

## Response of spring vetch (*Vicia sativa* L.) to organic production conditions

Natalia Georgieva<sup>1\*</sup>, Ivelina Nikolova<sup>1</sup> and Grozi Delchev<sup>2</sup>

<sup>1</sup>*Institute of Forage Crops, Department of Forage Production and Animal Production, 5800 Pleven, Bulgaria*

<sup>2</sup>*Trakia University, Department of Plant Production, 6000 Stara Zagora, Bulgaria*

\*Corresponding author: [imnatalia@abv.bg](mailto:imnatalia@abv.bg), [imnikolova@abv.bg](mailto:imnikolova@abv.bg)

### Abstract

Georgieva, N., Nikolova, I. & Delchev, G. (2020). Response of spring vetch (*Vicia sativa* L.) to organic production conditions. *Bulg. J. Agric. Sci.*, 26 (3), 520–526

Application of organic farming principles requires a change in the conventional technologies used so far. With an aim to evaluate the responsiveness of spring vetch (presented by cultivars Obrazets 666 and Tempo) to organic production conditions during the period 2012–2014, at the Institute of forage crops, was carried a field trial. The organic production system included four variants: cultivation under natural soil fertility and alone/combined treatment with organic products (foliar fertilizer Biofa, plant regulator Polyversum, bioinsecticide Neem Azal T/S). Control of the organic system was a variant with conventional cultivation and use of synthetic products (foliar fertilizer Masterblend, plant growth regulator Flordimex 420 and insecticide Nurelle D). The grain productivity of spring vetch grown under four variants of organic production was 31.9% lower than that obtained under conventional production. The use of triple combination (Biofa + Polyversum + NeemAzal) showed the highest stability of yield. The stability of this variant exceeded the stability of conventional vetch production. Compared to cultivar Tempo, cultivar Obrazets 666 responded to a greater extent to the application of organic products, but had lower stability of grain yield. In addition, the treatment with Neem Azal, as well as its combination with Biofa and Polyversum, had significantly higher efficacy (against *Acyrtosiphon pisum*) in cultivar Obrazets 666, than in cultivar Tempo.

*Keywords:* vetch; responsiveness; organic production; stability

### Introduction

Organic production is one of the fastest growing sectors of world agriculture. Although it presents only 1% of the arable land in the world, organic production is one of the most recognizable labels. There is a wide range of interpretations of what exactly organic farming means, but in the broadest sense, it is a comprehensive farming system aimed primarily at improving soil, plant and animal health, which leads to improvement of the people and society health. In a narrow sense, organic regulations should focus on the best environmental practices to guarantee that organic farming will contribute to achieving sustainability aims (Seufert et al., 2017).

Spring vetch has characteristics that are particularly valuable for organic farming systems and for systems with low production inputs (Vlachostergios et al., 2011). It is distinguished with a relative tolerance to soil-climatic conditions, adaptability and high productivity. Due to its high nutritional value, it is often used as grain feed for livestock and also for the production of hay, silage or for green manure (Abd El Moneim, 1993; Vlachostergios et al., 2011). Furthermore, as a legume crop, spring vetch fixes atmospheric nitrogen and increases the soil organic matter (Rinnofner et al., 2008). In addition, it is widely used in crop rotations to control pests (Rebolé et al., 2004) and contribute to increased yield and protein content in the subsequent crops (Vasilakoglou et al., 2011). Furthermore, it is used in intercrop systems with cereals (Lithourgidis et al., 2007).

Application of organic farming principles requires a change in the conventional technologies used so far. Organic production technologies are becoming increasingly widespread, and researches focus primarily on increasing yields, pest control and improving the production quality (Coppola et al., 2008; Nenova & Ivanova, 2010; Georgieva et al., 2015; Stoyanova et al., 2014; Stoyanova et al., 2015).

The purpose of this experiment was to study the response of spring vetch for growing in organic farming conditions and to compare it with conditions of conventional production.

## Material and Methods

The experimental activity was conducted at the Institute of Forage Crops (Pleven, Bulgaria) during the period 2012–2014. The long plot method was used, with four replications of the variants, plot size of 10 m<sup>2</sup> and natural soil stock with basic nutrients. Two vetch cultivars (Obrazets 666 and Tempo) belonging to *Vicia sativa* L. were registered in the Bulgarian official catalogue of varieties, and they were subjects of the present study. Sowing was carried out at the end of March with a sowing rate of 220 seeds per m<sup>2</sup> (for both cultivars).

