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THE INFLUENCE OF SUBSTRATE TYPE ON THE PRODUCTION OF ASPARAGUS GROWN IN DIFFERENT ENVIRONMENTAL CONDITIONS

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Abstract

The study was conducted within the Horticulture faculty in Bucharest using the cultivar Argenteuil of asparagus (Asparagus officinalis L.), during 2016-2018. We had grown the plants in three types of substrate, peat, perlite and mixture of perlite and peat and we used six type of fertilizers.
The earliest production was obtained in the greenhouse conditions on all types of substrate compared to the crops grown under field conditions.
The purpose of the study was to see what was the most effective method of getting an early asparagus production.

Key words*: asparagus, substrate, fertilizers, condition of growing.*

INTRODUCTION

Asparagus officinalis L. is native to North America it has acclimatized very well in Romania and in other geographical areas.
It is one of the species highly appreciated for its low calorie content (40 calories), without cholesterol or fat) being rich in minerals, especially in potassium and vitamins. It can be consumed fresh or preserved. In the world there is a growing demand for asparagus, mainly for fresh asparagus but also for frozen and preserved products.
In Europe, asparagus is grown on 66,500 hectares and is one of the most popular vegetables being consumed fresh or processed. In Europe the leading producers are Germany with 25 thousand ha and a production of 130,881 t, Spain with 13 thousand ha and 63,433 t, Italy with 6,863 ha and 46,419 t and Nederland with 20,800 t. China is the leading producer in the world with 57,000 t production in other continents is much lower: Africa (4,800 t), Asia (12,200 t excluding China) and Oceania (3,180 t).
The highest yields of asparagus are obtained in areas with temperate climate in late spring and early summer, but there is a period of when there is no fresh asparagus in temperate climates, which results in import insurance from tropical areas (Jakše, 2008; Nichols, 1992; Wolyn, 2018).
Asparagus is cultivated only on small areas, in individual households but in some countries such as Turkey, production is continuously increasing, at present it is 200 tons (Arman Badur, 2017). Crop technology, soil type and soil can influence the production of asparagus (H. Araki, 2002; Jishi, 2012) Wallace et al., (1993), Taga et al. (1980) showed that keeping the asparagus plants at temperatures of 22ºC led to higher shoots but the plants exposed to temperatures of 28ºC were stimulated for the emergence of the shoots but they were thinner.
Van Os and Simonse (1988) recommend for early production forcing before planting thus harvests are obtained 10 days earlier.
Green spears were produced in winter with warming cultural beds (Haruyama et al., 1985; Koizumi et al., 2002; 2003; 2013). Koizumi et al., 2013; Ku et al., 2007).
W. Chen (2018), also underlines this aspect that lower temperatures during the formation of shoots extends the harvesting period, being different in cultivation.
Some results from two years of experiments show asparagus rhizomes kept from the forcing period during February to July in a chamber at –1°C, then from August to September at 0°C then planted in containers. In each box either two or three rhizomes were placed, and were filled with different growing media, placed on a bench in a heated greenhouse and fertilized

either every one or two weeks. The effects of the different treatments applied were significant (Nicola, Hoeberechts and Fontana, 2003).
Growing asparagus plants in large containers filled with coco peat in greenhouses during the summer months, and forcing in the dark has the potential to provide consumers with a high quality local product year round. By forcing in the dark the plants can be grown at soil level, and the white spears harvested above the ground (Nichols, 2007).
Under field conditions, cultivation of other vegetable crops after deforestation of the asparagus crop, led to high vegetable yields (Asaduzzaman et al., 2013; Young, 1984; Young and Chou, 1985).

