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INTERCROPPING AS AN EXAMPLE OF SUSTAINABLE ORGANIC AGRICULTURAL SYSTEMS

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Abstract: The concept of agroecosystems is based on the understanding of functioning and mutually complementary connections between living organisms and their environment, which maintain stable, dynamic balance in time and space. The mix cultivation of two or more crops is based on ecological principles. Intercropping as an example of sustainable agricultural systems following objectives such as: ecological balance, more utilization of resources, increasing the quantity and quality of yield and reduce damage to pests, diseases and weeds. Mixed crops have their advantages due to the richer diversity of varieties, the use of natural resources, the positive interactions between crops, the various activity of absorption of nutritional substances from their root system, at different stages of the vegetation period and their characterization with stimulation of their growth and improvement of the production quality and yield. The attempt to bring it to the study experimental field of the Agroecological Center at the Agricultural University - Plovdiv during the vegetation years of 2014 and 2015. This research aims at determining the mutual impact upon combined cultivation of pepper *(Capsicum annuum* L.*)* of the variety of Kurtovska Kapiya 1619 and the crops- onion *(Allium cepa)*, basil *(Ocimum basilicum)*, salad beetroot *(Beta vulgaris L. ssp. rapacea var. atrorubra krass)*, celery *(Apium graveolens L.)*, and tagetes *(Tagetes minima L.)*, upon establishment of the impact of the biofertilizer Hemozym Bio No. 5 on biometric parameters and productive properties of crops, and on the study of ‘soil respiration’ upon mixed cultivation of crops. The height values of the plants show that the selected test type - basil, may have undisturbed development without having any inhibition effect under conditions of competition whenever placed in pepper crops, thus defining basil as a suitable crops to be added to the mixed crops. Basil is very suitable for the formation of buffer strips between the separate fields in the vegetable crop rotation, for it provides biological diversity in the farm, has a repellent role by pushing away pests and contributing to the pollination by bees. Celery is a suitable crops for mixed cultivation due to the fact that its requirements towards light, water and nutritional substances are identical to those of the pepper and both crops are no competition to one another because of their proximity, but the determining factor is the positive allelopathic effect of the essential oil substances released by the leaf-stalk part of the celery. The mixed crops in organic vegetable production are beneficial in view of the more complete exhaustion of nutritional substances and preservation of the typical characteristics of the soil and soil fertility. Productivity is the most important indicator upon the cultivation of every crop and is a complex reflection of all impacts throughout the entire vegetation period, as it gives the most accurate idea of the impact of the different factors - year, biofertilizer, crop. It was established that the vegetable crops (pepper, onion, salad beetroot, and celery) and the essential oil crop (basil) had a positive reaction to the applied fertilization with the biofertilizer Hemozym Bio No. 5, as the results showed higher values of the yields for all crops as compared to the non-fertilized control variants of the same. We believe that the mix cultivation of these two crops allows their combination in yard gardening on a small area.

Keywords: agroecosystems, intercropping, organic agriculture, sustainable agricultural systems.

