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FARMING FOR TOMORROW - ENSURING ENVIRONMENT'S SUSTAINABILITY BY INCREASING COMPETITIVENESS FOR ORGANIC SYSTEM

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Abstract

The current strategies and programs encourage the urgent need to develop and exploit climate-resilient cultivars addressed to organic vegetable production systems and the imperative need to use friendly environmental methods for plant cultivation to decrease the negative impact of agriculture on human health and environment. The research's purpose was to develop a study in organic versus conventional system to detect and select the most productive and qualitative vegetable genotypes, able to perform under application of environmental friendly inputs. The rationale choice of species portfolio was based on our area market request for organic vegetables. The main differences between experimental plots were the cultural practices as soil preparation and its management during vegetation period, the applied products for fertilization, pest and disease control, according to each species characteristics.

Key words: *vegetables, biodiversity, friendly practices, yield, quality.*

INTRODUCTION

A comprehensive screening of literature, polices, and funded projects have emphasized the need for major changes in the global food system: agriculture must meet the twin challenge of feeding a growing population, with rising demand for meat and high-calorie diets, while simultaneously minimizing its global environmental impacts (Charles et al., 2010; Foley et al., 2011). Conventional agriculture produces about one third of global greenhouse gases using chemical inputs, machinery, and livestock (FAO, 2011a). It results in wind and water erosion from soil surface, loss of soil fertility, water holding capacity and desertification (FAO, 2011b). Pesticides and herbicides are accumulated in groundwater, pest and disease become resistant to one or more pesticides. It has been reported that harmful pesticides spray applied by the farming community contaminated nearly 10-15 percent of stored food during storage (Ali et al., 2015). Salinity affected million hectares land and caused potential yield reduction. Organic agriculture can act as an important tool in sustainable food production. Despite the efforts there are still some limitative factors which affect the organic yields and surfaces extinction. For this reason, a strong need for fully understood, alongside assessments of the many social, environmental, and economic benefits of organic farming systems is still requested. Organic yields are typically lower than conventional yields. But these yield differences are highly contextual, depending on system and site characteristics, and range from 5% lower organic yields (rain-fed legumes and perennials on weak-acidic to weak-alkaline soils), 13% lower yields (when best organic practices are used), to 34% lower yields (when the conventional and organic systems are most comparable).

Some vegetable species are more suitable to organic cultivation, than other. The yield is under the severe incidence of pests and pathogens which is more aggressive in organic system. Organic system enhanced optimal production level but with higher cost of cultivation (certification procedures, higher cost per unit of fertilizer, phytosanitary treatments applied, more labor etc.), compared with conventional farming (Ilić et al., 2014).

Organic tomatoes achieve higher prices and a guaranteed placement compared to conventional tomatoes (Kapoulas et al., 2011), because these products are often linked to better quality and low footprint on environment during cultivation. Ilić S. Z. et al., in 2014, conducted a study about the quality of tomato fruits from organic and conventional production which concluded that in general, the significant differences between tomatoes grown in organic or conventional production systems are that organic tomatoes contain more carotenoids, more minerals (P, K, Mg, Ca), contain far less heavy metals (Pb, Zn, Cu, Ni), less nitrates, about 30-40% less, and do not contain any pesticide residues. Depending of the cultivar and growing conditions ascorbic acid content is around 14.6 mg per 100 g of fresh red tomato (Abushita et al., 2000). A lot of intrinsic and extrinsic factors act commonly to imprint tomato quality as for example: choice of cultivar, seed quality, cultural practices, harvest time and method, storage, and handling procedures. Increased interest in organic tomato production imposed the need to evaluate the quality and nutritional value of organic tomato (Ilić S. Z. et al., 2014). Some studies have shown higher levels of bioactive compounds in organically produced tomato fruits compared to conventional ones, but not all studies have been consistent (Ordonez-Santos et al., 2011; Chassy et al., 2006).

A comparative study about morphological characteristics of some pepper genotypes in organic and conventional system was conducted by Bicikliski et al. (2018). In this experiment, in the organic system for plant nutrition were applied organic fertilizers, foliar organic fertilizer from sea algae (*Ascophyllum nodosum*) and 12% humic acid. In the conventional system were applied foliar plant nutrition PK (30:20) and NPK (15:15:15) fertilizers in combination with soil fertilization with NPK magnesium pellets.