According to the requirements of organic farming, the field trial was situated in an area after a two-year conversion period. The organic production system included the following variants: V 1 – cultivation under natural soil fertility without use of bioproducts; V 2 – cultivation under use of organic foliar fertilizer and plant growth regulator (Biofa/500 ml ha<sup>-1</sup> + Polyversum /10g ha<sup>-1</sup>); V 3 – cultivation under use of bioinsecticide (Neem Azal T/S – 500 ml ha<sup>-1</sup>); V 4 – cultivation under use of three organic products (foliar fertilizer, growth regulator and an bioinsecticide: Polyversum /10g ha<sup>-1</sup> + Biofa /500 ml ha<sup>-1</sup> + Neem Azal T/S /500 ml ha<sup>-1</sup>).

Control of the organic system was variant V 5 – conventional cultivation with use of synthetic products (foliar fertilizer, plant growth regulator and an insecticide: Masterblend /1600 g ha<sup>-1</sup> + Flordimex 420 /50 ml ha<sup>-1</sup> + Nurelle D /400ml ha<sup>-1</sup>). A short characteristic of the products was presented in Table 1.

The treatment with organic and synthetic products was carried out twice, at stage 51–60 according to the BBCH scale (UPOV, 2013). During the vegetation period the population density of aphids was recorded as the method of sweeping with entomological net was used. The efficacy of the insecticides was calculated according to the formula of Abbott (1925) on the first, third, seventh and twelfth days after treatment. Harvesting was at technological maturity stage of the grain.

Stability parameters of grain yield were calculated. The variances of stability  $\sigma^2$  and  $S_i^2$  (Shukla, 1972) and ecovariance  $W_i$  (Wricke, 1962) demonstrate what part of the variation associated with the interactions between products and years is due to the particular variant. Using the stability criterion (YSi) of Kang (1993) was presented the value of each variant through simultaneously recording the yield value and the stability of the variant. The importance of this criterion is that by nonparametric methods and statistical significance of the differences, we obtain a generalized assessment ranking the variants in descending order according to their economic value.

## Results and Discussion

The spring vetch (presented by Obrazets 666 and Tempo) differed substantially in its agrobiological response to the different systems of growing (Figure 1). The yield was characterized by a minimum value of 0.68 t grain ha<sup>-1</sup> kg grain ha<sup>-1</sup> (cultivation under natural soil fertility without the use of

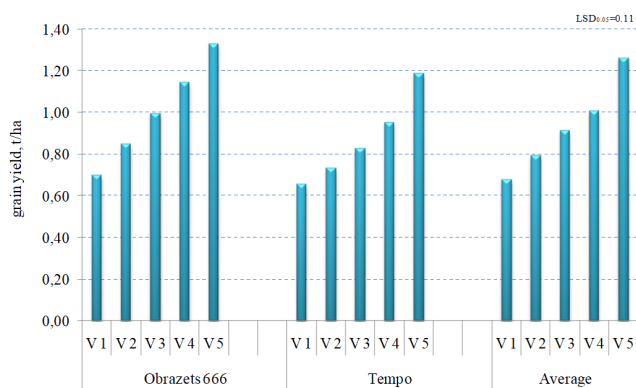
**Table 1. Characteristics of organic and synthetic products**

Products	Active ingredients	Application rates per ha
	organic products	
Biofa	Organic matter (9%), alginic acid (4%), natural plant hormone, total nitrogen (0.20%), total phosphorus (P <sub>2</sub> O <sub>5</sub> )– 8%, soluble potassium (K <sub>2</sub> O) – 14%;	500 ml
Polyversum	<i>Pythium oligandrum</i> (strain M1), 1 × 10 <sup>6</sup> oospores/g of product, natural product with double effect: a growth regulator and fungicide	100 g
Neem Azal T/S	1% azadirachtin A + 0.5% azadirachtin B,W,G,D + 2.5 neem substance	500 ml
	synthetic products	
Flordimex	420 g/l ethephon, a synthetic growth regulator which stimulates formation of generative organs;	50 ml
Master blend	combined leaf fertilizer, 20% nitrogen (6.22% nitrate + 3.88% ammonia + 9.90%urea), 20% soluble phosphorus (P <sub>2</sub> O <sub>5</sub> ), 20% solublepotassium (K <sub>2</sub> O) and minor elements (B, Cu, Fe, Mn, Mo,Zn, Mg;	1600 g
NurelleD	50 g/l a.i. cypermethrin + 500g/l a.i. chlorpyrifos-ethy+ 420 g/l ethephon	400 ml

