YIELDING AND QUALITY POTENTIAL IN SOME YELLOW BELL PEPPER HYBRIDS AS A RESULT OF FOLIAR FERTILISER BIONEX, OF THE BIOREGULATOR SOLEX AND OF FERTIRRIGATION WITH THE SOLUBLE FERTILISERS KEMIRA AND AGRIPLANT USE DURING VEGETATION

Arsenie HORGOŞ, Anişoara IENCIU, Alexandra BECHERESCU, Daniel POPA

Banat's University of Agricultural Sciences and Veterinary Medicine, Faculty of Agricultural Sciences, Timisoara, Aradului Street, no. 119, RO-300645, Romania,
Corresponding author: horgos_a@yahoo.com

Abstract: *In order to valorise the entire genetic yielding and quality potential of the yellow bell pepper cultivar or hybrid we need, besides ensuring optimal conditions of growth and development achieved technologically, special measures of stimulating flower fecundation which, under the impact of some negative factors abort, thus diminishing production. Research was carried out on competitive comparative crops, in a glasshouse, using a tri-factorial experiment set after the sub-divided plot method with three replications. Experiments aimed at studying hybrids under the impact of the interaction between experimental factors (Factor A – the cultivated hybrid, Factor B – the fertirrigation system with soluble fertilisers such as Kemira and Agriplant, and Factor C – type of stimulation of plant metabolism and flower fecundation with natural and synthesis preparations). Experimental results were processed with mathematical statistic calculus specific to the variance analysis method, resulting in significant yield differences on the ground of comparisons as a result of the interaction of the experimental factors. The three bell pepper hybrids under study, subjected to foliar treatments with a natural foliar fertiliser (Bionex) and with a bio regulator (Solex), are Italian; their destination is mainly industrial, due to the fruit features, but they are also destined to be consumed fresh. The conclusions of our analysis show that there is unilateral impact and interaction between experimental factors, which leads to the necessity to modernise cultivation technology in bell pepper. Modernity, in this case, is represented by the use of chemical fertilisers such as Kemira and Agriplant and by the idea of using natural foliar fertilisers and bio regulators whose range is more and more diversified. It is recommendable to use the fertilisation system Kemira on the studied hybrids since the yields obtained under the impact of this factor are statistically covered, with very significantly positive differences in yield. Natural or synthesis products used to stimulate plant metabolism and flower fecundation have a beneficial effect on bell pepper yields, that are higher than those of the control (not fertilised) with yield increases between 14.1 and 29.3%. The paper points out the level of the production thus obtained and its quality under the impact of some natural and synthesis products that stimulate plants' metabolism and flower fecundation in the studied hybrids.*

Key words: *hybrids, crop tehnology, fertilization-irrigation, productive potential, bioregulatory, fertilization system*

INTRODUCTION

Bell pepper, as a vegetable crop consumed in large amounts together with tomatoes, cucumbers, egg plants, cabbage, cauliflower, etc., plays an important role within the assortment of vegetables cultivated both in the field and particularly in greenhouses and solaria, where this crop is safer from the point of view of the yields obtained. These last years, new cultivars of bell pepper have appeared among the crops in our country, introduced by private cultivators for their quantitative and qualitative features, but whose shape and size, on one hand, and organoleptic features, on the other hand, could compete with the vegetables imported from abroad.

The hybrid or the cultivar, as one of the factors determining potential yield size, cannot have a decisive impact on yield unless the proper cultivation technology is applied to fully enhance its genetically determined yielding potential.

For pepper crop, in general, and for bell pepper and red pepper, in particular, both in field crops and particularly in protected areas, irrigation and root and extra-root fertilisation as main technological works, we can say that they are the premise of larger and higher-quality yields in this very water and nutrient demanding vegetable.

Our experimental approach aims at presenting the benefits of the soluble chemical fertilisers Agriplant and Kemira in applying the cultivation technology in the bell pepper cultivated in greenhouses together with the application through fertirrigation and extra-root products (foliar or bioregulator fertilisers) that can supply the eventful dysfunctions of the root system from different causes.

