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STATISTICAL EVALUATION OF ENVIRONMENTAL FACTORS AND SOIL FERTILIZERS EFFECTS ON GARDEN PEA (*Pisum sativum*) PRODUCTION PARAMETERS

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Abstract

The aim of the paper was to determine the effects of environmental factors and soil fertilizers (Universol Blue and Ferticare I, applied for 3 weeks), upon production parameters of garden pea (Pisum sativum). In this regard, there were analysed: soil pH and soil temperature at the moment of sowing. The garden pea, Bördi variety, was randomly sown in early April, on 18 plots, which formed 6 experimental variants (three plots on variant). First variant V1 was the control. Variants V2, V3 and V4 have been fertilised with Universol Blue (337.5g; 421.875g; 506.25 g/variant), and V5, V6 have been fertilised with Ferticare I (540g; 607.5g/variant). After harvesting, there were determined the statistical estimates of the peashells number/variant, estimates of total peashells weight/variant and individual peashells weight/variant. The results showed that soil pH values were in the weak acid range, pH of variants V2, V3 and V4 being slightly more acidic (6.59) than pH of V5 and V6. Soil temperatures was between 6^0 and 7^0 C all over the plots. The number of peashells was increased in all variants, relative to the control (control and V3 exhibited a high variability 26.12%, respectively 21.77%). Ferticare I fertilizer was more effective than Universol Blue (938.17 vs. 907.89 peashells). The t values were insignificant between variants, concerning most parameters. The evolution of pH to alkaline domain and the increase in soil temperature, favored the increase in the total weight of peashells (r=0.789, respectively r=0.882*). Fertilization have reduced the variability, caused by environmental conditions. The application of fertilizers did not increase the weight of peashells, but increased the total number of peashells.*

Key words**:** *fertilizers, pH, Pisum sativum, statistical evaluation, temperature*

INTRODUCTION

Environmental factors have a decisive influence on the growth and development of open-culture crops. It is rather complicated to control the variability of these factors. At the same time, there are some interdependences between factors, that affect the evolution of plants and field crops.
External factors, important and more difficult to control, are: light, radiation types, temperature, composition of the air (i.e. the percentage of carbon dioxide and oxygen), the amount of water (rain).
Also, the composition and soil structure, decisively influence the plant growth rate.
The content of the macro (N, P, K) and microelements (S, Mg, Mn, Fe, Mo, Cu, Co, V, etc.) of the soil, determines the field crop performances, plants health, necessary substances production (ie. vitamins, phytohormones etc) [26].
Gonzalez et all. (1996), studied the influence of UV radiation (280-315 nm) on the growth process of garden pea and observed that the height of plants fell by 24-38% and the leaf area decreased by 5-30%, compared to plants grown in natural light [14].
Light affects the development of pea, so that this plant should be sown earlier, considering that the vegetal mass develops in low light conditions (short days), and fructification