bioproducts) and a maximum value of 1.26 t ha<sup>-1</sup> (conventional cultivation). The average productivity of plants under the four variants of organic production was 31.9% lower than that obtained under conventional production, with significant differences between them. Although the problem of crop productivity in the conditions of organic and conventional farming is a discussion question (Oljača et al., 2010; Laursen et al., 2011), and in the scientific literature, there are statements for opportunities to be obtained not lower and even higher yields in alternative agriculture than the traditional one (Kalapchieva et al., 2010), it is obvious that this is not realized. According to Stancheva (2000), the permissible reduction in organic yields for most fodder crops is of the order of 20-30% (rye, oats, barley, wheat) to 40% (for soybeans). In this regard, the results of this study showed that spring vetch was no exception.

As a whole, the arranging of variants in ascending order was as follows: natural soil fertility without use of bioproducts; use of organic foliar fertilizer and plant growth regulator; protection with use of biolinsecticide; triple combination of bioproducts Biofa + Polyversum + Neem Azal T/S; triple combination of synthetic products Masterblend + Flordimex 420 + Nurelle D. High yields were formed in plants developing in conditions of using the complete combination of bioproducts (variant 4), as the decrease compared to conventional production was on average 16.8%.

The two cultivars, in the present experimental conditions, demonstrated a different response to the applied variants of organic production. Cultivar Tempo responded to a lesser extent to the application of organic products, with a yield



**Fig. 1. Grain yield in spring vetch grown in conditions of organic and conventional production, 2012–2014**

Organic cultivation: V 1 – natural soil fertility without use of bioproducts; V 2 – Biofa + Polyversum; V 3 –NeemAzal T/S; V 4 – Biofa + Polyversum + Neem Azal T/S; Conventional cultivation: V 5 – Masterblend + Flordimex 420 + Nurelle D