MATERIAL AND METHODS

The experimental study we initiated was carried out in a greenhouse covered with a poly-ethylene sheet heated with conventional fuel through metal conducts and through vegetative heating (at soil level near the plants with special hoses through which warm water is circulated).

The goal of our research was to determine the yielding and quality potential of three hybrids of yellow bell pepper of the California type of Italian origin, from the Company Esasem, under the impact of two modern fertilisation systems with the soluble chemical fertilisers Agriplant and Kemira applied through fertirrigation and of stimulating plant metabolism and flower fecundation through spraying with specific preparations (the foliar fertiliser Bionex and the bioregulator Solex).

The objectives of our research were as follows:

- studying the yielding and quality potential of the three hybrids in different conditions of fertilisation with soluble fertilisers and with stimulation of plant metabolism and flower fecundation by spraying the plants during vegetation with the foliar fertiliser Bionex and the bioregulator Solex;
- determining yielding elements competing at quantitative and qualitative levels.

To reach the goal and objectives mentioned previously, we carried out a tri-factorial experiment with the following factors:

Factor A – Hybrid:

a_1 – Tevere F_1 ; a_2 – Quadrus F_1 ; a_3 – Mohai F_1

Factor B – Fertilisation system:

b_1 – fertilisation with soluble chemical fertilisers of the Agriplant type; b_2 – fertilisation with soluble chemical fertilisers of the Kemira type (Cropcare in basic fertilisation and Ferticare during vegetation)

Factor C – Natural or synthesis products used to stimulate plant metabolism and flower fecundation

c_1 – control (not fertilised foliary); c_2 – foliar fertilizer Bionex; c_3 – bioregulator Solex

The experiment was set after the subdivided plot method with three replications (Figure 1). During vegetation, we made measurements concerning the number of fruit per plant, the mean weight of a fruit, and the mean yield per plant and per ha.

The crop was set planting 70 day old plantlets on April 20, at a row distance of 70 cm and at a plant distance per row of 50 cm. the density of bell pepper crop resulted from the cultivation scheme presented above was 28,400 pl/ha.

RESULTS AND DISCUSSIONS

During vegetation, we made biometric measurements and phenological observations concerning the number of flowers per plant branch, the number of flowers fecundated and aborted, the number of harvestable fruit per plant, the mean weight of a fruit and the mean yield per plant and per ha.

Tables 1 and 2 show experimental results in the three studied hybrids (a_1 – Tevere F_1, a_2 – Quadrus F_1, a_3 – Mohai F_1) under the impact of the two fertilisation systems (b_1 – fertilisation with the fertiliser Agriplant, b_2 – fertilisation with the fertiliser Kemira) and under the impact of the foliar fertiliser Bionex and of the bioregulator Solex applied during vegetation.

The number of harvestable fruit per plant differs from one hybrid to another, the variation interval being 25.2 fruits per plant and 32.6 fruits per plant.

The number of harvestable fruit per plant fertilised with fertilisers of the type Kemira is higher in all hybrids compared with plants fertilised with fertilisers of the type Agriplant. Fruits have a very high mean weight: in the first two hybrids a_1 – Tevere F1 and a_2 – Quadrus F1, they weight over 330 g per piece in all the combinations of the graduations of the experimental Factors B and C. In a_3 – Mohai F1, mean fruit weight is over 200 g per piece, reaching a maximum of 261.3 g per piece in the combination $a_3b_1c_2$.

Yields per plant and per ha are very variable, the lowest yields being in all the hybrids fertilised with the fertiliser of the type Agriplant (b_2) under the graduation of the combination c_1 – not fertilised of the Factor C. Foliar fertilisation with Bionex – c_2 and Solex – c_3 yield different yields in all the hybrids in both fertilisation systems.