INTRODUCTION

The concept of agroecosystems is based on the understanding of functioning and mutually complementary connections between living organisms and their environment, which maintain stable, dynamic balance in time and space (Xu and Mage, 2001; Médiène et al., 2011; Wezel et al., 2014; Vlahova and Stoyanova, 2015; Turetta et al., 2016; Wiggering et al., 2016). The mix cultivation of two or more crops is based on ecological principles (Ranganathan, 1993; Sullivan, 2003; Morgado and Willey, 2008; Machado, 2009; Lichtfouse, 2013; Parker et al., 2013, Himanen et al., 2017). Intercropping as an example of sustainable agricultural systems following objectives such as: ecological balance, more utilization of resources, increasing the quantity and quality of yield and reduce damage to pests, diseases and weeds (Brintha and Seran, 2009; Mousavi and Eskandari, 2011). Depending on their genetic structure, cultural cenoses are different types of communities: clear (monospecies and monovarieties); mixed multispecies; mixed multivarieties; combinations of mixed multispecies; combinations of mixed multivarieties (Ouma and Jeruto, 2010). Intercropping is an age old practice of growing simultaneously two or more crops on the same field such that the period of overlap is long enough to include vegetative stage (Gomez and Gomez, 1983; Darshan, 2008; Pour et al., 2016). Based on the location of the crops in space different varieties of cultivation are outlined, as they could be mixed (Anders et al., 1996; Matusso et al., 2012), row (Brintha and Seran, 2009; Amujoyegbe et al., 2016), row-strip (Gou et al., 2017), strip (Cruse et al., 1992; Maffeia and Mucciarelli, 2003; Gałęzewski et al., 2017; Gałęzewski et al., 2018). The location of crops in rows ensures the simultaneous development of two or more crops, as the arrangement of crops includes the selection of such species that are not inter-competitive as regards the resources of the environment and a level of interaction that is significantly lower (Coolman and Hoyt, 1993; Panayotov et al., 2006; Panayotov et al., 2008; Lauk and Lauk, 2009); local varieties are picked, which are easily adaptable to the conditions of the respective region; the availability of variety diversity is preferable; the terms of planting should be close to one another; there should be no common diseases and pests; there should be monotype agrotechnical practices (Maliwal and Mundra, 2011). Mixed crops have their advantages due to the richer diversity of varieties (Rämert, 2002; Yildirim and Ekinci, 2017), the use of natural resources, the positive interactions between crops (Malézieux et al., 2009; Parker et al., 2013), the various activity of absorption of nutritional substances from their root system, at different stages of the vegetation period (Cui et al., 2017) and their characterization with stimulation of their growth and improvement of the production quality (Huňady and Hochman, 2014) and yield (Dane and Laugale, 2011; Lithourgidis et al., 2011; Stoltz and Nadeau, 2014; Hamburda et al., 2016; Jalilian et al., 2017). The main advantage of intercropping is the more efficient utilization of the available resources and increasing productivity compared with each sole crop of the mixture, furthermore, intercropping agro-ecosystem could reduce incidence of weeds, insect pest, and diseases (Cui et al., 2017). In case of organic agriculture at its most, we count on maintenance of the biological diversity, ecological balance in the environment, and biological and agrotechnical fight against pests (Jones and Gillett, 2005; Sharaby et al., 2015), as the plant protection system should be planned and realized, so that to ensure the keep the losses from diseases and pests below the thresholds of their economic harm (Каров и Андреев, 2007). In agrophytocenosis weed species are a part of the biodiversity and should be kept with a lower density, instead of being entirely wiped out (Davies and Welsh, 2002), due to the fact that they are the habitat for the beneficial species in agrobiocenosis (Isart and Llerena, 1999; Marshall et al., 2003; Verschwele and Zwerger, 2005; Isbell et al., 2017). Many plants are characterized with phytopesticide properties because of their natural alkaloids, esters, glycosides, etc. (Васина, 1978; Koul, 2008). Plants provide the source of secondary metabolites possessing biological activities against pests (Koul et al., 2005). In fact, the use of biopesticides, specifically plant-based products, has gained a lot of importance, particularly chemicals/secondary metabolites from a plant that affect the pests through negative effects (Koul and Walia, 2009; Al-Samarrai et al., 2012). Repellents have insecticide effect and are beneficial in the system of biological plant protection (Oparaeke et al., 2005, Zoubiri and Baaliouamer, 2014). Upon mixed cultivation of crops, the role of allelopathy is also reported upon the selection of different types of crops, as well as the type of their released substances, along with the allelopathic role of the separate varieties of the same plant (Sharaby et al., 2015; Hikal et al., 2017). A main part of the allelopathic relations take part in the soil, thus determining to a great extent the composition, structure and dynamics of biocenoses (internal- and inter-species relations of components) (Работнов, 1983; Maia and Moore, 2011; Trezzi et al., 2016).