MATERIALS AND METHODS

The experiment was made during 2017-2018 in two condition of medium, in greenhouse (in Hortinvest greenhouse) and in field.
We used the Argenteuil cultivar of *Asparagus officinalis* L species.
We used three types of substrate, peat, perlite with 4 mm granulation and mixture of 50% perlite and 50%peatand five types of fertilizers. The fertilized variant was: V1 - control; V2 - Amalgerol; V3 - Formulex; V4 - Vermiplant; V5 - Poco and V6 - Iguana. Amalgerolis a product with effect on the plant and the soil obtained from natural oils, plant extracts and organic carbohydrates.
Vermiplant is a natural liquid, stabilisated, resulted thru product obtained from extraction from composting under the action of earthworms. It contains microelements (barium, zinc, iron, manganese and amino acids), all of which contribute to better growth and development of plants.
POCO is a organic product with contains of: 0.04-0.05% Calcium; 6.30-12.70 mg/l Iodine; 0,50-0,80 mg/l Magnesium; 0.025-0.038 mg/l Nitrogen; 0.50-0.64% Potassium;0.088-0.120% Sodium; 0.028-0.050% Sulf; 0.10-0.12%, Orange oil; 0.04-0.06% rape oil and Organic acids 0.20-0.25%.
Iguana is a 100% organic product with 4% nitrogen, 3% phosphorus, 6% potassium contains: Formulexis a organic product that contains nitric nitrogen 2.19; ammoniacal nitrogen 0.21; phosphorus (P2O5); Potassium (K2O) 3.36; Calcium (CaO) 1.85; ameliorated with Bor 0.0108; Cobalt 0.0006; Copper 0.0025; Iron 0.0526; Manganese 0.0131; Molybdenum 0.0012; and Zinc 0.036.
Planting was done in pots with a capacity of 4 litres filled according to the substrate variants.
I recorded the amount of water and nutrient solution administered. I watched in a dynamic way the vegetative growth, the number of shoots formed. The plants were in year 4 of culture. The care work consisted of watering, fertilization, temperature and light monitoring.
We have correlated the plant mass, fertilizer type and substrate type. The purpose of the study was to identify the best option for obtaining quality asparagus plants.
The results were statistically estimated by the average, median, maximal and minimal values.

RESULTS AND DISCUSSIONS

The temperature was recorded between 1 March and 31 May 2018 that is the period taken into consideration for asparagus culture, both in hot greenhouses and field (Figure 1).

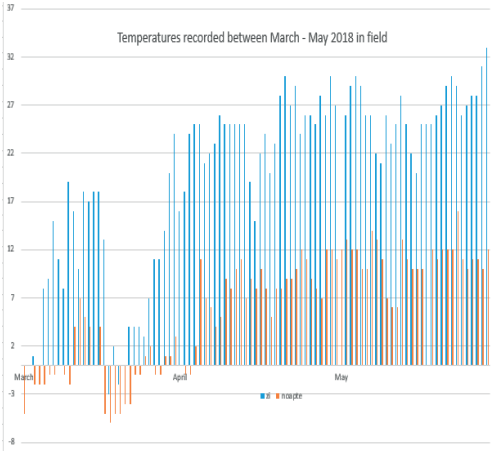

Figure 1. Temperatures recorded between March - May 2018 in field

During the period of emergence and harvest of the asparagus shoots we found that the sum of the registered temperature degrees was 3674ºC in the greenhouse and 2368ºC in the field. The temperature difference between the greenhouse and the field was 1306ºC (Table 1).

Table 1. The temperature recorded during March-May 2018

Harvest period		The sum of the temperature degrees, °C		Differences greenhouse/ field
		Greenhouse	Field	°C
March	Day	620	280	340
	Night	527	-17	544
April	Day	660	747	-87
	Night	558	233	325
May	Day	720	794	-74
	Night	589	331	258
Sum degrees of temperatures		3674	2368	1306

In March, no shoots were harvested at the plants grown in the field. In the greenhouse were harvested between 1 shoot (V1) and 3 shoots (Figure 2).

