FORMATION OF PRODUCTIVITY ELEMENTS IN DIOIC HEMP

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Abstract. *The present study aims to evaluate the formation of productivity elements in dioic hemp, under the influence of several factors. In this sense, at ARDS Lovrin a multifactorial experience was established, with the following factors: factor A - agricultural year (2017, 2018, 2019), factor B - variety (Lovrin 110, Silvana, Armanca and line Lv 457/08) and factor C - sowing density (7 plants / m^2, 37plants / m^2 and 150 plants / m^2). The elements studied and presented in this paper are the length of the plant and the length of the inflorescence of hemp plants. Of the three factors studied, the one that very significantly influences both parameters, both the length of the plant and the length of the inflorescence, is the density. As the number of plants per square meter is smaller thus the measured values of the two productivity indicators of hemp cultivation have higher values. The study took place in 2017-2019 in the experimental field of the dioecious hemp breeding laboratory at ARDS Lovrin. The soil on which the experimental field was located is a typical chernozem, with a medium clay structure, specific to the area of influence of the resort. The climate is temperate, with an annual average rainfall of around 520 mm and a multiannual average temperature of 10.7ºC. Hemp is one of the most important plants that produce fibers of vegetable origin and is one of the many plants that produce textile fibers. With very varied uses in the textile industry and in other industrial branches, hemp stems contain 26-32% fibers. Technological factors are very important and are influenced by climatic conditions. Hemp is sown when in the soil in the morning, at a depth of 5-7 cm, it is recorded 7-8 ºC. When sown too early, hemp plants grow unevenly, grow slowly, age and do not recover in the favorable conditions that follow.*
*A very significant positive correlation is established between the two parameters, the value of the correlation coefficient being r = 0.97 ***.*

Keywords: *hemp, variety, density, inflorescence, plant length*.

INTRODUCTION

Hemp is one of the most important plants that produce fibers of vegetable origin and is one of the many plants that produce textile fibers. With very varied uses in the textile industry and in other industrial branches, hemp stems contain 26-32% fibers (ŞANDRU, PARASCHIVOIU ET AL., 1996)

It is an important source of wood and fiber, the amount of wood produced by one hectare of hemp is equal to the growth made by one hectare of forest in a year (CEAPOIU, 1958), fibers used in the textile industry for various much appreciated fabrics, given the valuable physical-mechanical properties (POTLOG, VELICAN, 1972; LÜHR ET AL, 2018).

But hemp is also used successfully in various other sectors, such as: the food industry - a wide range of products are obtained (CALLAWAY, 2004), the pharmaceutical industry - a relatively recent challenge for the treatment of serious diseases (CROXFORD, 2008, BURSTEIN, 2015), constructions (INGRAO, 2015), for obtaining bioenergy (VOGL, 2004).

The stem represents 60-65% of the total weight of the plant (CEAPOIU, 1965). The hemp plant, due to its high cellulose content, can be used as a raw material in the pulp and paper industry. In this field, hemp can replace coniferous wood (ARNOUX, MATHIEU, 1968).

Technological factors are very important and are influenced by climatic conditions. Hemp is sown when in the soil in the morning, at a depth of 5-7 cm, it is recorded 7-8 0C.

When sown too early, hemp plants grow unevenly, grow slowly, age and do not recover in the favorable conditions that follow. The delay in sowing leads to a decrease in fiber production, especially in dry regions. The plants are attacked by fleas, bloom early and the stems remain short (BÎLTEANU, 2001).

For hemp for fiber, the optimum density is 350-380 harvestable plants/m^2. This density is ensured by the sowing density of 450 germinating seeds/m^2. The experiments with sowing densities carried out in our country, showed that at higher sowing densities there is an inevitable process of "self-thinning" of plants, a consequence of competition for vegetation factors, especially for light. For example, at a sowing density of 600 germinating seeds/m^2, about 40% of the seedlings perish until harvest. Thus, increasing the sowing density over 450 germinating seeds/m_2 is not justified, taking into account the observance of the optimal sowing time and ensuring a very well prepared germination bed (SEGĂRCEANU ET AL., 1981; TABĂRĂ, 1985).