Stolbur of pepper (*Capsicum annuum* L.) is an important disease from an economic point of view, it is caused by *Mycoplasma sp*., which is transferred from the planthopper *Hyalesthes obsoletus* Sing. (Наков и др., 1994; Sakalieva and Skandalis, 2003), as the bindweed (*Convolvulus arvensis*) acts as the main reservoir for the cause. *Hyalesthes obsoletus* is polyphage and feeds with a large number of plants from the families *Poligonaceas, Asparagus* (Маркова, 2011). The combination of cultural and flower plant species in the agroecosystem of a biological farm is a traditional practice, as flower species, except for enriching the biodiversity in the agroecosystem, also provide nutrition to the bee families.

Objectives

This research aims at determining the mutual impact upon combined cultivation of pepper of the variety of Kurtovska Kapiya 1619 and the crops - onion, basil, salad beetroot, celery, and tagetes, upon establishment of the impact of the biofertilizer Hemozym Bio No. 5 on biometric parameters and productive properties of crops, and on the study of 'soil respiration' upon mixed cultivation of crops.

MATERIALS AND METHODS

The attempt to bring it to the study experimental field of the Agroecological Center at the Agricultural University - Plovdiv during the vegetation years of 2014 and 2015, with rye (*Secale cereale*), as a predecessor. The soil is of an alluvial-meadow type, with good physical and chemical properties and a poor alkaline reaction (pH 7,0- 7,5), as the humus in the upper horizon reaches 1% (Vlahova, 2013). The sowing time of pepper is in the third ten-day period of March, and of the onion, basil, celery, salad beetroot and tagetes- in the second ten-day period of April. The prick-out is on a high-levelled seed-bed, in the third ten-day period of May, as the distance between the plants is 15 cm (pepper, onion); 25 cm (salad beetroot, celery, tagetes); 30 cm (basil). On the high-levelled seed-bed, the pepper *(Capsicum annuum* L.*)*. is placed in the right row, while the left right is filled with consecutive alternation of the crops: onion *(Allium cepa)*, basil *(Ocimum basilicum)*, salad beetroot *(Beta vulgaris L. ssp. rapacea var. atrorubra krass)*, celery *(Apium graveolens L.)*, and tagetes *(Tagetes minima L.)*, as each crops has two variants (a non-fertilized control and a variant with applied biofertilizer Hemozym Bio No.5) with a length of 7,5 meters per variant, in three replications. The varieties of crops are as follows: Kurtovska Kapiya 1619 (pepper); Asenovgradska Kaba No. 5 (onion); Jubileen (regular basil); Detroit 2 (salad beetroot); Pioner (celery); *Tagetes palula* (tagetes). All respective agrotechnical practices have taken place: manual earthing up (5 in number), weeding, watering, and vegetation soil feeding with the biofertilizer Hemozym Bio No. 5 with a solution of - 15 L/da imported via a drip-irrigation system*,* following prick-out- on the 30th day, on the 55th day, and on the 85th day. Soil respiration- the general microbiological activity is determined by the quantity of released CO_2 through the method of Stotzky (1965) (Sapundzhieva et al., 2010), as the soil samples have been taken from the rhizosphere area with double reporting- on the 15th day and on the 30th day, after the first feeding with a biofertilizer Hemozym Bio No. 5. In order to follow up the symptoms of the disease- Mycoplasma in the crop, trace investigations have been made along the external signs according to Sakalieva and Milusheva (1998). PVC Sticky Traps (yellow) have been installed preventively on wooden small stakes, chess-like in the crops against *Hyalesthes obsoletus*. Manual preventive spraying has been made with Bordeaux liquid - 1%; Funguran OH - 0,15%. For the purpose of fighting against the green peach aphid (*Myzus persicae*), treatment has been performed with NeemAzal-T/S- 0,3%, three times every 15 days since the beginning of July.

Biometric measurements and productivity of plants:

Onion- bulb height (cm); bulb diameter (cm); root length (cm); leaf length (cm); false stem height (cm); number of “feather” leaves; yield (kg/da). There have been 10 plants per variant analyzed in the end of the vegetation. Bulb weight (g)- 10 bulbs analyzed from each variant.

Basil - plant height (cm); cyme height (cm); number of leaves; number of cymes; number of nodes; total weight of the whole plants (g); yield (kg/da). There have been 10 plants per variant analyzed in the end of the vegetation.