Organic food is increasingly attracting the interest of consumers, as it is perceived to be healthier than food produced by conventional agriculture, and to be more sustainable for the environment. (Gomiero, 2018).

MATERIALS AND METHODS

The experiments were conducted at Vegetable Research and Development Station, Bacau. (2016, 2017, 2018). Laboratory and field experiments were set up. The open field experiments were conducted in 2015, 2016, 2017 and 2018. Location is placed at an elevation of 91 m, latitude 46.521946 N, longitude 26.910278 E., average annual temperatures during the experimental period averaged between 9 to 11°C. During the summer temperature reached 42°C. Precipitation ranged from 500 and 1100 mm per year.

The biological material was represented by genotypes of *Solanum lycopersicum, Capsicum annum, Cucumis melo, Zea mays* var. *sacharata, Cucurbita moschata*. The species and genotypes selection was based on market request for organic vegetables. The aim was to select the most appropriate varieties suitable to organic cultivation (yield and quality).

The experimental fields were established using genotypes which were investigated comparatively in both systems: conventional and certified organic farm (conformant to European laws). The main differences between cultivation systems were cultural practices, such as soil preparation and its management during vegetation period, the plant densities and the applied products for fertilization, pest and diseases control, according to each species characteristics. The differences between cultivation systems are highlighted in the table 1.

For each species, randomized plots were placed in organic and conventional conditions. The investigations related to the yield potential (t ha^{-1}) included the number of fruits/plants, weight of fruits/ plant, fruit shape and size, total yield. Pest and disease tolerance/resistance was accomplished to all experimental variants. To investigate the pathogens attack, a conventional scale was applied, giving the notes according to the degree of attack.

The laboratory experiment was accomplished to assess the quality. In terms of quality, we investigated the items related to taste acceptability and visual quality: the total dry matter content (%), total soluble matter, (°Brix), pigments content (mg 100 g^{-1}) carotene and lycopene, vitamin C (mg 100 g^{-1}).

The determination of total dry matter substance was carried out gravimetrically, by weighing the fresh vegetal material, drying it for 24 hours at 105°C, cooling it outside and then weighing again the dry vegetal material. The results were

expressed in percentage. The difference till 100% represents the water content.
The soluble dry matter content was determined using refractometry (°Brix).
The pigment content, lycopene and β-carotene, were extracted in petrol ether and spectrometrically determined. The content was expressed in mg/100 g.
Ascorbic acid was extracted in oxalic acid and titration with 2.6 dichlorophenolindophenol to a light pink color. The quantity of ascorbic acid was expressed in mg/100 g.

Table 1. Applied technologies in both cultivation systems: organic and conventional

Item	Organic system	Conventional system
Biological material	Same material (seeds obtained from organic) in both systems.	
Field preparation	No tillage	Tillage
Weed control	Organic mulch (dried legumes)	Herbicide application
Fertilizer requirement	Organic fertilizer	NPK fertilizer
Irrigation requirement	3-5/ vegetation period	3-5/ vegetation period
Pest management	Biological control	Pesticides application

The biological material used in our investigations was represented by lines from breeding programs, featured by heat and specific pathogen tolerance. The genotypes were: tomatoes (*L 161, L 162, L 167, L 168, L 213*), sweet pepper (*L 335, L 336, L 337, L 339, L 340*), sweet corn (*L 1, L 2, L 12, L18, L 29*), melon (*L 555, L 556, L 557, L 558, L 559*), pumpkin (*L 535, L 536*).

RESULTS AND DISCUSSIONS

Usually, the consumers evaluate tomato fruit quality using visually appreciation of size, color and firmness. Color evolution during fruit ripening is mainly related to the breakdown of chlorophyll and synthesis of lycopene, which is responsible for the red color and constitutes 75-83% of the total pigment content at full ripeness (Radzevičius et al., 2016; Schouten et al., 2014).
The taste is appreciated according to the fruit sweetness given by the report between soluble solids and titratable acidity. The total content of water is also important in taste appreciation. In our study five lines were investigated to detect basic quality and their suitability to ecological cultivation. The growth was determinated, having a total height between 101 and 109 cm. The total number of shoots was 3 to 6. The foliage varied from 28 to 55 leaves. The fruits were big, round (Figure 2), and the index shape was around 1 to all lines. The fruits were red to dark red at physiological maturity, with strong firmness and good resistance to cracking. Figure 1 and Figure 2 present other morphological features of the investigated material. The total number of fruits varied from 31 to 38, and the fruit weight ranged in small limits, between 110 and 130 g. The lines developed 195 to 280 seeds in one fruit (figure 1). The total weight of fruits per plant varied from 4.07 to 4.48 kg plant^{-1} (Figure 2).