The density of hemp plants for fiber influences both fiber production and fiber quality. At low densities, the stems grow thicker, are uneven and have a low percentage of fiber. At high densities, thin and uniform plants with a high fiber content are obtained, but in such conditions, the tupins remain shorter, which is why the production of fibers per hectare decreases.

Hemp seed cultivation is established in areas favorable to this plant, especially in the Western Plain and other areas that provide conditions for seed maturation.

The sowing density at which the highest seed production is obtained is 110-120 bg/m^2 (TABĂRĂ, 1984). The limits of variation of the number of germinating seeds/m^2 are, according to BÂRNAURE, between 60 and 125, which corresponds to 12-25 kg of seeds per hectare.

Also, the chemical composition of the hemp seeds obtained depends on several factors - genetic, technological and climatic (BERTOLI, 2010; ASCRIZZI, 2019).

In 4 different localities (Lovrin, Popăuți-Botoșani, Secuieni-Roman, Turda), the optimal sowing density from the experiments was 79 bg/m^2 (15 kg seeds/ha) (SEGĂRCEANU, PARASCHIVOIU ET AL., 1982).

For hemp crops, the rains in May and June for hemp for twigs and in July for seed hemp are extremely favorable. The high humidity in the first part of the hemp vegetation period favors the growth and development of the plants.

Drought during the flowering period reduces the production and quality of fibers. Prolonged drought during this period can also reduce seed production.

From the point of view of precipitation, hemp meets the best cultivation conditions in areas where during the vegetation period 250-300 mm of precipitation fall, for hemp for fiber, or 350-450 mm for hemp for seed.

Due to the less developed root system, soil moisture plays a particularly important role in the growth of hemp plants. Hemp has a soil moisture of 60-70% in the U.S. (active humidity range), (TABĂRĂ, 2005).

MATERIAL AND METHODS

The study took place in 2017-2019 in the experimental field of the dioecious hemp breeding laboratory at ARDS Lovrin. The soil on which the experimental field was located is a typical chernozem, with a medium clay structure, specific to the area of influence of the resort. The climate is temperate, with an annual average rainfall of around 520 mm and a multiannual average temperature of 10.7^{0}C.

A multifactorial experiment was set up, with the following factors: factor A - agricultural year (2017, 2018, 2019), factor B - variety (Lovrin 110, Silvana, Armanca and line Lv 457/08) and factor C - sowing density (7 plants / m^2, 37 plants / m^2 and 150 plants / m^2).

Of all the productivity elements studied, those presented in this paper are the size of the plant and the length of the inflorescence of hemp plants.

The statistical interpretation of the obtained data was performed according to the variance analysis model.

RESULTS AND DISCUSSIONS

Analyzing the period in which it was experienced, in terms of average annual temperature, in each of the three agricultural years it exceeded the multiannual average by over 1.5 ^{0}C, with the warmest period - the spring months. The largest deviation from the average is recorded in the agricultural year 2017-2018, with + 2 ^{0}C.

The present study highlights the formation of productivity elements in dioic hemp, under the influence of the three factors studied.

Regarding the plant height, depending on the analyzed factors, in Table 1 is presented the analysis of variance for this parameter.

Table 1

Analysis of variance for plant length

Source	**Degrees of freedom**	**The sum of the squares**	**Variance**	**Test F**	
				Value	**Significance**
Repetition	2	13493.375	6746.687	0.8839	
Factor A	2	53484.638	26742.319	3.5037	ns
Error (A)	4	30530.309	7632.577		
Factor B	3	1666.149	555.383	1.8576	ns
AB	6	3380.960	563.493	1.8847	ns
Error (B)	18	5381.609	298.978		
Factor C	2	26556.582	13278.291	20.3230	***
AC	4	10293.388	2573.347	3.9386	**
BC	6	5780.724	963.454	1.4746	ns
ABC	12	4072.728	339.394	0.5195	ns
Error (C)	48	31361.421	653.363		
Total	107	186001.883			

Analyzing the table shows the very significant influence of factor C - crop density - on plant length. How much density is lower, with that much the length of the stem is longer, fact explained by increasing the individual nutrition space of plants. A distinctly significant contribution to the growth of the stem, in the analyzed period, is the interaction between the nutrition space and the variety.