Table 1

Synthesis of yield results in yellow bell pepper hybrids cultivated in heated greenhouses covered with polyethylene sheets during the 1st cycle prolonged (2009)

Factor A (Hybrid)	Factor B (Fertilisation system)	Factor C (Flower fecundation stimulator)	Harvestable fruit per plant	Mean fruit weight (g/ piece)	Mean yield for the Factor C			Mean yield for the Factor B					Mean yield for the Factor A			
					kg/ plant	t/ha	%	Average number of Harvestable fruit per plant	Mean fruit weight (g/piece)	kg/ plant	t/ha	%	Average number of Harvestable fruit per plant	Mean fruit weight (g/piece)	kg/plant	t/ha
a_1 – Tevere F1	b_1 – fertilisation Agriplant	c_1 – not fertilised	22.2	351.2	7.796	221.4	100.0	25.2	362.6	9.156	260.0	100.0	26.9	343.5	261.9	100.0
		c_2 - Bionex	26.9	374.7	10.080	286.3	129.3									
		c_3 - Solex	26.5	361.8	9.588	272.3	122.4									
	b_2 – fertilisation Kemira	c_1 – not fertilised	25.1	314.5	7.894	224.2	100.0	28.6	324.4	9.285	263.7	101.4				
		c_2 - Bionex	30.4	336.3	10.225	290.4	123.5									
		c_3 - Solex	30.2	322.4	9.736	276.5	123.3									
a_2 – Quadrus F1	b_1 – fertilisation Agriplant	c_1 - not fertilised	26.6	342.7	9.116	258.9	100.0	30.4	352.1	10.732	304.8	100.0	31.5	341.9	305.9	116.8
		c_2 - Bionex	31.9	362.6	11.567	328.5	126.9									
		c_3 - Solex	32.8	351.0	11.514	327.0	126.3									
	b_2 – fertilisation Kemira	c_1 - not fertilised	30.7	319.8	9.817	278.8	100.0	32.6	331.6	10.812	307.1	100.8				
		c_2 - Bionex	34.1	343.7	11.722	332.9	119.4									
		c_3 - Solex	32.9	331.3	10.901	309.6	117.9									
a_3 – Mohai F1	b_1 – fertilisation Agriplant	c_1 - not fertilised	25.2	241.0	6.074	172.5	100.0	26.8	250.3	6.725	191.0	100.0	28.4	240.1	193.5	73.9
		c_2 - Bionex	27.8	261.3	7.264	206.3	113.6									
		c_3 - Solex	27.5	248.6	6.838	194.2	112.6									
	b_2 – fertilisation Kemira	c_1 - not fertilised	28.1	219.6	6.173	175.3	100.0	29.9	229.8	6.898	195.9	102.6				
		c_2 - Bionex	31.0	241.1	7.475	212.3	121.1									
		c_3 - Solex	30.8	228.8	7.046	200.1	114.1									

We can see there is a considerable difference between fruit mean weight, so that mean weight of a fruit from plants fertilised with fertilisers of the type Agriplant in all three hybrids is larger, the differences between the first two hybrids being 7.2-10.5 g per piece, while the difference between the first and the third hybrids (Mohai F1) is larger (101.8-112.3 g per piece). Mean yield per plant despite these differences is larger in the plants fertilised with Kemira and, as a consequence, the mean weight per ha are larger, the differences in yield in each hybrid being rather modest (2.3-4.9 t/ha).

Mean yield per ha for the Factor B oscillates between 251.9 t/ha in b_1 (fertilisation with Agriplant) and 256.6 t/ha in b_2 (fertilisation with Kemira), the difference in yield in b_2 being not significant (only 1.5%). Likewise, in the case of each hybrid, yields in b_2 (fertilisation with Kemira) are 0.8-2.6% larger, which leads to the conclusion that neither of the fertilisation systems we applied is determining in obtaining large yields per surface unit.

Table 2.