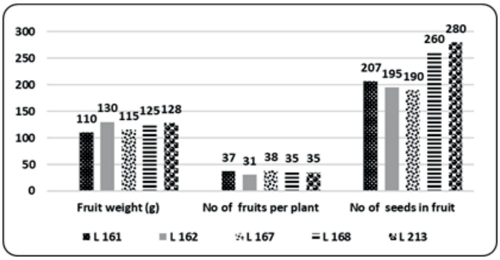

Figure 1. Number of fruits per plant, and seeds in fruit, fruit weight

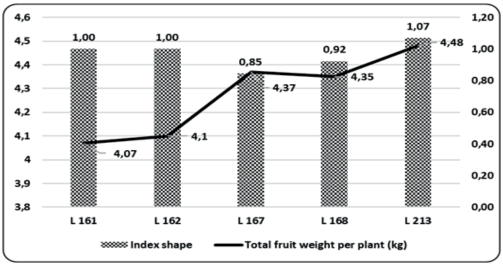

Figure 2. Index shape and total weight of fruit per plant

Table 2 presents the data related to yield, accomplished in conventional and ecological system. All investigated lines obtained higher yields in conventional system, L213 being the most productive in both systems. All lines registered superior yields compared to control.
The main differences between organic and conventional tomato cultivation were represented by applied strategies for fertilization, disease and pest's management. According to conventional practices, insecticides, fungicides and miticides were applied for plant protection, while in organic system, were applied extracts of garlic, nettle;

Bordeaux mixture, and biofertilizer for control the disease and pests and were applied. Our results related yield in conventional versus organic, confirming the previous results published by Bettiol et al., 2004 and Kapoulas et al. 2011.

Table 2. Tomatoes yield in both cultivation systems

Genotype	Yield in conventional system			
	Yield t ha^{-1}	Yield %	Difference compared to control	Significance
L 161	122	103,4	+4,0	-
L 162	123	104,2	+5,0	***
L 167	131	111,0	+13,0	***
L 168	130	110,0	+12,0	***
L 213	134	113,6	+16,0	***
Control	118	100	-	-

DL (p 5 %)= 2,90 t ha^{-1}
DL (p 1%) = 3,19 t ha^{-1}
DL (p 0.1%) = 4,12 t ha^{-1}

Genotype	Yield in ecologic system			
	Yield t ha^{-1}	Yield %	Difference compared to control	Significance
L 161	84,4	102,2	+ 1,8	-
L 162	85,1	103,0	+ 2,5	*
L 167	90,7	109,8	+ 8,1	***
L 168	90,0	109,0	+ 7,4	***
L 213	92,8	112,3	+10,2	***
Control	82,6	100,0	-	-

DL (p 5%) = 2,22 t ha^{-1}
DL (p 1%) = 3,19 t ha^{-1}
DL (p 0.1%) = 4,10 t ha^{-1}

Other investigations related to quality from this study confirms data of Toor et al. (2006), Caris-Veyrat et al. (2004): the mean ascorbic acid content, soluble solids, total dry matter, and pigments registered in organically fertilized tomatoes higher values than the results obtained from tomatoes that were fertilized with mineral solutions. As in Figures 3 and 4, all investigated items registered slightly superior values in ecological, compared to conventional. The medicinal value is attributed to the high content of vitamins and minerals; peppers are recognized for their beneficial effects on the human body, for maintaining health and hygiene. They are an excellent source of vitamin A and C, which are two powerful antioxidants that together neutralize free radicals. Red pepper contains lycopene, with antitumor effects in prostate, breast, pancreatic, skin, uterine, intestinal cancer. According to literature, many studies that investigate the effects of organic system on *Capsicum annuum* plants, in terms of growth, yield, fruit quality or morphological characteristics and also the differences between the organic and conventional production system were developed thanks to pepper biodiversity, economic importance, suitability to be exploited in different industries (food, agriculture, pharmacy).