Tables 2,3 and 4 show the values obtained for each of the three factors studied.

Thus, in table 2 is presented the Student test for factor A - the agricultural year of experimentation.

Table 2

The influence of the climatic conditions of the experimental year on the lenght plants

Factor A – experimental year	**Lenght plants**		**Diff. [cm]**	**Significance**
	cm	**%**		
a1 - year 2017	240.05	100.00	mt	mt
a2 – year 2018	276.06	115.0	36.01	ns

a3 – year 2019	293.49	122.3	53.44	ns

DL 5% = 57.16 cm; DL 1% = 94.81; DL 0,1% = 177.30

Although the climatic conditions of the three agricultural years were very different, no statistically significant differences in plant size were obtained during the three vegetation cycles. The highest value of this parameter was obtained in the third year of experiments, 293.49 cm, by 22.3% more than in 2017 and by 6% more than in 2018. And in 2017 the increase obtained compared to the control is 15 %.

From the four genotypes studied, the Lovrin 110 variety was chosen as a control. The results obtained are presented in Table 3.

Table 3

The influence of factor B - the variety studied - on the lenght plants

Factor B – variety	Lenght plants		Diff. [cm]	Significance
	cm	%		
b1 – Lovrin-110	272.60	100.00	mt	
b2 - Silvana	270.40	99.2	-2.20	ns
b3 - Armanca	273.20	100.2	0.60	ns
b4 – Lv-457/08	263.30	96.6	-9.30	ns

DL 5% = 9.89 cm; DL 1% = 13.54; DL 0,1% = 18.46

The height of the plant, in all four varieties studied, is closely grouped around the value obtained by the control variant - 272.6 cm. The highest value is presented by the control variety, and the lowest by the Lv 457/08 line.

Table 4

The influence of sowing density on lenght plants

Factor C – density	Lenght plants		Diff. [cm]	Significance
	cm	%		
c1 - 7 plants/m^2	292.02	100.00	mt	
c2 – 37 plants/m^2	259.77	89.0	-32.25	000
c3 – 150 plants/m^2	257.82	88.3	-34.20	000

DL 5% = 12.12 cm; DL 1% = 16.17; DL 0,1% = 21.13

The third factor studied, density, very significantly influences the lenght of plants. The variant in which 7 plants / m^2 were sown was chosen as a control. In this variant, the determined length was 292.02 cm, the highest value recorded. At densities of 37 plants and 150 plants, respectively, their length is significantly reduced by up to 19%. The recorded values are 259.77 cm (at 37 plants / m^2) and 257.82 cm (at 150 plants / m^2), statistically assured values as very significant, for the probability of transgression of 0.1%.

Analyzing the combined interaction of the three experimental factors on the lenght of hemp plants, presented in Table 5, we can conclude that in the first year of experimentation the most obvious differences between the studied factors were obtained.

Table 5

The combined interaction of the three experimental factors on lenght plants, in dioic hemp

		Lenght plants cm	Lenght plants %	Diff.[cm]	Signif.	Lenght plants cm	Lenght plants %	Diff. [cm]	Signif.	Lenght plants cm	Lenght plants %	Diff. [cm]	Signif.
		a1				a2				a3			
c1	b1	266.81	100.00	mt		287.41	100.00	mt		308.45	100	mt	
	b2	272.79	102.24	5.97		287.16	99.91	-0.25		299.65	97.1	-8.80	
	b3	289.23	108.40	22.41		292.07	101.62	4.65		308.32	100.0	-0.13	
	b4	292.51	109.63	25.69		285.97	99.50	-1.44		313.82	101.7	5.36	
c2	b1	229.68	86.08	-37.13		260.59	90.67	-26.83		289.84	94.0	-18.61	
	b2	218.76	81.99	-48.05	0	281.19	97.83	-6.23		275.16	89.2	-33.29	
	b3	228.44	85.62	-38.37		276.49	96.20	-10.92		288.39	93.5	-20.07	
	b4	222.09	83.24	-44.72	0	241.25	83.94	-46.16	0	305.36	99.0	-3.09	
c3	b1	212.71	79.72	-54.11	0	304.13	105.82	16.72		293.77	95.2	-14.68	
	b2	225.68	84.58	-41.13		278.27	96.82	-9.15		294.97	95.6	-13.48	
	b3	216.76	81.24	-50.05	0	274.88	95.64	-12.53		283.92	92.0	-24.53	
	b4	205.13	76.88	-61.68	00	243.35	84.67	-44.07	0	260.25	84.4	-48.20	0

