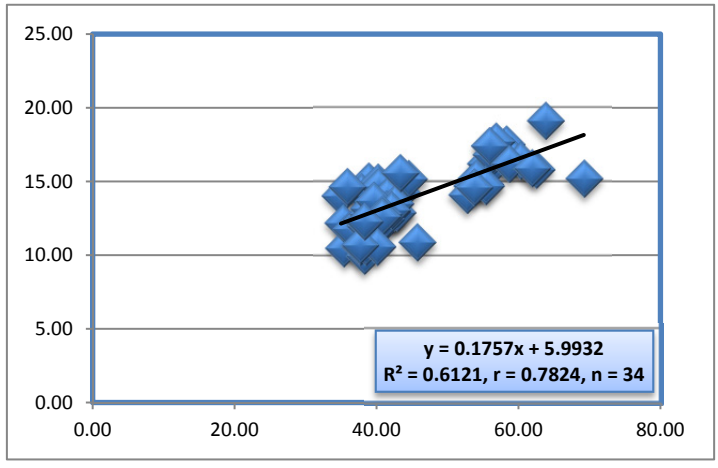

Figure 2. Significant correlation between fruit weight (g) and fruit soluble solids content (% Brix)

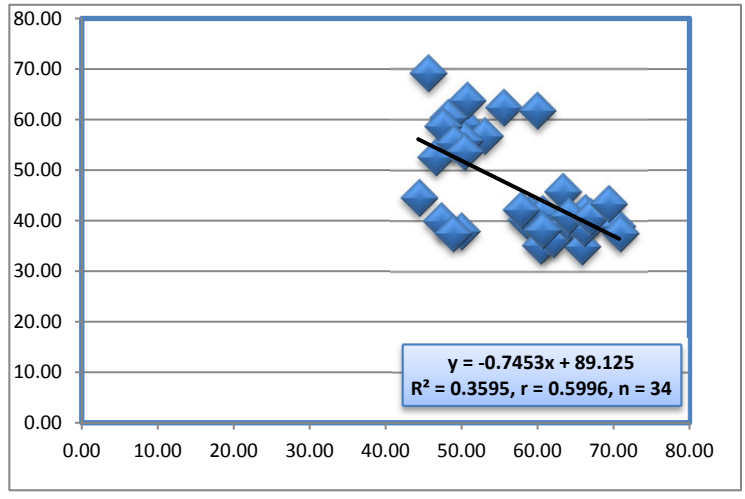

Figure 3. Significant correlation between firmness (HPE units) and fruit weight (g)

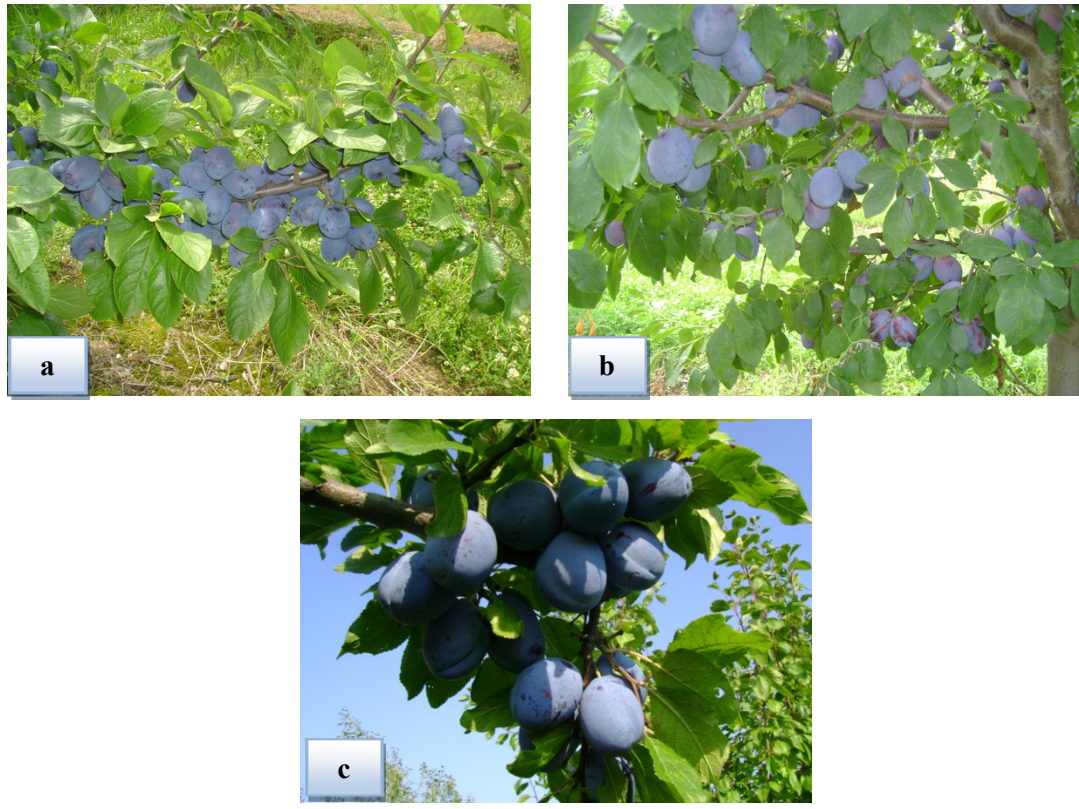

Figure 4. The fruit yield (kg/tree) of plum cultivars (a – 'Centenar', b – 'Tita', c – 'Stanley'') in fertilization variant 3 (Biohumus – 0,9 l/tree, soil application + Macys BC 28 – 2 l/ha, foliar application + Cifamin BK – 1 l/ha, foliar application)