Salad beetroot- R-crop height (cm); R-crop diameter (cm); root length (cm); leaf stalk length (cm); leaf lamina length (cm); leaf lamina width (cm); number of leaves; yield (kg/da). There have been 10 plants per variant analyzed in the end of the vegetation. R-crop weight (g)- 10 R-crops analyzed from each variant.

Celery- R-crop height (cm); R-crop diameter (cm); number of leaves; leaf stalk length (cm); leaf lamina length (cm); leaf lamina width (cm); yield (kg/da). There have been 10 plants per variant analyzed in the end of the vegetation.

Tagetes - Plant height (cm); Number of leaves per plant; Number of blossoms per plant. There have been 10 plants per variant analyzed.

Pepper- biometric parameters are: plant height (cm), number of leaves, number of internodes. There have been 10 plants per variant analyzed in the end of the vegetation. Standard yield (kg/da); number of fruits per plant - 10 plants analyzed from each variant; fruit mass (g) - 10 fruits analyzed from each variant.

Statistical data- processing used Ms Office Excel 2007 (Average ± STDEV).

RESULTS AND DISCUSSION

The separate crops differ from one another in their vegetation development with respect to their needs from the factors of the external environment - light, temperature, water, elements of mineral nutrition, etc. The results from the biometric measurements of the **onion** from the vegetation years of 2014 and 2015 show definitive positive impact of the feeding with the biofertilizer Hemozym Bio No. 5 on the amount of the formed bulb (diameter and height) and the greater length of the formed leaves- “feathers”. The results for the average number of leaves per plant during both experimental years show that the variant with the applied biofertilizer has values that are higher than those reported for the non-fertilized control (Table 1).

The average bulb weight during both years has its highest values for the plants of the variant with applied biofertilizer Hemozym Bio No. 5, which is due to the favorable climatic conditions expressed in drier weather, with lower air humidity and scattered showers. The timely irrigation of the onion maintain the good turgor of the tubular green “feathers”, which are also characterized with a wax cover that determines the lower transpiration and the general better vegetation condition of the onion plants. The last phase of the development of the onion plants- bulb formation, is at its best at high temperature. Onion essential oil is the reason for its phytoncide action. The mixed cultivation of onion and pepper does not have any negative impact on the development of onion, for there is no disturbance of the light regime, whereas it is a well-known fact that in case of very intensified sowing and lack of sufficient sunlight the onion does not produce satisfactory results.

Table 1. Parameters of Onion (*Allium cepa*)

Parameters	Year	Non-fertilized control	With the biofertilizer Hemozym Bio No.5
Bulb height (cm)	2014	5.06 ± 0.207	5.97 ± 0.447
	2015	5.28 ± 0.249	6.16 ± 0.321
Bulb diameter (cm)	2014	5.02 ± 0.259	7.18 ± 0.211
	2015	5.17 ± 0.250	7.37 ± 0.240
Root length (cm)	2014	4.64 ± 0.343	5.77 ± 0.250
	2015	4.78 ± 0.367	6.07 ± 0.335
Leaf length (cm)	2014	30.77 ± 0.346	40.53 ± 0.456
	2015	31.86 ± 0.416	41.59 ± 0.580
False stem height (cm)	2014	2.81 ± 0.136	3.47 ± 0.194
	2015	2.87 ± 0.212	4.08 ± 0.156
Number of “feather” leaves	2014	10.33 ± 0.500	13.56 ± 0.527
	2015	12.00 ± 1.000	14.00 ± 0.707
Bulb weight (g)	2014	89.34 ± 16.659	139.30 ± 39.349
	2015	96.91 ± 34.268	146.90 ± 55.775

Upon comparing the results from both vegetation years, the height values of the **basil** plants are higher for the variant with an applied biofertilizer as compared to the control plants, as the cyme height varies, with superiority for the fertilized variant (Table 2).