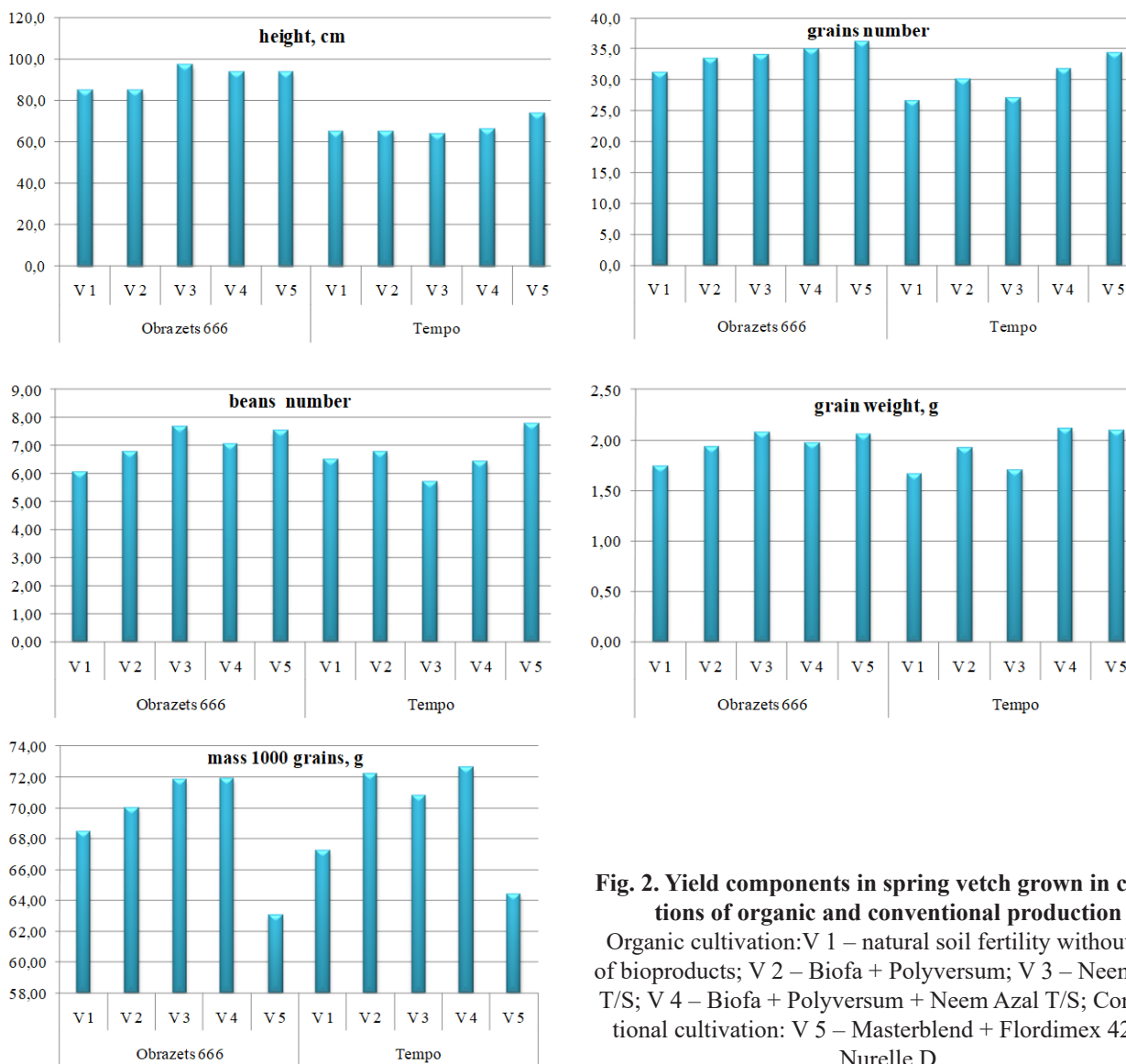
increase of 11.9 to 44.9% (V 2, V 3 and V 4) compared to the cultivation under natural soil fertility (V 1). Greater responsiveness was exhibited by Obrazets 666, with an increment ranging from 21.4 to 63.4%, and significant differences between the variants. In addition, the comparison of organic variants with the conventional cultivation showed a lesser reduction in the grain yield in Obrazets 666 (by 14.1% to 47.4%, on average 30.7%), and greater one in Tempo (by 19.8 to 44.7%, on average 33.2%). Kalapchieva et al. (2010) also reported different manifestations of pea genotypes (*Pisum sativum* L.) under conditions of organic and conventional growing. The authors found a well-pronounced differentiation in their agrobiological reaction, determined by the genetic features of the varieties. Significantly higher yields under organic production were shown by cultivars Vyatovo and Pulpudeva, while Skinado was more productive in conventional cultivation.

Reduced productivity in organic farming systems is determined by lower values of the yield components (Sadowski & Rychcik, 2009; Kuś et al., 2011) (Figure 2). In the spring vetch, the largest deviation in decrease direction (compared to the conventional production) was found in beans number (-13.7%) and grains number per plant (-11.6%), and the smallest deviation – in terms of plant height (-7.2%). With regard to 1000 grains mass, an increase in organic variants (10.8% on average) was established, probably due to the smaller number of grains and beans formed under these conditions and the compensating mechanisms of the plant.

The variation in yield components in spring vetch was weak. The traits of seeds number (VC = 7.7%) and seed weight (VC = 7.7%) were more variable, and plant height (VC = 4.8%) and 1000 seeds mass (VC = 5.1%) were more stable.

*Acyrtosiphon pisum*, commonly known as the pea aphid, is one of the major pests in spring vetch. Its effective control determined to a great degree the yield quantity and quality. The application of synthetic insecticide Nurelle D in combination with Flordimex 420 and Masterblend in cultivar Obrazets 666 during the experimental period was associated with the lowest number of aphids and statistically the highest efficacy of 92.5% on the first day after treatment (F = 3.612; df-5, 12; P = 0.001) (Figure 3). Compared to the bioinsecticide, this combination exhibited a rapid initial effect, which gradually decreased, but twelve days after treatment, it occupied a high value close to 70%. The synthetic combination had statistically the highest efficacy throughout the reporting period, not only for Obrazets 666, but also for Tempo.