takes place under wider illumination conditions (long days).
The amount of water used by plants during development depends on many factors, including: temperature, sweat coefficient and perspiration productivity, water balance and the usage efficiency of the consumed water.
The sowing season, which is directly related to soil temperature, is considered to be a significant factor in cultures technology. The moment of sowing sets the climatic conditions in which the plants arise and develop and in particular, when the fruits mature [5, 15]. Some studies have shown that in the case of pea spring crops, sowing in early April, instead of March, causes a decrease in the content of alcohol-insoluble substances and an increase in chlorophyll content [22, 27]. Sowing of pea in June causes an increase in protein content compared to sowing the plant in May [2, 3].
The effect of soil temperature on nodulation and nitrogen fixation should not be neglected in this context. The *Rhizobium* species involved in this process are specific to the host, but are also conditioned by optimal temperatures, for the symbiosis processes required, such as: root formation, survival of rhizomes in the soil, exchange of molecular signals between the two symbionts etc. [25].
Nodulation and nitrogen fixation takes place at optimal temperatures between 20 and 30^0 C. There have been observed specific adaptations of the plant root microbiome to the climate they are in (tropical, temperate or arctic) [6].
Wrinkled pea type is a plant whose arise requires relatively low temperatures of $2\text{-}3^0$ C. Smooth pea type requires slightly higher arise temperatures, i.e. $4\text{-}5^0$ C. If the temperature conditions are satisfied, the pea will emerge within 8 to 10 days [23].
The influence of soil reaction on the growth and development of plants (vegetables, fruits, cereals) has been studied, under experimental conditions, in the acidic, neutral and alkaline pH zone [8].
In nutritional solutions, at a high concentration in hydrogen ions (H^+), plants develope much better than in soils with the same hydrogen ion concentration.
Consequently, it can be said that in acidic soils, besides the high concentration of H^+, there are other factors that hinder plant growth and development.
The unfavorable effect (which will influence the biosynthesis of amino acids, vitamins, pigments etc.) is due to the compounds that are solubilizing in acid soils and their solubility increases in proportion to soil acidity (compounds of iron, aluminum, manganese, zinc etc.) [20]. Thus, at soil pH values of 6.8-7.5, the best yields (e.g. corn and wheat) were obtained. For example, at pH values of 4.7 the pea beans production was the lowest 65%, versus 100% at pH 6.8 [32]. Acidic soils ($pH<4$) frequently contain lower levels of phosphorus, calcium and molybdenum, and alkaline soils ($pH>8$) contain higher concentrations of NaCl, bicarbonates and borates [29].
In the case of plants which are associated with nitrogen fixative bacteria (*Rhizobium spp*.), soil pH can also influence the plants growth, due to the effects on the microbial population.
Reduced or too high pH values affect the formation of associations between plant and fixative bacteria, with effects on soil nitrogen uptake by plants [6, 21].
Fertilizers play an extremely important role in the cultivation of *Leguminosae* crops (pea, beans), from the nutritional point of view [10].
The microelements in fertilizers, in particular, stimulate the growth of plants foliage mass. Microelements have a catalytic role in plants growth and can be administered in very small amounts. The microelements metabolic role is important and complex and it is always necessary in plants fertilization, in particular, in the case of garden pea [4, 13].
The degree of the nutrients uptake for plants development, depends on the soil pH. Macroelements such as N, P, K are assimilated to pHs greater than 6, while Fe, Zn, Mn, Cu and Co are easily assimilated to pH=4-6.5.
It has been observed that in too acidic soils garden pea does not assimilate important nutrients such as macroelements. Garden pea prefers soils with a pH in the slightly acid or slightly alkaline range, between 6.0 and 7.5.
One of the essential elements for plant growth

and development is nitrogen. Apparently, in the case of **Leguminosae**, due to the symbiotic mechanisms involved in fixing and assimilating nitrogen in the soil, crops fertilization with nitrogen could be considered as of secondary importance.
However, some studies have shown that the application of low-dose nitrogen fertilizers could have favorable effects on nodulation and nitrogen fixation, while high doses have adverse effects [11, 12, 19, 31].
Nitrogen fixation is catalysed by nitrogenase, an enzyme made up of two metalproteins: one containing the Fe-Mo pair, and the other only Fe. Jongruaysup et al. (1993) showed that the development of symbiosis with rhizobi increases the need for Mo of pea crops [16]. This was subsequently confirmed by numerous studies [7, 28].
Application of fertilizers with P and K stimulates vegetative growth and pea beans production [1, 9, 17, 18, 30]. Some studies have shown that the lack of K and P leads to the accumulation of legumina in pea beans, while the lack of S leads to a significant reduction of this globulin in pea beans [24].
Other studies suggested that seed treatment with a series of microelements such as Mn, Cu, Co, have a positive influence on chlorophyll synthesis, and besides these, Mo and V cause the increase of N content of the leaves. Applied to soil, vanadium has a positive influence on the protein content of the pea beans [5].
The objective of the research was to highlight the influence of environmental factors and fertilizers treatments on the production parameters of garden pea (*Pisum sativum*).

MATERIALS AND METHODS

There were sown with garden pea, variety *Bördi*, 18 plots, the characteristics of which are shown in Table 1. Sowing was done in early April, in a temperate climate zone (46 ° 10 'N; 21 ° 18' E).
We mention that the *Bördi* variety of pea is semi-early.

Table 1. Experimental plots

Experimental plot	Size/unit measure
The length of the plot	2.50 m
The width of the plot	1.50 m
The surface of the plot	3.75 m^2

Source: Own experiment.

The 18 plots were randomly grouped into 6 variants, three on variant, depending on how the fertilizer treatments, with microelements, were applied (Table 2).

Table 2. Randomized plots pattern

Control V1	V2	V3
V4	V5	V6
V3	Control V1	V2
V6	V4	V5
V2	V3	Control V1
V5	V6	V4

Source: Own experiment.

Variant 1 was the unfertilized control. Variants 2, 3 and 4 were fertilized with Universol Blue. Variants 5 and 6 were fertilized with Ferticare I. The composition of the fertilizers used is shown in Table 3.