Table 2. Parameters of Basil (*Ocimum basilicum*)

Parameters	Year	Non-fertilized control	With the biofertilizer Hemozym Bio No.5
Plant height (cm)	2014	44.76 ± 0.866	69.53 ± 0.524
	2015	45.28 ± 0.545	70.46 ± 1.020
Cyme height (cm)	2014	6.33 ± 0.332	7.91 ± 0.237
	2015	5.63 ± 0.218	9.26 ± 0.292
Number of leaves	2014	200.00 ± 6.652	265.44 ± 4.333
	2015	232.44 ± 17.749	285.67 ± 7.106
Number of cymes	2014	38.44 ± 0.527	64.22 ± 0.833
	2015	40.11 ± 1.453	70.33 ± 1.225
Number of nodes	2014	8.78 ± 0.441	11.33 ± 0.500
	2015	8.89 ± 0.333	12.00 ± 0.500
Total weight of the whole plant (g)	2014	192.79 ± 20.004	349.68 ± 26.521
	2015	209.37 ± 9.409	380.17 ± 21.677

The height values of the plants show that the selected test type- basil, may have undisturbed development without having any inhibition effect under conditions of competition whenever placed in pepper crops, thus defining basil as a suitable crops to be added to the mixed crops. The allelopathic substances released by basil do not have any negative impact on the cultivated neighbouring crops - pepper (Table 6), which determines their mixed cultivation as beneficial for the species, which may be of practical application in small farms and organic farms. A larger number of nodes and number of cymes has been established for the plants of the variant with the biofertilizer Hemozym Bio No.5, which is probably due to the biofertilizer and the suitable meteorological conditions. In view of the phytosanitary condition of pepper plants next to the basil, the positive impact of the basil is reported, which releases specific volatile substances, thus impacting the overall condition of the neighbouring pepper. Basil is very suitable for the formation of buffer strips between the separate fields in the vegetable crop rotation, for it provides biological diversity in the farm, has a repellent role by pushing away pests and contributing to the pollination by bees.

For the mixed cultivation of **salad beetroot** with pepper, the necessary space has been provided for the rows and the salad beetroot is not overshadowed by the growing neighbouring pepper. It has been established that the mixed cultivation of salad beetroot and pepper is favorable for both crops, accordingly their relation to the light regime despite the well-known fact that the salad beetroot does not tolerate being overshadowed due to the fact that it is also a long-day plant. The results for the length of the leaf stalk of the salad beetroot are close during both experimental years, as the same tendency has been also reported for the leaf lamina (width and length), thus showing that the cultivation of this test type is not impacted negatively by the pepper close to it as a neighbouring crops (Table 3).

Table 3. Parameters of Salad beetroot *(Beta vulgaris L. ssp. rapacea var. atrorubra krass)*

Parameters	Year	Non-fertilized control	With the biofertilizer Hemozym Bio No.5
R-crop height (cm)	2014	10.22 ± 0.976	13.74 ± 0.557
	2015	10.67 ± 0.768	14.16 ± 0.522
R-crop diameter (cm)	2014	10.28 ± 0.311	11.22 ± 0.519
	2015	9.84 ± 0.469	12.34 ± 0.240
Root length (cm)	2014	6.77 ± 0.908	8.33 ± 0.324
	2015	6.87 ± 0.829	8.87 ± 0.328
Leaf stalk length (cm)	2014	11.48 ± 0.228	13.86 ± 0.174
	2015	11.69 ± 0.169	14.39 ± 0.401
Leaf lamina length (cm)	2014	10.36 ± 0.309	13.47 ± 0.339
	2015	11.76 ± 0.270	14.17 ± 0.421
Leaf lamina width (cm)	2014	7.46 ± 0.219	9.16 ± 0.167
	2015	8.33 ± 0.387	9.60 ± 0.218
Number of leaves	2014	11.22 ± 2.167	12.67 ± 1.414
	2015	12.56 ± 0.527	13.44 ± 0.726
R-crop weight (g)	2014	212.20 ± 10.238	504.43 ± 37.425
	2015	235.81 ± 18.176	736.70 ± 25.042

After the salad beetroot starts the active accumulation of nutritional substances and the increase of the size of the R-crops, it is supposed that the more powerful root system of the neighbouring pepper may have a negative impact by depleting the nutritional substances. The above assumption is confuted upon reporting the results for the diameter and height of the formed R-crop, thus showing that the so valuable edible part of these crops is not impacted negatively by the neighbouring pepper. The timely vegetation soil feeding with the biofertilizer Hemozym Bio No. 5, which is characterized with the high content of nitrogen, has favorable impact on the development of the crops, for there is an increase of the reserve of nutritional substances having its impact on the growth of the already formed R-crops. We believe that the mix cultivation of these two crops allows their combination in yard gardening on a small area.