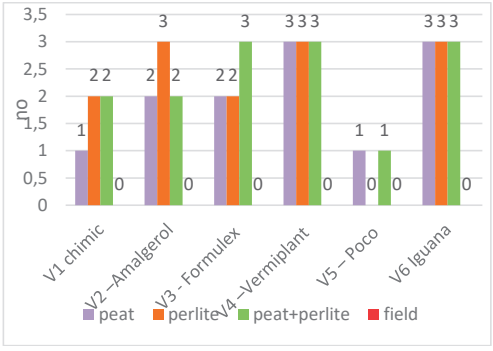

Figure 2. Sprouts harvested in March

In April shoots were harvested from all variants (Figure 3).

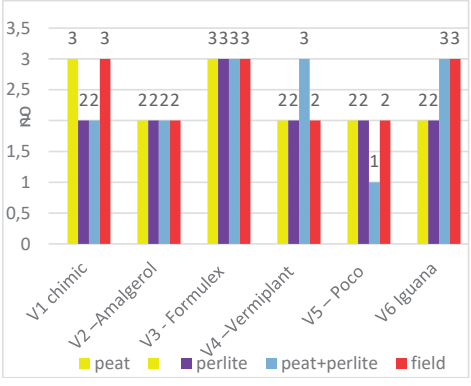

Figure 3. Sprouts harvested in April

In May, at the variant fertilized with Amalgerol no shoots were harvested. But for the rest of the variants only one sprout was harvested at the chemically fertilized variant on the peat, pearl and pearl + peat substrates (Figure 4).

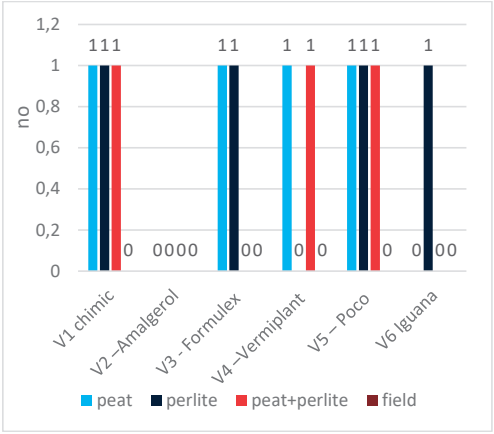

Figure 4. Sprouts harvested in May

The highest number of shoots harvested per square meter was recorded at V4, on peat + pellet substrate (7 shoots/m^2) and the lowest in field cultivated and fertilized with Amalgerol and Poco (Figure 5).

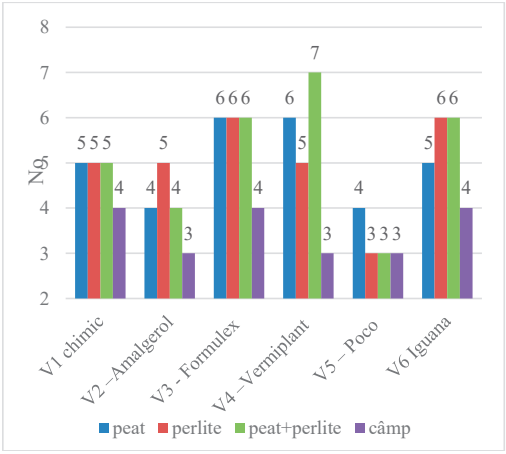

Figure 5. The total number of shoots harvested on square meter

The total number of shoots harvested per square meter in field crops was only three shoots in V2, V4, V5 and four shoots in V1, V3 and V6 If we analyze statistically the total number of shoots from the experimental variants, we found statistically insignificant differences (Table 2).