Table 3. Fertilizers composition (%)

Composition	Universol Blue	Ferticare I
Total nitrogen (N)	18.000	14.000
Phosphates (P_2O_5)	11.000	11.000
Potassium (K_2O)	18.000	25.000
Magnesium (MgO)	2.500	2.800
Iron (Fe) EDTA	0.100	0.100
Bore (B)	0.010	0.020
Copper (Cu) EDTA	0.010	0.010
Manganese (Mn) EDTA	0.040	0.030
Molybdenum (Mo)	0.001	0.001
Zinc (Zn) EDTA	0.010	0.020

Source: Specifications on the fertilizers package.

Fertilization was applied for 3 weeks, with progressive fertilizer amounts, as shown in Table 4. The mode of administration was extraroot to all variants. The fertilization model has been chosen to comply with the maximum application limits.
The pH of the soil was determined before the first fertilization, with a portable pH meter Testo 205, to see if it is suitable for pea sowing. At the same time, the soil temperature was measured with a soil thermometer.

Table 4. Fertilizers application model

No. plot	Fertilizer	g/m^2 / week	Total fertilizer/ parcel (g)	Total fertilizer/ variant (g)
Con-trol 1	-	-	-	-
2	Universol	10.0	112.50	337.500
3	Universol	12.5	140.62	421.875
4	Universol	15.0	168.75	506.250
5	Ferticare I	16.0	180.00	540.000
6	Ferticare I	18.0	202.50	607.500

Source: Own experiment.

We mention that the soil was chernozem type. Pea arising occurred in the second half of April and was harvested in mid-June on all plots. Production parameters were determined, namely the number of peashells and their weight, on each plot.
These parameters were subjected to computer-assisted statistical calculation, using the professional IBM SPSS Statistics Program.

RESULTS AND DISCUSSIONS

The soil pH values for the control and the other variants are shown in Table 5.

Table 5. Estimates of soil pH variability (n=3)

Variant	Mean (X)	Stand. dev. (s_x)	s (variance)	Variab. coeff. (CV, %)
V1 (Control)	6.567	0.208	0.043	3.160
V2	6.533	0.058	0.003	0.880
V3	6.533	0.153	0.023	2.340
V4	6.733	0.058	0.003	0.860
V5	6.667	0.153	0.023	2.290
V6	6.733	0.153	0.023	2.270

Source: Own calculation based on the experiment results.

Soil pH values were in the weak acid range, which favors plants growth. Variability was higher for variants V3, V5 and V6, but within normal limits, and lower than to the control. V4 and V6 exhibited less acidic pH values. At the same time, the average pH of variants V2, V3 and V4 was slightly more acidic (6.59) than variants V5 and V6 (6.70), without reaching the significance level (t=1.1209). Table 6 shows the soil temperature values when sowing garden pea.

Table 6. Estimates of soil temperature variability (^{0}C, n=3)

Variant	Mean (X)	Stand. dev. (s_x)	s (variance)	Variab. coeff. (CV, %)
V1 (Control)	6.533	0.058	0.003	0.880
V2	6.700	0.100	0.010	1.490
V3	6.533	0.115	0.013	1.760
V4	6.633	0.153	0.023	2.300
V5	6.600	0.100	0.010	1.515
V6	6.633	0.208	0.043	3.135

Source: Own calculation based on the experiment results.

Temperatures were placed on average between 6^0 and 7^0 C all over the plots, with slightly higher variations at V4 and V6. Last but not least, we mention that the average soil temperature of V2+V3+V4 variants, was 6.622^0 C, comparable to the average soil temperature of V5+V6 variants (6.616^0 C). After the pea harvest, the peashells were counted on each plot and the mean was calculated per each variant (Table 7).

Table 7. Estimates of the number of peashells/variant variability (n=3)

Variant	Mean (X)	Stand. dev. (s_x)	s (variance)	Variab. coeff. (CV, %)
V1 (Control)	828.330	216.380	46820.304	26.122
V2	904.000	85.860	7371.939	9.490
V3	916.000	199.480	39792.270	21.770
V4	903.670	52.990	2807.940	5.860
V5	884.670	63.720	4060.238	7.202
V6	991.670	47.080	2216.526	4.747

Source: Own calculation based on the experiment results.