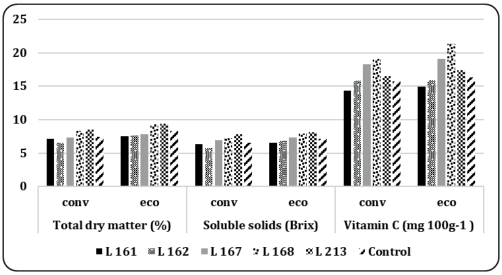

Figure 3. Dry and soluble matter, vitamin C

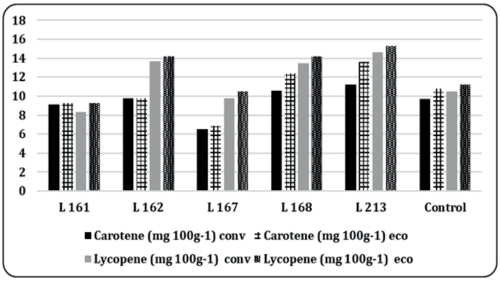

Figure 4. Pigments content in tomatoes fruits

Our study included five genotypes and one control variant of sweet pepper. The fruits are distinguished by red color, exception L340 which was orange. Figure 5 presents the variation of height, diameter, and fruit weight as it was registered for each cultivation system. As a general remark, fruits obtained in conventional cultivation system developed bigger size being heavier than those obtained in ecological conditions.

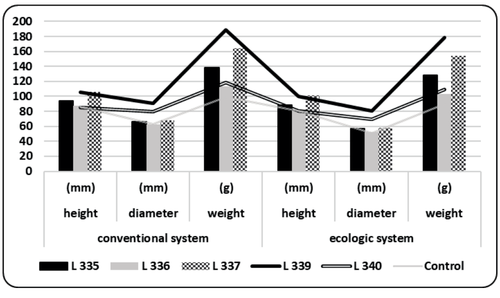

Figure 5. Sweet pepper fruit characteristics (height, diameter, weight)

Comparing the yield (Table 3), all genotypes were more productive in conventional system; L 337 has accomplished the highest level of production in both systems: 50.3 t ha^{-1} (conventional) and 35.23 t ha^{-1} (organic).

Table 3. Pepper yield in conventional and ecological cultivation systems

Genotype	Yield in conventional system			
	Yield t ha^{-1}	%	Difference compared to control	Signifi-cance
L 335	48,5	126	+ 10,0	***
L 336	46,2	120	+7,7	***
L 337	50,3	131	+11,8	***
L 339	51,0	132	+12,5	***
L 340	49,6	129	+11,1	***
Control	38,5	100	-	-

DL (p 5%) = 1,90 t ha^{-1}
DL (p 1%) = 2,49 t ha^{-1}
DL (p 0.1%) = 3,72 t ha^{-1}

Genotype	Yield in ecologic system			
	Yield t ha^{-1}	%	Difference compared to control	Signifi-cance
L 335	34,0	137	+7,0	***
L 336	32,3	120	+5,3	***
L 337	35,2	130	+8,2	***
L 339	35,7	132	+8,7	***
L 340	34,7	129	+7,7	***
Control	27,0	100	-	-

DL (p 5%) = 1,82 t ha^{-1}
DL (p 1%) = 2,11 t ha^{-1}
DL (p 0.1%) = 3,22 t ha^{-1}

All investigated germplasm was suitable to ecological cultivation, no significant attach of pest and pathogens was registered. The differences between the total conventional yield and ecological one can be explained by the influence of fertilization schemes, with allowed and specified products for each system. Our results confirm previous published results of Bicikliski et al. (2018), who developed a comparative study about morphological characteristics of some pepper genotypes in organic and conventional system. The values of the primary statistical estimators corresponding to the data characterizing the degree of dispersion of the results obtained for the total dry matter content of the 6 pepper genotypes (*Capsicum annuus*) were reduced. Thus, the standard error of the mean was within the limits of 0.06 ÷ 1.18. The analysis regarding the homogeneity of the results for the studied parameters obtained from the 6 genotypes showed a very good homogeneity for dry matter (%), and a relative homogeneity for the values for the soluble dry matter content, carotene and lycopene.