Table 2. The influence of the number of shoots obtained on the asparagus plants grown in the field

VARIANTS	Shoots (No)	Difference significance (No)	(%)	
V(0) Average	3.50	-0.50	87.50	N
V(1)	4.00	0.00	100.00	Control
V(2)	3.00	-1.00	75.00	N
V(3)	4.00	0.00	100.00	N
V(4)	3.00	-1.00	75.00	N
V(5)	3.00	-1.00	75.00	N
V(6)	4.00	0.00	100.00	N
DL5% =	1.460	DL5% in % =	36.5000	
DL1% =	2.090	DL1% in % =	52.2500	
DL0.1% =	3.020	DL0.1% in % =	75.5000	

In the variant cultivated on peat substrate, in the greenhouse, the total number of shoots collected per 1 m^2 was between 4 shoots at V2 and V5, the difference from the control was only 80%. For variants 3 and 4, a number of 6 shoots/m^2 were harvested, with 20% over the control variant. From a statistical point of view, the differences between the various ones were insignificant (Table 3).

Table 3. The influence of the number of shoots obtained on asparagus plants grown on peat substrate

VARIANTS	Shoots (No)	Difference significance (No)	(%)	
V(0) Average	5.00	0.00	100.00	N
V(1)	5.00	0.00	100.00	Control
V(2)	4.00	-1.00	80.00	N
V(3)	6.00	1.00	120.00	N
V(4)	6.00	1.00	120.00	N
V(5)	4.00	-1.00	80.00	N
V(6)	5.00	0.00	100.00	N
DL5% =	1.460	DL5% in % =	29.2000	
DL1% =	2.090	DL1% in % =	41.8000	
DL0.1% =	3.020	DL0.1% in % =	60.4000	

Analyzing the cultivated variant, on perlite substrate, we found that only V5 presented the smallest number of shoots of only 3 shoots / m^2, the difference being 40% below V1 control. From a statistical point of view the difference was with negatively significant. In the other variants the differences were insignificant (Table 4).

Table 4. The influence of the number of shoots obtained from asparagus plants on the perlite substrate

VARIANTS	Shoots (No)	Difference significance (No)	(%)	
V(0) average	5.00	0.00	100.00	N
V(1)	5.00	0.00	100.00	Mt
V(2)	5.00	0.00	100.00	N
V(3)	6.00	1.00	120.00	N
V(4)	5.00	0.00	100.00	N
V(5)	3.00	-2.00	60.00	O
V(6)	6.00	1.00	120.00	N
DL5% =	1.970	DL5% in % =	39.4000	
DL1% =	2.800	DL1% in % =	56.0000	
DL0.1% =	4.050	DL0.1% in % =	81.0000	

In the variant grown on 50% pearlite and 50% peat substrate, we observed significant positive differences at V4, in which we harvested a number of 7 shoots/m^2. At the V5 were harvested only 3 shoots/m^2, the difference being from a statistically significant negative point of view (Table 5).

Table 5. Influence of the number of shoots obtained on asparagus plants grown on perlite + peat substrate

VARIANTS	Shoots (No)	Difference significance (No)	(%)	
V(0) Average	5.17	0.17	103.33	N
V(1)	5.00	0.00	100.00	Mt
V(2)	4.00	-1.00	80.00	N
V(3)	6.00	1.00	120.00	N
V(4)	7.00	2.00	140.00	*
V(5)	3.00	-2.00	60.00	O
V(6)	6.00	1.00	120.00	N
DL5% =	1.970	DL5% in % =	39.4000	
DL1% =	2.800	DL1% in % =	56.0000	
DL0.1% =	4.050	DL0.1% in % =	81.0000	

Analyzing the influence of the type of fertilizer used according to the type of substrate, we found an influence on the total number of shoots per square meter. Thus, in the case of chemical fertilization the total number of shoots per square meter was five shoots in the case of peat, pearl and mixture 50% peat + 50% pearlite and in the field of four shoots. The correlation coefficient being $R^2 = 0.6$ (Figure 6.).