Synthesis of yield results in yellow bell pepper hybrids cultivated in heated greenhouses covered with polyethylene sheets under the impact of the interaction between experimental factors during the 1st cycle prolonged (2009)

Factor A (Hybrid)	Factor B (fertilisation system)	Factor C (Flower fecundation stimulator	Mean yield per plant and per ha for				Mean yield per ha (t/ha and %) for						
			Factor C				Factor B		Factor A			Mean (Mx)	
			Kg per plant	t/ha (%) for			$a_{1-3}b_{1-2}$	$a_{1-3}b_1$ şi $a_{1-3}b_2$	a_{1-3}	% compared to a_1	% compared to Mx	t/ha (%)	% compared to a_{1-3}
				c_1-c_3	b_{1-2} c_{1-3}	a_{1-3} c_{1-3}							
a_1 – Tevere F1	b_1 – fertilisation Agriplant	c_1 - not fertilised	7,796	221,4	b_{1-2} c_1 228,8/100,0%		260,0/100,0		261,9	100,0	103,2		96,9
		c_2 - Bionex	10,080	286,3	b_{1-2} c_2 288,4/129,4%								
		c_3 - Solex	9,588	272,3	b_{1-2} c_3 274,4/123,2%								
	b_2 – fertilisation Kemira	c_1 - not fertilised	7,894	224,2		$a_{1-3}c_1$ 221,9/100,0%	263,7/101,4	$a_{1-3}b_1$ 251,9/100,0					
		c_2 - Bionex	10,225	290,4									
		c_3 - Solex	9,736	276,5									
a_2 – Quadrus F1	b_1 – fertilisation Agriplant	c_1 - not fertilised	9,116	258,9	b_{1-2} c_1 268,9/100,0%		304,8/100,0		306,0	116,8	120,6	253,8 (100,0)	82,9
		c_2 - Bionex	11,567	328,5	b_{1-2} c_2 330,7/123,0%								
		c_3 - Solex	11,514	327,0	b_{1-2} c_3 318,3/118,4%								
	b_2 – fertilisation Kemira	c_1 - not fertilised	9,817	278,8		$a_{1-3}c_2$ 276,1/124,4%	307,1/100,8						
		c_2 - Bionex	11,722	332,9									
		c_3 - Solex	10,901	309,6									
a_3 – Mohai F1	b_1 – fertilisation Agriplant	c_1 - not fertilised	6,074	172,5	b_{1-2} c_1 173,9/100,0%	$a_{1-3}c_3$ 263,3/118,7%	191,0/100,0	$a_{1-3}b_2$ 255,6/101,5	193,5	73,9	76,2		131,2
		c_2 - Bionex	7,264	206,3	b_{1-2} c_2 209,3/120,4%								
		c_3 - Solex	6,838	194,2	b_{1-2} c_3 197,2/113,4%								
	b_2 – fertilisation Kemira	c_1 - not fertilised	6,173	175,3			195,9/102,6						
		c_2 - Bionex	7,475	212,3									
		c_3 - Solex	7,046	200,1									

Mean yields under the impact of the graduations of the Factor C (c_1 –control not fertilised foliary, c_2 – foliar fertilisation with Bionex, c_3 – spraying with the bioregulator Solex) differ very much in the case of each hybrid, with shares between 13.4 and 29.4% compared to c_1 – the control not fertilised foliary.

The mean of the yield in c_2 (foliar fertilisation with Bionex) is 276.1 t/ha (124.4%) compared to c_3 (spraying with the bioregulator Solex) of 263.3 t/ha (118.7%) and to c_1 (control not fertilised foliary) of 221.9 t/ha (100.0%).

The conclusion we can draw here concerning the impact of the Factor C on yield is that applying the foliar fertilise Bionex and the bioregulator Solex is particularly beneficial for bell pepper plants, the increases in yield being very significant – 54.2 t/ha (c_2) and 41.4 t/ha (c_3) respectively (24.4% and 18.7% more than c_1 – control not fertilised foliary).

Mean yield per ha for the Factor A is clearly differentiated so that in a_2 – Quadrus F_1 the yield was 306.0 t/ha, 16.8% larger than in a_1 – Tevere F_1, and in Mohai F_1, 26.1% smaller than in a_1. Therefore, mean yields are variable and they range within 73.9%-116.8% compared to the control a_1 – Tevere F_1 (100.0%).

Table 3.