Figure 6 presents the variation of dry matter and soluble solid content in condition of conventional and ecological cultivation. Figure 7 presents variation of carotene and lycopene accumulation in both cultivation system.

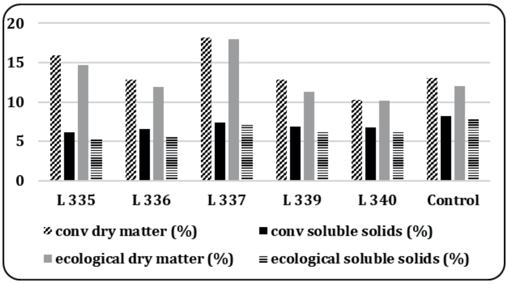

Figure 6. Dry and soluble matter variation

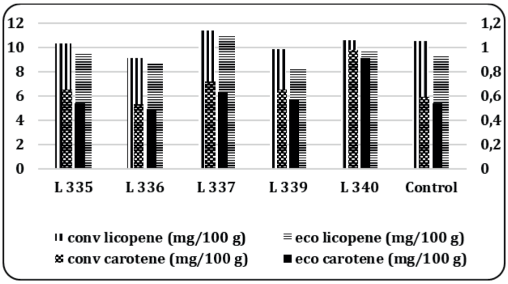

Figure 7. Carotene and lycopene variation

As a general conclusion, sensitive higher level of accumulation was detected in conventional system. All items reflect the accumulation at physiological maturity.

Sweet corn is an appreciated horticultural product, being continuously demanded by farmers.

One of the main reasons can be its short production life and a relatively high price, being considered profitable to be cultivated. Our unit produces seeds for farming and develops different breeding programs to answer farmers request to decrease the cultural inputs and to have available resources for ecological cultivation. The collection under investigation included five lines featured by plant following traits: height ranging from 179 to 193 cm, a total need of 551.3 to 558.3°C till silk appearance, cold test value between 90 and 92, and 15.2 to 21.4% broken plants (Figure 8). Traits related yield varied in quite small limits, cob length from 20 to 23 cm, seed weight per cob from 93.2 to 99.8 g, and MMB from 241 to 255 g (Figure 9).

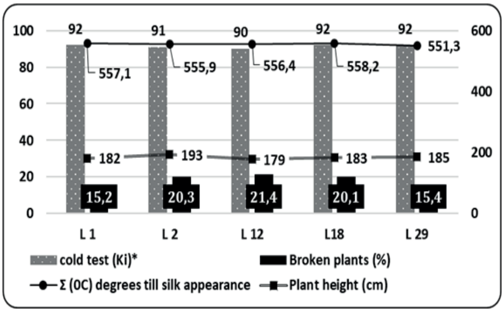

Figure 8. Parameters for plant development

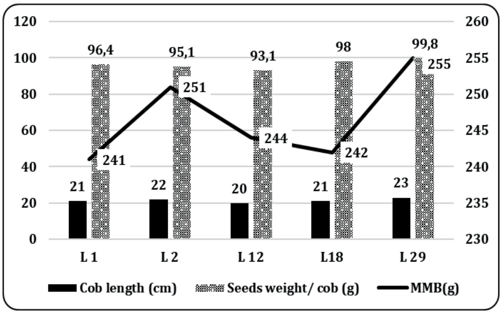

Figure 9. Traits related to yield capacity

Table 4. Sweet corn yield in both cultivation systems

Line	**Yield in conventional system**			
	Yield t ha^{-1}	**%**	**Difference compared to control**	**Signifi-cance**
L 1	12,2	152,5	+4,5	*
L 2	14,1	176,2	+6,1	***
L 12	13,8	172,5	+5,8	***
L18	14,5	181,2	+6,5	***
L 29	15,2	190,0	+7,2	***
control	8,0	100	-	-

DL (p 5%) = 2,10 t ha^{-1}
DL (p 1%) = 3,60 t ha^{-1}
DL (p 0.1%) = 4,40 t ha^{-1}