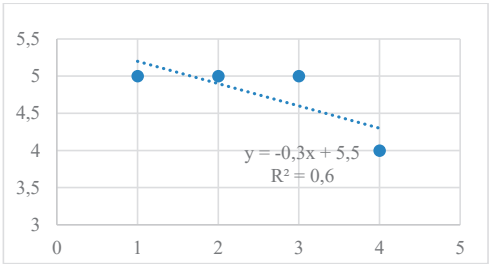

Figure 6. The variant chemically fertilized

In the case of fertilization with Amalgerol, an average number of 3 shoots were harvested, for the variant cultivated in field and 5 shoots for the variant cultivated on the pearl substrate, the correlation coefficient being $R^2 = 0.4$ (Figure 7).

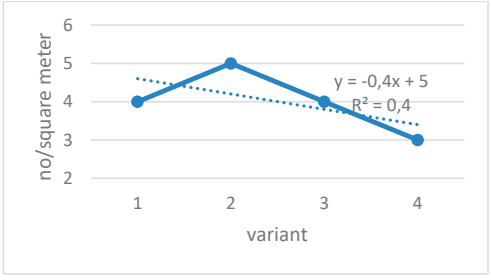

Figure 7 The variant with Amalgerol fertilizer -Number of shoots obtained on square meter

At the variant three, fertilized with Formulex, were obtained 6 shoots per square meter and for variants 1-3 and for the variant cultivated in the field only 4 shoots per square meter. The correlation coefficient being $R^2 = 0.6$.

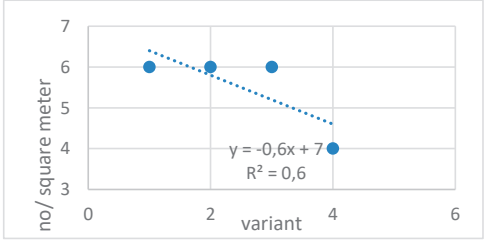

Figure 8 The variant with Formulex fertilizer

In the case of the variant fertilized with Vermiplant, we obtained a greater number of shoots per square meter in the case of the culture on substrates, in the greenhouse. The total number of shoots harvested was 6 shoots at the peat substrate, 5 shoots at the pearlite substrate and 7 shoots at the peat + pellet substrate.

The correlation coefficient being $R^2 = 0.28$ (Figure 9).

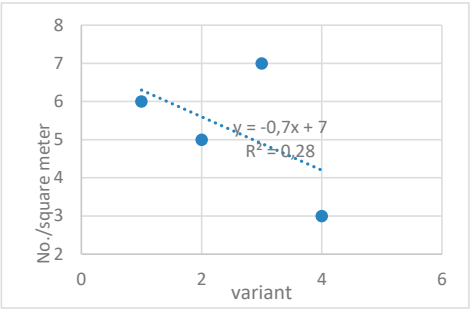

Figure 9. The variant with Vermiplant fertilizer

The application of the Poco product had positively influenced the number of shoots in the case of the variant cultivated on perlite substrate (4 shoots/m^2). The coefficient of correlation being $R^2 = 0.6$ (Figure 10).

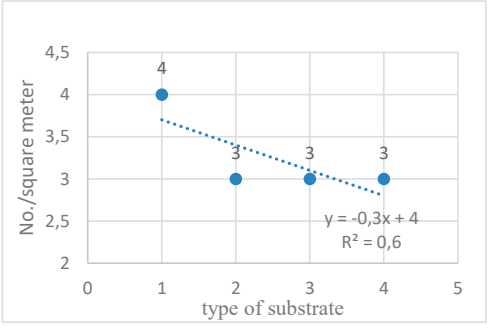

Figure 10. The variant with Poco fertilizer

In the case of variant 6 fertilized with the Iguana product were obtained 6 shoots/m^2 on the substrates of perlite and 50% perlite +50% peat and only 4 shoots on the variant cultivated on the soil in the field. The correlation coefficient being $R^2 = 0.1636$ (Figure 11).