Synthesis of yield results in yellow bell pepper hybrids cultivated in heated greenhouses covered with polyethylene sheets under the impact of the singular impact and of the interaction between experimental factors during the 1st cycle prolonged (2008)

Variant	Mean yield (kg/ha)		Relative yield (%)	Difference (± t/ha)	Significance of the difference
1. Singular impact of the hybrid on yield					
a2-a1	305.95	261.85	116.84	44.10	***
a3-a1	193.45	261.85	73.88	-68.40	000
a3-a2	193.45	305.95	63.23	-112.50	000
DL 5%= 2.67 DL 1%= 4.04 DL 0.1%= 6.49					
2. Singular impact of the fertilisation system on yield					
b2-b1	255.57	251,93	101,44	3,63	***
DL 5%= 1.12 DL 1%= 1.55 DL 0.1% = 2.13					
3. Singular impact of the fertiliser on yield					
c2-c1	276.12	221.85	124.46	54.27	***
c3-c1	263.28	221.85	118.68	41.43	***
c3-c2	263.28	276.12	95.35	-12.83	000
DL 5%= 2.67 DL 1%= 3.61 DL 0.1% = 4.83					
4. Impact of the interaction between different hybrids and the same fertilisation system or different fertilisation systems					
a2b1-a1b1	304.80	260.00	117.23	44.80	***
a3b1-a1b1	191.00	260.00	73.46	-69.00	000
a2b2-a1b1	307.10	260.00	118.12	47.10	***
DL 5% = 3.00 DL 1% = 4.44 DL 0.1% = 6.91					
5. Impact of the interaction between the same hybrid and different systems of fertilisation					
a1b2- a1b1	263.70	260.00	101.42	3.70	***
a2b2- a2b1	307.10	304.80	100.75	2.30	*
a3b2- a3b1	195.90	191.00	102.57	4.90	***
DL 5% = 1.95 DL 1% = 2.68 DL 0.1% = 3.69					
6. Impact of the interaction between the same hybrid and different foliar fertilisers					
a1c2- a1c1	288.35	222.80	129.42	65.55	***
a1c3- a1c1	274.40	222.80	123.16	51.60	***
a1c3- a1c2	274.40	288.35	95.16	-13.95	000
a3c3- a3c2	197.15	209.30	94.19	-12.15	000
DL 5% = 4.62 DL 1% = 6.26 DL 0.1% = 8.36					
7. Impact of the interaction between the same fertilisation system and different foliar fertilisers					
b1c2- b1c1	273.70	217.60	125.78	56.10	***
b2c2- b2c1	278.53	226.10	123.19	52.43	***
b2c3- b2c2	262.07	278.53	94.09	-16.47	000
DL 5% = 3.77 DL 1% = 5.11 DL 0.1% = 6.83					
8. Impact of the interaction between different fertilisation systems and the same foliar fertiliser or different foliar fertilisers					
b2c1- b1c1	226.10	217.60	103.91	8.50	***
b2c3- b1c3	262.07	264.50	99.08	-2.43	-
DL 5% = 3.28 DL 1% = 4.45 DL 0.1% = 5.97					
9. Impact of the interaction between different hybrids and the same foliar fertilise or different foliar fertilisers					
a2c1- a1c1	268.85	222.80	120.67	46.05	***
a3c1- a1c1	173.90	222.80	78.05	-48.90	000
a3c3- a2c2	197.15	330.70	59.62	-133.55	000
DL 5% = 4.60 DL 1% = 6.45 DL 0.1% = 9.18					
10. Impact of the interaction between the same hybrid and the same fertilisation system and different foliar fertilisers					
a1b1c2- a1b1c1	286.30	221.40	129.31	64.90	***
a1b1c3- a1b1c1	272.30	221.40	122.99	50.90	***
a2b2c3- a2b2c2	309.60	332.90	93.00	-23.30	000
DL 5% = 6.53 DL 1% = 8.85 DL 0.1% = 11.83					
11. Impact of the interaction between the same hybrid and different fertilisation systems and the same foliar fertiliser					
a1b2c1- a1b1c1	224.20	221.40	101.26	2.80	-
a2b2c2- a2b1c2	332.90	328.50	101.34	4.40	-
a3b2c3- a3b1c3	200.10	194.20	103.04	5.90	*
DL 5% = 5.68 DL 1% = 7.70 DL 0.1% = 10.33					
12. Impact of the interaction between different hybrids and the same fertilisation system and the same foliar fertiliser					
a2b1c1- a1b1c1	258.90	221.40	116.94	37.50	***
a3b1c1- a1b1c1	172.50	221.40	77.91	-48.90	000
a3b2c1- a1b2c1	175.30	224.20	78.19	-48.90	000
a3b2c3- a2b2c3	200.10	309.60	64.63	-109.50	000
DL 5 % = 6.11 DL 1% = 8.44 DL 0.1% = 11.71					