The data for the **celery** biometric parameters from the vegetation years of 2014 and 2015 show superiority of the values of all indicators of the fertilized plants as compared to the non-fertilized plants, which show the positive effect of the applied biofertilizer. The mixed cultivation of celery is not affected negatively by the grown neighbouring crops - pepper, despite the fact that the celery has high requirements towards light intensity. Celery is a suitable crops for mixed cultivation due to the fact that its requirements towards light, water and nutritional substances are identical to those of the pepper and both crops are no competition to one another because of their proximity, but the determining factor is the positive allelopathic effect of the essential oil substances released by the leaf-stalk part of the celery. The results for the average number of leaves per plant during both vegetation years show a larger number for the variant with applied biofertilizer (Table 4).

Table 4. Parameters of Celery *(Apium graveolens L.)*

Parameters	Year	Non-fertilized control	With the biofertilizer Hemozym Bio No.5
R-crop height (cm)	2014	9.23 ± 0.173	13.03 ± 0.335
	2015	9.60 ± 0.097	13.97 ± 0.415
R-crop diameter (cm)	2014	7.46 ± 0.336	9.87 ± 0.287
	2015	7.83 ± 0.283	10.14 ± 0.274
Leaf stalk length (cm)	2014	14.78 ± 0.295	18.34 ± 0.317
	2015	15.08 ± 0.307	19.12 ± 0.418
Leaf lamina length (cm)	2014	9.59 ± 0.322	11.58 ± 0.239
	2015	10.31 ± 0.491	11.64 ± 0.201
Leaf lamina width (cm)	2014	6.24 ± 0.433	8.31 ± 0.209
	2015	7.43 ± 0.527	9.34 ± 0.400
Number of leaves	2014	13.44 ± 0.527	18.44 ± 1.236
	2015	14.56 ± 0.726	19.44 ± 1.509

The mixed crops in organic vegetable production are beneficial in view of the more complete exhaustion of nutritional substances and preservation of the typical characteristics of the soil and soil fertility. The polyculture cultivation provides a possibility for the plants to better utilize the reserve of moisture and nutritional substances in the rhizosphere zone in accordance with the depth of location of the root system, which is also favored by the different periods of absorption of the elements of the mineral nutrition during vegetation by the various crops.

Table 5. Parameters of Tagetes *(Tagetes minima L.)*

Parameters	Year	Non-fertilized control	With the biofertilizer Hemozym Bio No.5
Plant height (cm)	2014	19.06 ± 0.682	25.12 ± 0.614
	2015	20.62 ± 0.538	26.36 ± 0.635
Number of leaves per plant	2014	45.89 ± 1.453	50.56 ± 1.424
	2015	46.44 ± 1.130	55.44 ± 0.882
Number of blossoms per plant	2014	7.78 ± 0.667	12.11 ± 0.928
	2015	8.67 ± 0.866	13.22 ± 0.972

The results from the biometric and productive indicators from both years show the positive impact of the biofertilizer Hemozym Bio No. 5 on the development of pepper plants (Table 6).