The average number of peashells was increased in all variants, relative to the control. The best-performing variant was V6, with the lowest variability (4.74%). In V5, the number of peashells was lower, closest to the control. Variant V3, although having an appreciable average number of peashells, showed increased variability (21.77%).
The control variant V1 showed a lower productivity and a considerable high variability (26.12%), compared to fertilized variants. It can be deduced that fertilization, besides increasing productive performances,

homogenizes the conditions of plant growth and reduces the variability induced by environmental conditions.

In variants fertilized with Universol Blue (V2+V3+V4) the average number of peashells was 907.89. This average was exceeded by the average of V5+V6 variants, fertilized with Ferticare I, which was 938.17 peashells.

There were no significant differences between statistical averages (t=0.7529). However, it is possible that Ferticare I fertilizer was still more effective than Universol Blue.

The mean of harvested peashells total weight, per each variant is shown in Table 8.

Table 8. Estimates of total peashells weight/variant (g, n=3)

Variant	Mean (X)	Stand. dev. (s_x)	s (variance)	Variab. coeff. (CV, %)
V1 (Control)	5380.000	1405.840	1976386.100	26.130
V2	5646.670	535.290	286535.380	9.470
V3	5396.670	1173.560	137724.300	21.760
V4	5846.670	343.120	117731.330	5.860
V5	5646.670	408.080	166529.280	7.222
V6	6110.000	289.310	83700.276	4.735

Source: Own calculation based on the experiment results.

Compared to the control, all variants showed higher peashells total weight. The V3 variant was closest to the control, including the variability values, quite large, on the other hand (21.76% and 26.13% respectively).

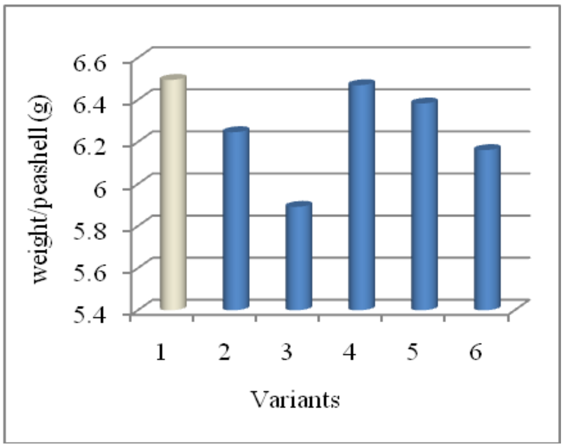

Fig. 1. Average weight of a peashell/variant
Source: Own design based on the experiment results.

The weight of a peashell was calculated by the formula: the total weight of the peashells/the number of peashells. In Figure 1 we can see the average weight of a peashell, belonging to the control (V1) and to each of the fertilized variants (V2, V3, V4, V5, V6).Variants V4 and V5 showed the highest average values of the peashell weight, but smaller than the control. Compared with the other variants, V3 showed a higher number of peashells, but the peashells had the smallest weight. Interestingly, the application of fertilizers did not increase the weight of a peashell, but increased the total number of peashells.

Table 9. The significance of the mean difference between the variants

Variants pairs	Mean difference	t
The significance of soil pH difference		
V2-V4	6.533-6.733	4.223*
V2-V6	6.533-6.733	2.117
V3-V4	6.533-6.733	2.117
The significance of soil temperature difference		
V1-V2	6.533-6.700	2.502
The significance of the difference between the number of peashells/variant		
V4-V6	903.670-991.670	2.150
V5-V6	884.670-991.670	2.339
The significance of the peashells total weight difference/variant		
V2-V6	5646.670-6110.000	1.318
V5-V6	5646.670-6110.000	1.604

*p < 0,05; **p < 0,01; ***p < 0,001
Source: Own calculation based on the experiment results.

Concerning the control (V1), it was observed that fewer peashells have been formed, but the average weight of a peashell exceeded the average weight of a peashell in the fertilized variants.

The t test, between the variants, regarding all the analyzed parameters, is shown in Table 9. Only values of t higher than 1.3 have been shown.

Generally, the t values were small, insignificant. Only soil pH differed significantly between V2-V4 (4.223*). It is noted that V6 had distinguished most from the other variants. However, differences between V6 and V1 (control) were not significant, concerning the number of peashells (t=1.277), nor their weight (t=0.880).

The regressions calculation revealed the

significant dependence of the total peashells weight on soil pH, where the determination coefficient R^2 reached 0.624 (r=0.789*).
Figure 2 shows the linear regression between the total peashells weight, for all variants and the soil pH for the same variants.