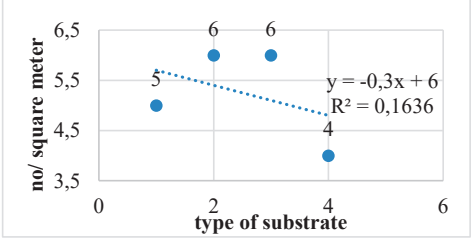

Figure 11. The variant with Iguana fertilizer

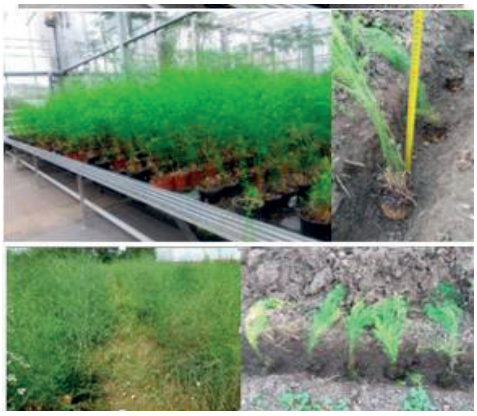

Figure 12. The experiment in greenhouse and in field

If the total number of shoots did not provide us a clear information regarding the experiment, we can see that the mass of the shoots was influenced by the type of fertilization. Thus, in the case of chemical fertilization, we found that the highest amount of shoots was obtained at the variant planted on the perlite substrate in the greenhouse with 98.8 g. As shown in the Table 6, the differences were positively significant at V2 and negatively distinctly significant at V4.

Table 6. The influence of chemical fertilization on the mass of shoots

VARIANTS	Mass (g/m^2)	Difference (g/m^2)	(%)	significance
V(0) average	82.83	-7.80	91.40	O
V(1)	90.63	0.00	100.00	Ct.
V(2)	98.80	8.17	109.02	*
V(3)	78.90	-11.73	87.06	OO
V(4)	63.00	-27.63	69.52	OOO
DL5% =	6.270	DL5% in % =	6.9185	
DL1% =	9.490	DL1% in % =	10.4715	
DL0.1% =	15.120	DL0.1% in % =	16.6838	

In the case of variants fertilized with Formulex we observed differences regarding the total mass of the shoots between 83.63 g / m2 with a very significant negative statistical significance and 135.4 g/m^2 in the variant grown in greenhouse on 50% perlite and 50% peat substrate (Table 7).

The fertilized variant with Vermiplant showed a total average mass of shoots of between 63 g/m^2 with a differences negative distinctly significant. Results over V1 (the control variant) regarding productions were also recorded at variants 2 and 3 with positive distinctly significant, statistical (Table 8).

In the variant to which the Poco product was applied there were no significant differences in production only in the variant cultivated on the substrate of 50% perlite + 50% peat where harvested on average 40.90 g/m^2. At this variance, we recorded statistically a negative distinct significative (Table 9).

Table 7. The influence of Formulex fertilization on the mass of shoots

VARIANTS	Mass (g/m^2)	Difference (g/m^2)	(%)	significance
V(0) average	116.10	-0.08	99.93	N
V(1)	116.18	0.00	100.00	Ct.
V(2)	129.20	13.02	111.20	N
V(3)	135.40	19.22	116.54	*
V(4)	83.63	-32.55	71.98	OO
DL5% =	14.040	DL5% in % =	12.0843	
DL1% =	21.240	DL1% in % =	18.2815	
DL0.1% =	33.830	DL0.1% in % =	29.1178	

Table 8. The influence of Vermiplant fertilization on the mass of shoots

VARIANTS	Mass (g/m^2)	Difference (g/m^2)	(%)	significance
V(0) average	95.72	8.72	110.03	*
V(1)	87.00	0.00	100.00	Ct
V(2)	118.20	31.20	135.86	***
V(3)	114.30	27.30	131.38	***
V(4)	63.40	-23.60	72.87	OOO
DL5% =	8.460	DL5% in % =	9.7241	
DL1% =	12.800	DL1% in % =	14.7126	
DL0.1% =	20.390	DL0.1% in % =	23.4368	