DL 5% = 41.97 cm; DL 1% = 56.02; DL 01% = 73.21

Regarding the contribution of experimental factors to the growth of hemp stems, an important indicator for the subsequent production of fiber, factor A (climate) contributes in proportion of 28.8%, factor C (density) in proportion of 14.3%, while factor B (variety), contributes only 0.9%. All interactions between factors have a small contribution, below 3%, except for the AxC interaction, which has a contribution of 5.5%.

An important indicator of hemp crop productivity is the length of the inflorescence. The data obtained are presented in the following tables.

Table 6

The influence of the climatic conditions of the experiment year on the length of the inflorescence

Factor A – experimental year	Inflorescence lenght cm	Inflorescence lenght %	Diff. [cm]	Signif.
a1 - year 2017	47.48	100	mt	mt
a2 – year 2018	75.46	158.9	27.98	ns
a3 – year 2019	65.23	137.4	17.75	ns

DL 5% = 35.12; DL 1% = 58.24; DL 0,1% = 108.92

The agricultural year 2018 is the year in which the highest inflorescence length was registered, 75.46 cm, with 58.9% more than in 2017, the driest of all three studied. And in 2019 this parameter highlights a higher value than the control, exceeding it by 58.9%.

As in the case of stem length, the length of the inflorescence does not show significant differences from the control, when the influence of the variety is studied unilaterally (Table 7).

Table 7

The influence of factor B - the variety studied - on the length of the inflorescence

Factor B – variety	Inflorescence lenght		Diff. [cm]	Signif.
	cm	**%**		
b1 – Lovrin-110	66.05	100.0	mt	
b2 - Silvana	62.37	94.4	-3.68	ns
b3 - Armanca	63.24	95.7	-2.81	ns
b4 – Lv-457/08	59.24	89.7	-6.81	ns

DL 5% = 6.95 cm; DL 1% = 9.53; DL 0,1% = 12.98

The highest value is obtained in the control variant, the Lovrin 110 variety - 66.05 cm, followed by the Armanca variety - 63.24 cm. The lowest value is recorded by the line Lv 457/08 - 59.24 cm, with 10.3% less than in the control version.

Table 8

The influence of sowing density on the length of the inflorescence

Factor C – density	Inflorescence lenght		Diff. [cm]	Signif.
	cm	**%**		
c1 - 7 plants/m^2	80.43	100.0	mt	
c2 – 37 plants/m^2	56.64	70.4	-23.79	000
c3 – 150 plants/m^2	51.1	63.5	-29.33	000

DL 5% = 5.24; DL 1% = 6.99; DL 0,1% = 9.14

The nutritional space obviously influences all the elements of plant productivity. Regarding the influence of density on the length of the inflorescence, it is very significantly influenced by this factor. The highest value is found at the lowest density - 80.43 cm and decreases very significantly at the other densities studied, by up to 37%.

Factor A (climate) contributes to the length of the inflorescence in proportion of 23.0%, and factor C (density) in proportion of 27.8%, while factor B (variety), contributes only 1%. All interactions, both ordinal I and ordinal II, have a small contribution below 1.7%.

Regarding the correlation that is established between the analyzed indicators, presented in figure 1, a very significant positive correlation can be observed, indicated by the value of the correlation coefficient (r = 0.79 ***).