The organic product Neem Azal was characterized by a relatively lower initial effect (43.5 and 38.4%), which increased and reached (on the 7<sup>th</sup> day after treatment) maximum



**Fig. 2. Yield components in spring vetch grown in conditions of organic and conventional production**

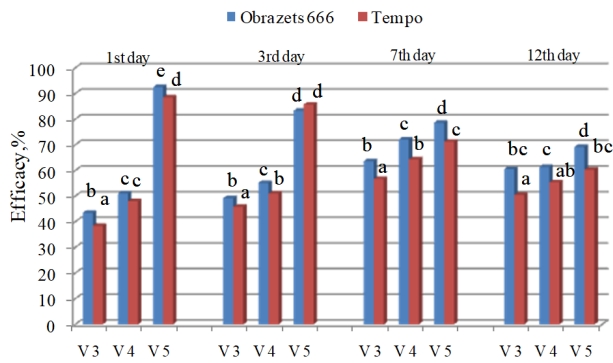
Organic cultivation: V 1 – natural soil fertility without use of bioproducts; V 2 – Biofa + Polyversum; V 3 – NeemAzal T/S; V 4 – Biofa + Polyversum + Neem Azal T/S; Conventional cultivation: V 5 – Masterblend + Flordimex 420 + Nurelle D

values of 63.6 and 56.7% (for Obrazets 666 and Tempo, respectively), followed by some reduction on the 12<sup>th</sup> day. The efficacy of the bioinsecticide was higher in Obrazets 666 on the 1<sup>st</sup> day ( $F = 3.612$ ;  $df=5, 12$ ;  $P = 0.001$ ), 3<sup>rd</sup> day ( $F = 3.074$ ;  $df=5, 12$ ;  $P = 0.001$ ), 7<sup>th</sup> day ( $F = 3.010$ ;  $df=5, 12$ ;  $P = 0.001$ ), and 12<sup>th</sup> day after treatment ( $F = 5.681$ ;  $df=5, 12$ ;  $P = 0.003$ ).

Under combined application of Neem Azal with Biofa and Polyversum, in both cultivars was observed a positive interaction and a significant increment in the efficacy of bioinsecticide compared to its alone use. A statistical difference in toxicity was established on the 1<sup>st</sup> day after treatment. Then it increased and reached maximum values of

72.1 and 64.3% on the 7<sup>th</sup> day, in Obrazets 666 and Tempo respectively. Twelve days after treatment, the efficacy of the combination decreased and occupied values close to the alone use of NeemAzal. The biological activity of the combination was more pronounced in Obrazets 666, where toxicity was significantly higher on the 3<sup>rd</sup>, 7<sup>th</sup> and 12<sup>th</sup> day after application.

According to Morgan (2009), Neem Azal contains biologically active substances from the group of lemons and shows considerable insecticidal, growth inhibitory and anti-inflammatory properties. The product affects insect nutritional behavior and leads to reduced food consumption,



**Fig. 3. Efficacy of biological and synthetic products against *Acyrthosiphon pisum*, average 2012–2014**

V 3 – Neem Azal; V 4 – Neem Azal+Biofa+Polyversum; V 5 – Nurelle D+ Flordimex+Masterblend; 1<sup>st</sup> – first day after treatment; 3<sup>rd</sup> – third day after treatment after treatment; 7<sup>th</sup>–seventh day after treatment; 12<sup>th</sup>–twelfth day after treatment

decreased mobility and death within a few days (Mordue & Blackwell, 1993). This explains the increasing efficacy of Neem Azal with increasing the number of days after treatment.

The raised biological efficacy of Neem Azal under combined application was due to the action of the algae extract (Biofa), which formed a fine coating on the leaves. This coating allowed better retention and absorption of the bioinsecticide and increased its efficacy. In addition, Biofa was rich in macro and micro elements, plant hormones, etc., which

enhanced the natural immune response of plants to biotic stress and contributed to resistance to *A. pisum*. In the present study, algae extract improved the activity of Neem Azal and helped to better protection against aphids.