Table 6. Parameters of Pepper *(Capsicum annuum L.)*

Parameters	Year	Non-fertilized control	With the biofertilizer Hemozym Bio No.5
Plant height (cm)	2014	48.7 ± 0.608	59.4 ± 0.839
	2015	49.3 ± 0.700	61.20 ± 0.557
Number of leaves	2014	94.00 ± 1.000	154.33 ± 1.155
	2015	99.00 ± 1.000	170.67± 2.517
Number of internodes	2014	7.00 ± 1.000	9.67 ± 0.577
	2015	7.67 ± 0.577	10.00 ± 1.000
Number of fruits per plant	2014	5.33 ± 0.577	8.00 ± 1.000
	2015	4.67 ± 0.577	9.00 ± 1.000
Fruit mass (g)	2014	63.8 ± 0.100	72.3 ± 0.404
	2015	64.9 ± 0.208	76.4 ± 1.012

Productivity is the most important indicator upon the cultivation of every crop and is a complex reflection of all impacts throughout the entire vegetation period, as it gives the most accurate idea of the impact of the different factors - year, biofertilizer, crop. It was established that the vegetable crops (pepper, onion, salad beetroot, and celery) and the essential oil crop (basil) had a positive reaction to the applied fertilization with the biofertilizer Hemozym Bio No. 5, as the results showed higher values of the yields for all crops as compared to the non-fertilized control variants of the same (Table 7).

Table 7. Yield of crops- (kg/da, from 2014 to 2015)

Crops	Year	Non-fertilized control	With the biofertilizer Hemozym Bio No.5
Pepper	2014	987.6 ± 35.354	2068.5 ± 62.319
	2015	994.7 ± 10.859	2182.4 ± 80.915
Onion	2014	927.6 ± 18.272	1426.8 ± 15.500
	2015	981.3 ± 64.410	1541.2 ± 14.171
Basil	2014	489.6 ± 21.118	630.7 ±12.063
	2015	512.9 ± 15.856	694.5 ± 9.650
Salad beetroot	2014	1894.5 ± 16.850	2621.4 ± 55.100
	2015	1950.9 ± 21.866	2714.3 ± 42.761
Celery	2014	1123.6 ± 22.453	1757.7 ± 41.722
	2015	1213.5 ± 16.416	1793.6 ± 7.718

The weed species - common purslane (sedum) *Portulaca oleracea*, when placed between the row spacings, during the summer period of active vegetation ensure the preservation of humidity used by the crops. In order to limit the flight of the planthopper (*Hyalesthes obsoletus)*, a barrier corn crop positioned in the pepper row was created as a preventive measure. Visual observations were performed upon route inquiries of the pepper crop (from the beginning of July during both vegetation years) with the purpose of determining the number of pepper plants attacked by the planthopper and observation of stolbur. It was established that the pepper plants planted in front of onion was characterized with the largest number of attacked pepper plants due to the fact that the onion “lodged” and probably did not act as a “barrier” against the planthoppers. In view of the above, we believe that the mixed cultivation of onion and pepper in neighbouring rows is not suitable.

Table 8. Number of pepper plants with Stolbur

Mixed Crops	Year	Number
Pepper opposite Onion	2014	15
	2015	17
Pepper opposite Basil	2014	5
	2015	4
Pepper opposite Salad beetroot	2014	8
	2015	6
Pepper opposite Celery	2014	12
	2015	15
Pepper opposite Tagetes	2014	9
	2015	11

Furthermore, a higher level of the attack by planthopper (*Hyalesthes obsoletus)*, was also found for pepper crops planted in front of the celery. Salad beetroot may be determined as the suitable crops for mixed pepper cultivation. It was found that the pepper crops planted in front of the basil row had the lowest number of attacked plants by the planthopper, thus determining basil as a favorable crops for mixed planting and a crops of practical application upon mixed cultivation. Out of the agrotechnical methods for fight against the planthopper, the following are applied: higher thickness of pepper plants, regular fight against weeds and especially against bindweed and corn thistle, planting of a barrier corn crop into the row. Upon mixed cultivation of different crops, the values of yields were good and showed that in practice the combined cultivation of crops had a positive effect and could be applied successfully in small private farms.

The results upon reporting soil activity- “soil respiration” during both vegetation years, reflect the change in the respective variants (Table 9).