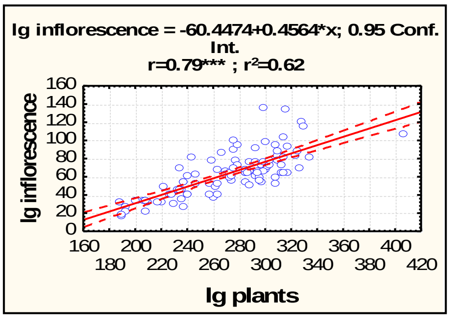

Figure 1. Correlation between plant length and inflorescence length

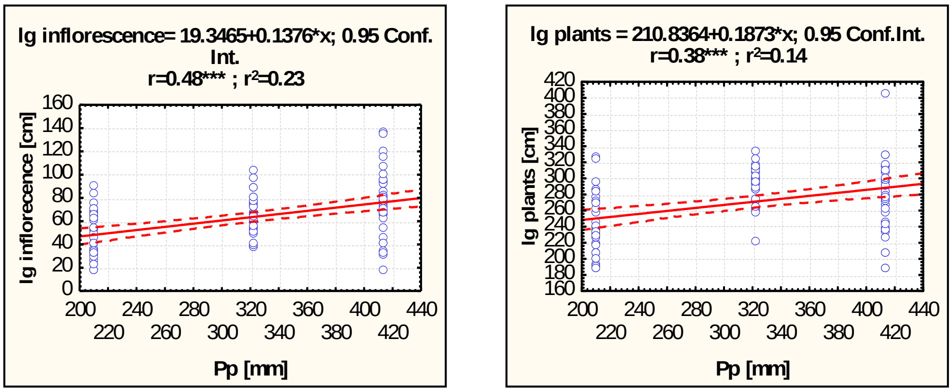

Figure 2. Linear correlation between precipitation during the analyzed period and the two analyzed parameters

Analyzing Figure 2, which shows the influence of rainfall in the three agricultural years and the two parameters studied, plant length and inflorescence length, we notice a very significant linear correlation in both cases, given the upward slope of the regression line and the value of correlation coefficients (plant length - r = 0.38 *** and inflorescence length - r = 0.48 ***).

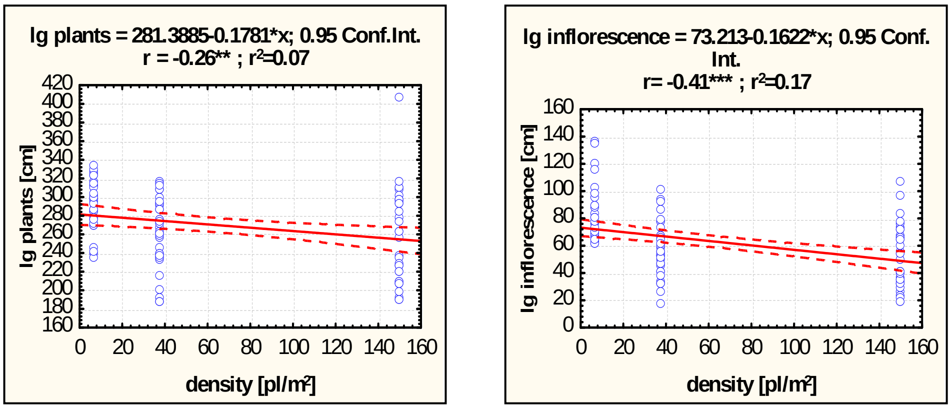

Figure 3. Linear correlation between sowing density, plant length and inflorescence length

Between the density of the crop and the length of the plant, respectively the length of the inflorescence, there is a distinctly significant and very significant negative correlation (plant length - r = 0.26 **; inflorescence length - r = 0.41 ***).

CONCLUSIONS

Of the three factors studied, the one that very significantly influences both parameters, both the length of the plant and the length of the inflorescence, is the density. The lower the number of plants per square meter, the higher the measured values of the two productivity indicators of hemp cultivation.

A very significant positive correlation is established between the two parameters, the value of the correlation coefficient being r = 0.97 ***.

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