It should be emphasized that treatment with Neem Azal, as well as its combined application, was more efficient in cultivar Obrazets 666 compared to cultivar Tempo, probably due to the morphological characteristics of the cultivars. The presence of significantly higher plants in Obrazets 666 ( $F = 2.789$ ;  $df-1, 19$ ;  $P = 0.001$ ), as well as better leafiness ( $F = 8.452$ ;  $df-1, 19$ ;  $P = 0.001$ ) and more leaf trichomes ( $F = 5.063$ ;  $df-1, 19$ ;  $P = 0.001$ ), favored the better coating and retention of products on the leaf surface (Table 2). A similar dependence, related to plant morphological characteristics and application of plant protection products, was described by Buchman & Cuddington (2009). The author focused on plant height, leaf surface and other morphological traits.

The analysis of variance regarding grain yield showed that the years had a considerable impact on this indicator – 13.1% of the total variation in the studied variants (Table 3). The impact was due to an uneven reaction of variants to the change in environmental conditions. This was due to large differences in the meteorological conditions during the three experimental years. The influence of factor C (products) was greatest – 37.1%. The influence of cultivars was insignificant compared to the total variation of the variants – 1.3%. The impact of years and products was significant at a probability level of  $\leq 0.01$ , and the impact of cultivars was insignificant.

There was significant interaction of products with the

**Table 2. Morphological characteristics in vetch cultivars**

Cultivars	Height, cm	Number of leaflet/compound leaf	Number of trichomes/1 cm <sup>2</sup>
Obrazets 666	105.6 b	22.3 b	49.71 b
Tempo	72.9 a	16.5 a	32.78a

**Table 3. Analysis of variance for grain yield in spring vetch**

Source of variation	Degrees of freedom	Sum of squares	Influence of factors, %	Mean squares
Total	119	1.3	100	–
Blocks	3	96120	0.7	32040.2
Variants	29	7450856	65.1	256926.1***
Factor A – Cultivars	1	42912	1.3	42912.7
Factor B – Years	2	1770888	13.1	885444.0***
Factor C – Products	4	5008440	37.1	1252110.0***
A×B	2	88912	1.9	44456.6
A×C	4	36592	1.2	39148.8
B×C	8	424040	9.1	53005.3**
A×B×C	8	79072	1.4	39884.4
Error	87	5966040	34.2	28575.2

\* $p \leq 0.5$  \*\* $p \leq 0.1$  \*\*\* $p \leq 0.01$

**Table 4. Stability parameters for grain yield in spring vetch cultivars**

Variants		$\sigma_i^2$	$S_i^2$	$W_i$	$YS_i$
Obrazets 666	natural soil fertility	34389.4**	18879.0	61600.9	-10
	Biofa + Polyversum	28159.9*	61377.2**	51633.7	-3
	Neem Azal T/S	47509.7**	25253.0*	82593.3	-1
	Biofa + Polyversum + NeemAzal T/S	25569.3	14648.8	47488.7	7+
	Masterblend + Flordimex + NurelleD	13424.6*	1771.6	18057.0	5+
Tempo	natural soil fertility	22144.4**	7433.4	42008.8	-6
	Biofa + Polyversum	-419.5	3051.0*	15906.5	-1
	NeemAzal T/S	58675.5**	2189.6*	100458.6	-4
	Biofa + Polyversum + Neem Azal T/S	16647.3	11307.1	33213.4	9+
	Masterblend + Flordimex + NurelleD	12787.8*	15276.7	49038.3	8+

conditions of the years (B × C) – 9.1%. This means that the efficiency of some products and their combinations is strongly influenced by the meteorological conditions. The interaction of the cultivars with the years (A × B), between cultivars and products (A × C) and between the three studied factors (A × B × C) was not mathematically significant.

Based on the significant interaction year × product (B × C), the stability of the manifestations of each variant was evaluated (Table 4). The variances of stability  $\sigma_i^2$  and  $S_i^2$  (Shukla, 1972), ecovalence  $W_i$  (Wricke, 1962) and stability criterion ( $YS_i$ ) of Kang (1993) were calculated. The variances of stability  $\sigma^2$  and  $S_i^2$  take into account the linear and nonlinear interactions and evaluate the stability of the variants. These variants, which show lower values, are estimated to be more stable because they interact weakly with environmental conditions. These variants, which demonstrate lower values, are considered to be more stable because they interact less well with environmental conditions. The negative values of the indicators  $\sigma_i^2$  and  $S_i^2$  are assumed to be 0. For ecovalence  $W_i$ , the higher the values of the indicator, the more unstable is the variant.