It was established that upon the first reporting of the results the average values for the two-year period were higher for the variants with applied biofertilizer for the following crops: basil followed by pepper and onion, as compared to the values of the control plants for every crop. Upon the second reporting of the highest value, the average value for the period was established for the variant with basil fertilized with the biofertilizer Hemozym Bio No. 5, as the value was higher in comparison with the value from the first reporting, which was also typical for the variants with pepper and celery. A tendency was established towards a decrease of the soil activity of the onion and the sale beetroot, as compared to the first reporting, as the lower activity was reported for the variants with onion explained with the end of the vegetation development of the crop.

Table 9. Parameters of 'Soil respiration'

Variants	Year				Average
	2014		2015		
	1st reporting	2 nd reporting	1st reporting	2 nd reporting	
Pepper- Non-fertilized control	15.7 ± 0.67	16.4 ± 0.12	16.5 ± 0.50	17.6 ± 0.40	16.55
Pepper- With the biofertilizer Hemozym Bio No.5	27.3 ± 0.30	28.2 ± 0.25	26.5 ± 0.50	27.2 ± 0.26	27.30
Onion- Non-fertilized control	16.2 ± 0.97	11.3 ± 0.25	15.3 ± 0.42	12.3 ± 0.44	13.77
Onion- With the biofertilizer Hemozym Bio No.5	25.8 ± 0.85	17.2 ± 0.26	25.7 ± 0.36	18.4 ± 0.53	21.77
Basil- Non-fertilized control	17.8 ± 0.40	17.9 ± 0.32	18.9 ± 0.81	19.1 ± 0.06	18.42
Basil - With the biofertilizer Hemozym Bio No.5	29.7 ± 0.56	29.9 ± 0.12	28.5 ± 0.50	29.1 ± 0.10	29.30
Salad beetroot- Non-fertilized control	14.8 ± 1.39	13.3 ± 0.35	15.2 ± 0.47	12.8 ± 0.20	14.02
Salad beetroot- With the biofertilizer Hemozym Bio No.5	19.6 ± 0.66	18.5 ± 0.50	18.7 ± 0.75	19.5 ± 0.30	19.07
Celery- Non-fertilized control	15.1 ± 0.17	16.4 ± 0.59	15.8 ± 0.10	17.9 ± 0.10	16.30
Celery- With the biofertilizer Hemozym Bio No.5	24.4 ± 0.55	25.8 ± 0.15	24.8 ± 0.30	25.9 ± 0.10	25.22

Organic production is directed not only towards obtaining quality and eco-friendly production, but also towards optimization of the fertilization systems for ensuring a stable ecological environment, where soil fertility is preserved and enriched, as the application of a biofertilizer also provides nutritional substances used by the following crop in the crop rotation.

CONCLUSION

The height values of the plants show that the selected test type- basil, may have undisturbed development without having any inhibition effect under conditions of competition whenever placed in pepper crops, thus defining basil as a suitable crops to be added to the mixed crops.

In view of the phytosanitary condition of pepper plants next to the basil, the positive impact of the basil is reported, which releases specific volatile substances, thus impacting the overall condition of the neighbouring pepper. Basil is very suitable for the formation of buffer strips between the separate fields in the vegetable crop rotation, for it provides biological diversity in the farm, has a repellent role by pushing away pests and contributing to the pollination by bees.

Productivity is the most important indicator upon the cultivation of every crop and is a complex reflection of all impacts throughout the entire vegetation period, as it gives the most accurate idea of the impact of the different factors - year, biofertilizer, crop. It was established that the vegetable crops (pepper, onion, salad beetroot, and celery) and the essential oil crop (basil) had a positive reaction to the applied fertilization with the biofertilizer Hemozym Bio No. 5, as the results showed higher values of the yields for all crops as compared to the non-fertilized control variants of the same.

Salad beetroot may be determined as the suitable crops for mixed pepper cultivation. It was found that the pepper crops planted in front of the basil row had the lowest number of attacked plants by the planthopper (*Hyalesthes obsoletus)*, thus determining basil as a favorable crops for mixed planting and a crops of practical application upon mixed cultivation.

Upon mixed cultivation of different crops, the values of yields were good and showed that in practice the combined cultivation of crops had a positive effect and could be applied successfully in small private farms.

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