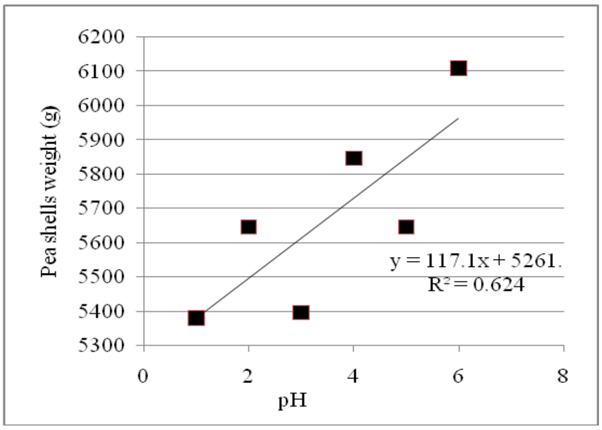

Fig. 2. Peashell total weight - soil pH regression
Source: Own design based on the experiment results.

The peashells total weight correlated positive significant with the soil temperature (r=0.882*).
Figure 3 shows the polynomial regression total peashells weight - soil temperature.
The pH variation, in the sense of its alkalinization, influenced 77% the increase in the weight of the peashells. The individual weight of the peashells was significant negative correlated (r=-0.784 *) with the total number of peashells.

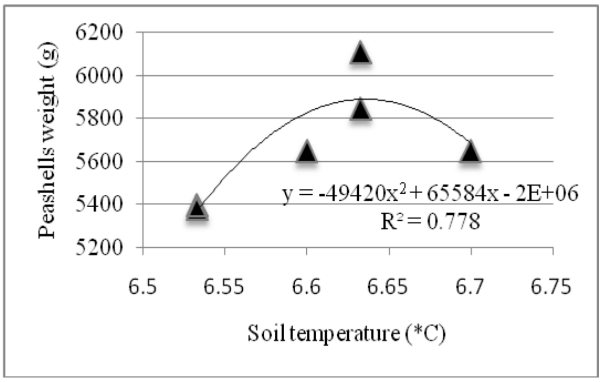

Fig. 3. Total peashells weight - soil temperature regression
Source: Own design based on the experiment results.

Figure 4 shows the polynomial regression between these parameters and a good coefficient of determination was recorded (R^2=0.615).

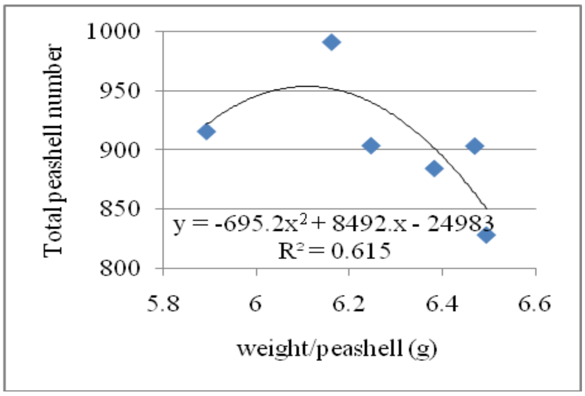

Fig. 4. Regression between the total number of peashells and the average weight of a peashell
Source: Own calculation based on the experiment results.

Practically, as the weight of a peashell increased, the decrease in the total number of peashells was influenced in a proportion of 61%.

CONCLUSIONS

The randomized plots (in the number of 18), which formed the 6 experimental variants (3 plots/ variant), did not present homogeneous characteristics of the soil parameters. There was even a significant difference between V2-V4 concerning soil pH (t=4.223 *).
Control (V1) and V3 had low variability coefficients of soil pH and soil temperature, but increased compared to other variants.
At the same time, variability of V1 and V3, concerning production parameters, namely: the number of peashells (26.122% and 21.77% respectively) and the weight of peashells (26.130% and 21.760% respectively), was the highest, compared to other variants.
Fertilizer treatments have increased production parameters, but insignificant in most cases. It is possible that the insignificant differences, were mainly due to insufficient differences between the quantities of fertilizers applied progressively.
Fertilization, in addition to productive performances increase, have homogenized plant development conditions and reduced variability, caused by environmental conditions. It was also noticed that application of fertilizers did not increase the weight of peashells, but increased the total number of

peashells. Between these two parameters a significant negative correlation has been established (r=-0.784*).

Soil temperature and soil pH are important factors that can influence the productive parameters of garden pea. It had been found that the evolution of pH to alkaline domain, as well as the increase in soil temperature, had favored the increase in the total weight of peashells (r=0.789*, respectively r=0.882*).

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