On this basis, using these three stability parameters, it was found that the most unstable was the variant with bioinsecticide Neem Azal, followed by that one with natural soil fertility. This instability was mainly due to the essential differences in grain yields in these variants over the experimental years.

In order to make an overall assessment of the effectiveness of each variant, account should be taken of both its impact on grain yield and its stability. Very valuable information about the technological value of the variants gives the indicator  $YS_i$  for simultaneous assessment regarding yield and stability.

The summarizing criterion of stability  $YS_i$  gave the lowest negative assessment of the natural soil fertility variant, characterizing it as the most unstable and low-productive.

Negative assessments also received the variants with combined use of Biofa and Polyversum, and the alone use of Neem Azal. They received these estimates, both because of the smaller increase in grain yields and the high instability of yields over the experimental years. According to this criterion, the most valuable variant for both cultivars was Biofa + Polyversum + Neem Azal. This variant combined high grain yields and very high stability of this indicator over the years. From the point of view of growing technology, the triple combination Masterblend + Flordimex 420 + Nurelle D also received a high estimation. It combined very good grain yields, but with a lower stability over the years.

In terms of cultivars, the summarizing criterion  $YS_i$  determined higher stability of the yield in Tempo in the different variants compared to Obrazets 666. Such dependence was established by Moll & Stuber (1974) and Kosev (2014), which observed higher stability in genotypes with lower or average productivity due to their weaker reaction to environmental conditions.

## Conclusions

The grain productivity of spring vetch grown under four variants of organic production was 31.9% lower than that obtained under conventional production.

The two cultivars, Obrazets 666 and Tempo, demonstrated a different response to the applied variants of organic production. Cultivar Tempo responded to a lesser extent to the application of organic products, with a yield increase of 11.9 to 44.9% compared to the cultivation under natural soil fertility. Greater responsiveness was exhibited by Obrazets 666, with an increment ranging from 21.4 to 63.4%. The comparison of organic variants with the conventional cultivation showed a lesser yield reduction in Obrazets 666 (by 30.7% averagely), and a greater one in Tempo (33.2%).

Stability parameters determined higher stability of the yield for the different cultivation variants in cultivar Tempo compared to Obrazets 666. The combined application of organic fertilizer Biofa, growth regulator Polyversum and bioinsecticide Neem Azal showed the highest stability in both cultivars. The stability of this variant exceeded the stability of conventional production.

In both cultivars, under combined use of Neem Azal with Biofa and Polyversum was observed a positive symbiotic interaction and a significant increment in the efficacy of bioinsecticide against pea aphids, compared to its alone use. The treatment with Neem Azal, as well as its combination with Biofa and Polyversum, had significantly higher efficacy in cultivar Obrazets 666 than in cultivar Tempo.