Compared to the experimental mean (Mx) – 253.8 t/ha, yields in a_1- Tevere F1 and a_2 – Quadrus F1 are 3.2% and 20.6% larger, and in a_3 – Mohai F1 it is 23.8% smaller.

Table 3 presents, on the basis of calculus of statistics mathematics, specific to the variance analysis method, the significance of differences in yield compared to the impact of the interdependence between experimental factors.

Analysing experimental factors under 1 unilaterally, we can see that the significance of the differences in yield between a_2 (Quadrus F_1) and a_1 (Tevere F_1) and between a_3 (Mohai F1), a_1 (Tevere F1) and a_2 (Quadrus F_1) is very significantly positive in the first case and significantly negative in the last two cases, which shows the superiority of the hybrid Quadrus F1 (a_2) compared to Tevere F1 (a_1) and to Mohai F1 (a_3) and the superiority of Tevere F1 (a_1) compared to Mohai F1 (a_3). The same unilateral analysis under 2 shows that the impact of the fertilisation system of the plants in the case of these hybrids is pregnant enough, which is also supported by the fact that the significance of the differences in yield between b_2 (fertilization system Kemira) and b_1 (fertilization system Agriplant) is very significantly positive.

A first conclusion resulting from the analysis of the unilateral impact of the two factors is that the hybrid Quadrus F_1 ranges first due to its yield, but not necessarily when fertilising with fertilisers of the type Kemira, since the difference in yield is not significant compared to the mean yield per ha.

The same analysis under 3 points out yields resulted after application of the foliar fertiliser Bionex (c_2) and of the bioregulator Solex (c_1) during vegetation, the yields being ensured statistically, with very significantly positive differences in yield in the first two cases ($c_2 \rightarrow c_1$ and $c_3 \rightarrow c_1$) and very significantly negative in the last case ($c_3 \rightarrow c_2$), which pleads for the better efficacy of the foliar fertiliser Bionex (c_2) compared to that of the bioregulator Solex (c_3).

Likewise, the complex analysis under 4-12 concerning the impact of the interaction of the three factors shows that the differences in yield are characterised as very significantly positive and negative, with no significance whatsoever or significantly positive or negative.

CONCLUSIONS

1. The hybrids Tevere F1, Quadrus F1 and Mohai F1 are new hybrids of yellow bell pepper tested for expansion due to the features of their fruit, features that recommend them for both industrialisation and fresh consumption.
2. Yields are over 190 t/ha, except for the hybrid Quadrus F1, with a maximum of over 330 t/ha, yields that are above all yield in the other hybrids cultivated in greenhouses in Romania.
3. Among the three hybrids, to note the hybrid Quadrus F1 with yields over 300 t/ha in each of the two fertilisation systems and of each of the fertilisers (foliar fertiliser Bionex or bioregulator Solex) to stimulate flower fecundation.
4. It is recommendable to use the fertilisation system Kemira (b_2) on the studied hybrids (Tevere F1, Quadrus F1 and Mohai F1) since the yields obtained under the impact of this factor (b2) are statistically covered, with very significantly positive differences in yield.
5. Natural or synthesis products used to stimulate plant metabolism and flower fecundation have a beneficial effect on bell pepper yields, that are higher than those of the control (not fertilised) with yield increases between 14.1 and 29.3%.
6. It is recommendable to pursue our research on the behaviour of these hybrids in heated greenhouses from the point of view of their yielding and quality potential under the impact of foliar fertilisers Bionex and Solex during vegetation and of soluble fertilisers such as Kemira and Agriplant.

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