Line	**Yield in ecologic system**			
	Yield t ha^{-1}	**%**	**Difference comparing control**	**Signifi-cance**
L 1	8,5	151,8	+2,9	**
L 2	9,9	176,8	+4,3	***
L 12	9,7	173,2	+4,1	***
L18	10,2	182,1	+4,6	***
L 29	10,7	191,1	5,1	***
control	5,6	100	-	-

DL (p 5%) = 1,95 t ha^{-1}
DL (p 1%) = 2,60 t ha^{-1}
DL (p 0.1%) = 3,50 t ha^{-1}

Table 4 presents a comparative synthesis for organic and conventional yield. Ecological seed yield registered inferior values. L29 had the best behavior in both system, 15.2 t ha^{-1}, 10.7 t ha^{-1}, respectively.

Table 5. Melon yield in both cultivation systems

Line	**Yield in conventional system**			
	Yield t ha^{-1}	**%**	**Difference comparing control**	**Signifi-cance**
L 555	155	158,2	+57	***
L 556	158	161,2	+60	***
L 557	175	178,6	+77	***
L 558	170	173,5	+72	***
L 559	185	188,8	+87	***
Control	98	100,0	-	

DL (p 5%) = 2,10 t ha^{-1}
DL (p 1%) = 3,60 t ha^{-1}
DL (p 0.1%) = 4,40 t ha^{-1}

Line	**Yield in ecologic system**			
	Yield t ha^{-1}	**%**	**Difference comparing control**	**Signifi-cance**
L 555	8,5	151,8	+2,9	**
L 556	9,9	176,8	+4,3	***
L 557	9,7	173,2	+4,1	***
L 558	10,2	182,1	+4,6	***
L 559	10,7	191,1	5,1	***
Control	5,6	100	-	-

DL (p 5%) = 1,95 t ha^{-1}
DL (p 1%) = 2,60 t ha^{-1}
DL (p 0.1%) = 3,50 t ha^{-1}

The *Cucurbitaceae* species, represented by melon and pumpkin, exhibit proper behavior in ecological cultivation. Melon is highly requested on Romanian market thanks to its exceptional flavor and its application in traditional medicine (especially organic melons). All melon genotypes registered superior yields compared to control in ecological system. Conventional system was slightly more productive. L 559 registered the highest level of yield in both systems (Table 5).

Table 6. Pumpkin yield in both cultivation systems

Line	**Yield in conventional system**			
	Yield t ha^{-1}	**%**	**Difference compared to control**	**Signifi-cance**
L 535	190	190	+90	***
L 536	185	185	+85	***
Control	100	100	-	***

DL (p 5%) = 5,1 t ha^{-1}
DL (p 1%) = 7,6 t ha^{-1}
DL (p 0.1%) = 14,4 t ha^{-1}

Line	**Yield in ecologic system**			
	Yield t ha^{-1}	**%**	**Difference compared to control**	**Signifi-cance**
L 535	133	190	+63	***
L 536	129	184	+59	***
Control	70	100	-	-

DL (p 5%) = 5,85 t ha^{-1}
DL (p 1%) = 7,80 t ha^{-1}
DL (p 0.1%) = 13,80 t ha^{-1}

In the case of pumpkin, two different genotypes were comparatively investigated. The highest value of yield was obtained in conventional system (Table 6).

CONCLUSIONS

The study investigated yield potential (t ha^{-1}) and quality as taste acceptability and visual quality: the total dry matter content (%), total soluble matter, (°Brix), pigments content (mg 100 g^{-1}) carotene and lycopene, vitamin C (mg 100 g^{-1}), shape index. The most productive genotypes obtained highest yield in conventional system against ecological system in case of all species: tomatoes 134 versus 92.8 t ha^{-1}, sweet pepper 50.3 versus 35.23 t ha^{-1}, pumpkin 190 respectively 133 t ha^{-1}, 185 against 129 t ha^{-1}melon and sweet corn 15.2 and 10.7 t ha^{-1}, respectively. Under certain conditions, which includes proper varieties, good management practices, growing conditions, ecological systems can ensure the obtaining of yields, comparable to those achieved in conventional. Considering the multiple benefits of organic, it is expected that agricultural policies will pay more attention to organic, agroecological and low-input agricultural practices, and invest in research and innovation.

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