Table 9.The influence of Poco fertilization on the mass of shoots

VARIANTS	Mass (g/m^2)	Difference (g/m^2)	(%)	significance
V(0) average	51.38	-4.13	92.57	N
V(1)	55.50	0.00	100.00	Ct
V(2)	52.50	-3.00	94.59	N
V(3)	40.90	-14.60	73.69	OOO
V(4)	56.60	1.10	101.98	N
DL5% =	5.330	DL5% in % =	9.6036	
DL1% =	8.060	DL1% in % =	14.5225	
DL0.1% =	12.840	DL0.1% in % =	23.1351	

In the case of the fertilized variant with the Iguana product the average mass was 106.0 g/

m^2 in the variant cultivated on perlite substrate, and 110.5 g/m^2 in the variant on 50% perlite and 50% peat substrate, with a significance statistically positive very significant (Table 10).

Table 10. The influence of Iguana fertilization on the mass of shoots

VARIANTS	Mass (g/m^2)	Difference (g/m^2)	significance (%)	
V(0) average	98.89	7.64	108.37	N
V(1)	91.25	0.00	100.00	Ct
V(2)	106.00	14.75	116.16	**
V(3)	110.50	19.25	121.10	**
V(4)	87.80	-3.45	96.22	N

DL5% =	9.570	DL5% in % =	10.4877
DL1% =	14.470	DL1% in % =	15.8575
DL0.1% =	23.060	DL0.1% in % =	25.2712

Figure 13. The asparagus shoots

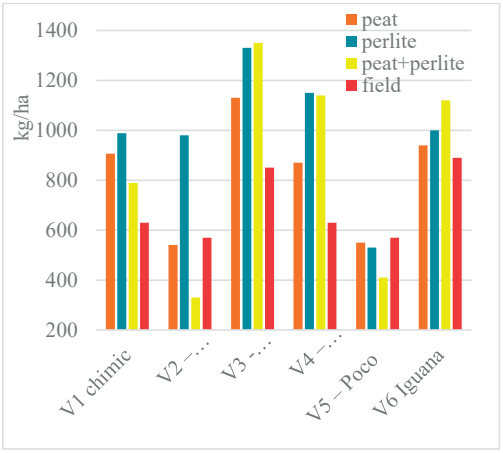

Figure 14. Production evaluated on hectare in the first year

In the Figure 14, the data regarding the evaluation of asparagus production are presented, in the first year of culture. Taking into account the fact that during the first year of cultivation, a small number of shoots are harvested in order to fortify the plant. In the first year of cultivation (after 3 years after planting) on the plant there must be at least one shoot that ensures the fortification of the plant, the production in the first year according to the specialized literature, can be 500-900 g/m^2.
The smallest productions were obtained in the field culture. We noticed that the highest yields were obtained on the perlite and peat substrate.

CONCLUSIONS

During the course of the experiments, regarding the appearance of the asparagus shoots, we recorded in the greenhouse a sum of temperature degrees of 3674ºC and in the field 2368ºC. The temperature difference between the greenhouse and the field was 1306ºC. In March we harvested asparagus shoots only in variants grown in the greenhouse these being different depending on the type of substrate, varying between 1 and 3 shoots. In April, shoots were collected from all varieties cultivated in the greenhouse but also from those cultivated in the field. The number of shoots being between 2 and 3, depending on the variant.

In May, shoots were harvested only from the chemically fertilized variant from the greenhouse, from the variant 3 fertilized with Formulex on 50% peat and 50% perlite substrate, respectively variants 4 and 5. Most shoots were harvested at variant cultivated in the field.

In this experiment we determined that the highest number of shoots harvested per square meter was recorded at V4, on 50% peat + 50% perlite substrate (with 7 shoots/m^2) and the lowest in field cultivated and fertilized with Amalgerol and Poco.

In present study we obtained the smallest productions in the field culture and we noticed that the highest yields were obtained on the perlite and peat substrate, in greenhouses.

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