CONCLUSIONS

- The major reason to choose organically grown fruits, besides the concern for environmental issues, is the improvement of fruits quality.
- As results of the investigations we found that:
- the highest fruits yield was obtained at 'Centenar' (47.36 kg/tree) and 'Stanley' (41.00 kg/tree) cultivars in fertilization variant 3 (Biohumus – 0,9 l/tree, ground application + Macys BC 28 – 2 l/ha, foliar application + Cyfamin BK – 1 l/ha, foliar application);
- The best results regarding the fruits weight were also obtained in the 3rd fertilization variant (Biohumus – 0,9 l/tree, ground application + Macys BC 28 – 2 l/ha, foliar application + Cyfamin BK – 1 l/ha, foliar application), among the varieties being noted the 'Tita' cv. with an average fruit weight of 59. 14 g;
- The fruits soluble solid content was higher in the case of the fertilized variants than in the unfertilized variant;
- The fruits acidity was higher in the case of the unfertilized variant than in the fertilized variants.
- The fruits of all cultivars studied had higher flesh firmness at harvest time in all fertilization variants than unfertilized variant.

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REFERENCES

1. Amarante C.V.T., Steffens C.A., Mafra Á.L., Albuquerque J.A. (2008).Yield and fruit quality of apple from conventional and organic production systems.Pesq.agropec. bras. vol.43 no.3 Brasília.
2. Cuevas F.J., Pradas I., Ruiz-Moreno M.J., Arroyo F.T., Perez-Romero L.F., Montenegro J.C., Moreno-Rojas J.M. (2015).Effect of organic and conventional management on bio-functional quality of thirteen plum cultivars (*Prunussalicina*Lindl.).PLos One, 2015; 10(8): e0136596.
3. DeEll J.R., Prange R.K (1993). Postharvest quality and sensory attributes of organically and conventionally grown apples.Hortscience , v. 73, p 223-230.
4. Holb I.J., Jong P.F. de,Heijne B. (2003). Efficacy and phytotoxicity of lime sulphur in organic apple production. Annals of Applied Biology, v.142, p.225-233.
5. Hristova D., Georgiev D., Brashlyanova B.,Ivanova P.(2017). Study on influence of some conventional and biological fertilizers on the biochemical composition of fresh and dried fruits of Tegera plum cultivar. 3rd International Symposium for Agriculture and food – ISAF, 2017, 19-25.
6. Jönsson Å.H. (2007). Organic apple production in Sweden: cultivation and cultivars. 33p. Thesis (Ph.D.) - Swedish University of Agricultural Sciences, Balsgård.
7. Malezieux E., Lesur-Dumoulin C., Ben-Ari T., Langlais C., Makowski D. (2018). Yield variability in organic versus conventional systems: a meta-analysis for horticultural systems. In: Boook of abstracts of the XV European Society for Agronomy Congress: Innovative cropping and farming systems for high quality food production systems, p. 52. Agroscope, Geneve, Suisse.
8. McArtney S.J. and Walker J.T.S. (2004). Current situation and future challenges facing the production and marketing of organic fruit in Oceania. ActaHorticulturae, v.638, p.387-396.
9. Peck G.M., Andrews P.K.,Reganold J.P. Fellman J.K. (2006). Apple orchard productivity and fruit quality under organic, conventional, and integrated management.HortScience, v.41, p.99-107.
10. RaigónMaD, Rodríguez-Burruezo An, Prohens J. (2010). Effects of organic and conventional cultivation methods on composition of eggplant fruits.Journal of Agricultural and Food Chemistry. 58(11):6833–40.
11. Reganold J.P., Glover J.D., Andrews P.K, Hinman H.R. (2001). Sustainability of three apple production systems. Nature, v. 410, p. 926-930.
12. Weibel F., Widmer F., Husistein A. (2004). Comparison of production systems: integrated and organic apple production. Part. III: Inner quality: composition and sensory. Obst-und Weinbau., v. 140, p. 10-13.
13. Yadav R.L., Dwivedi B.S, Pandey P.S (2000). Rice-wheat cropping system: assessment of sustainability under green manuring and chemical fertilizer inputs. Field Crop Res, 65: 15-30.
14. Young JE, Zhao X, Carey EE, Welti R, Yang S-S, Wang W. (2005). Phytochemical phenolics in organically grown vegetables.Molecular Nutrition & Food Research. 49(12):1136–42.
15. *** (2007). Regulation EC 834/2007.