## References

- Abd El Moneim, A. M. (1993). Agronomic potential of three vetches (*Vicia* spp.) under rainfed conditions. *J. Agron. Crop Sci.*, 170(2), 113-120.
- Buchman, N. L. & Cuddington, K. (2009). Influences of pea morphology and interacting factors on pea aphid reproduction. *Environ. Entomol.*, 38(4), 962-970.
- Coppola, F., Haugaard-Nielsen, H., Bastianoni, S. & Østergård, H. (2008). Sustainability assessment of wheat production using Emergey. In: D. Neuhoff, N. Halberg, T. Al-fidi, et al. (eds.), *Proceedings of 16th IFOAM Organic World Congress*, Modena, Italy, June 16-20, 2008, Italy, 1-4.
- Georgieva, N., Nikolova, I. & Delchev, G. (2015). Organic cultivation of field pea by use of products with different action. *Span. J. Agric. Res.*, 13(4), e090.
- Kalapchieva, S., Masheva, S. & Yankova, V. (2010). Characterizing of the agrobiological response of garden pea in organic production. *Scientific Works, LV(1)*, 87-93.
- Kang, M. (1993). Simultaneous selection for yield and stability: Consequence for growers. *Agron. J.*, 85, 754-757.
- Kosev, V. (2014). Seed yield as affected by the ecological stability of the field pea (*Pisum sativum*). *Banats J. Biotechnol.*, V(9), 45-50.
- Kuś, J., Jonczyk, K., Stalenga, J., Feledyn-Szewczyk, B. & Mróz, A. (2011). Yields of the selected spring wheat varieties cultivated in organic and conventional crop production systems. *J. Res. Appl. Agric. Eng.*, 56(4), 18-23.
- Laursen, K. H., Schjoerring, J. K., Olesen, J. E., Askegaard, M., Halekoh, U. & Husted, S. (2011). Multielemental fingerprinting as a tool for authentication of organic wheat, barley, faba bean, and potato. *J. Agric. Food Chem.*, 59(9), 4385-4396.
- Lithourgidis, A. S., Dhima, K. V., Vasilakoglou, I. B., Dordas, C. A. & Yiakoulaki, M. D. (2007). Sustainable production of barley and wheat by intercropping common vetch. *Agron. Sustain. Dev.*, 27, 95-99.
- Moll, R. H. & Stuber, C. W. (1974). Quantitative genetics-empirical results relevant to plant breeding. *Adv. Agron.*, 26, 277-313.
- Mordue, A. J. & Blackwell, A. (1993). Azadirachtin: an update. *J. Insect. Physiol.*, 39, 903-924.
- Morgan, E. D. (2009). Azadirachtin, a scientific gold mine. *Bio-org. Med. Chem.*, 17, 4096-4105.
- Nenova, L. & Ivanova, I. (2010). Productivity and quality traits of spring forage oats Prista 2 variety grown under conditions of organic agriculture in the region of North-east of Bulgaria. *J. Mt. Agric. Balk.*, 13(4), 880-896.
- Oljača, S. I., Dolijanovic, Ž. K., Glamočlija, Đ. N., Đorđević, S. S. & Oljača, J. M. (2010). Productivity of winter rye in organic vs. conventional cropping system. *J. Agric. Sci.*, 55(2), 123-129.
- Rebolé, A., Alzueta, A., Ortiz, L. T., Barro, C., Rodríguez, M. L. & Caballero, R. (2004). Yields and chemical composition of different parts of the common vetch at flowering and at two seedfilling stages. *Span. J. Agric. Res.*, 2(4), 550-557.
- Rinnofner, T., Friedel, J. K., de Kruijff, R., Pietsch, G. & Freyer, B. (2008). Effect of catch crops on N dynamics and following crops in organic farming. *Agron. Sustain. Dev.*, 28, 551-558.
- Sadowski, T. & Rychcik, B. (2009). Yield and chosen quality traits of oat grown in the period of conversion to organic cropping system. *Acta Sci. Pol. – AGRIC*, 8(1), 47-55.
- Seufert, V., Ramankutty, N. & Mayerhofer, T. (2017). What is this thing called organic? – How organic farming is codified in regulations. *Food Policy*, 68, 10-20.
- Shukla, G. (1972). Some statistical aspects of partitioning genotype – environmental components of variability. *Heredity*, 29: 237-245.
- Stancheva, Y. (2000). Ecological bases of agriculture. Pensoft, Trakia University, 346 (Bg).
- Stoyanova, S., Ivanova, I., Zhekova, E., G. Ginchev, G. & Ivanova-Kovacheva, G. (2015). Impact of some organic fertilizers on yield and quality traits of wheat and malting barley, grown in system of organic farming. *Proceedings of the Union of Scientists – Ruse*, 3(7), 145-150.
- Stoyanova, S., Zhekova, E. & Ivanova, I. (2014). Productivity and quality traits of common bean and forage peas grown in organic farming conditions in Northeastern Bulgaria. In: *Proceedings National Conference Organic Crop Production, Animal Production and Foods*, 27-28 November, 2014, Troyan, Bulgaria, 251-255.
- Vlachostergios, D. N., Lithourgidis, A. S., Dordas, C. A. & Baxevanos, D. (2011). Advantages of mixing common vetch cultivars developed from conventional breeding programs when grown under low-input farming system. *Crop Sci.*, 51, 1274-1281.
- Wricke, G. (1962). Methods for conducting ecological field experiments. *Pflanzenzucht*, 47, 92-96.

Received: June, 14, 2018; Accepted: August, 21, 2019; Published: June, 30, 2020