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Assessment of the Impact of Different Irrigation Regimes on Several Biometric Indicators for Celery through Mathematical - Statistical Analysis

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Abstract- The aim of the development is to analyse, with the help of a two-factor dispersive analysis, the impact of the factors “year`s character” and “irrigation regime” on the separate biometric indicators for celery. Data for the yield and its structural elements was received and used by a field experiment for examining the irrigation regime that was conducted during the period 2010 – 2012 at the Training Experimental Field of Agricultural University, Plovdiv. Five options were examined: irrigation with 130 % from m norm; irrigation with 100 % from m; with 70 % from m; with 50 % from m; with 30 % from m and without irrigation. It was statistically proved, at a high degree of reliability, the impact of the examined factors and their interaction upon the three observed indicators: mass of the root crop, leaf mass and yield. Strongest impact had the factor “irrigation regime” (94 %).

Index Terms- celery, irrigation regime, ANOVA

I. Introduction

Conduction of field experiments for examining the irrigation regime of the agricultural cultures usually involves different years of meteorological characteristics, which gives an opportunity for an analysis regarding the impact degree of the two factors (year`s character and irrigation regime).

Celery is a well known culture in many countries around the world and in Bulgaria. At home it is cultivated for leaf mass and heads. Its root system is situated shallowly – from 20 to 70 cm of depth [1-5]. Besides, celery has a very long vegetation period, which passes during the driest and hottest months of the year in Bulgaria – from the end of June to the end of September. It is also a significant factor for the culture`s cultivation. All this is a condition for the celery cultivation, obligatory with irrigation. Scientific research proves that the character of the year in relation to the climate, as well as the application of a disturbed irrigation regime, impact significantly the quality and quantity of yield [5-8].

The aim of the development is to analyse, with the help of a two-factor dispersive analysis, the impact of the factors “year`s meteorological characteristics” and “irrigation regime” on the plant`s biometric indicators. It must be determined their influence force in their separate action and in their interaction. Such an approach was used for the soybean [9].

II. MATERIALS AND METHODS

The experiment was conducted during the period 2010 – 2012 at the Training Experimental Field of “Meliorations and Geodesy” Department, AU – Plovdiv on an alluvial-meadow and former marsh soil with celery. The experiment was made with the method of long parcels in four repetitions [10]. The following options were tested: 1) irrigation with 130 % **m**; 2) 100 % m; 3) 70% m; 4) 50% m; 5) 30% m; 6) without irrigation (**m –** half norm). The irrigation norms for all experimental options were estimates regarding this for option 2, at which there was a pre-irrigating moisture 80 % from the FC (field capacity) for the layer 0-40 cm. The indicators “mass of the root crop”, “leaf mass” and “yield” were examined.

The received experimental data was set on a two-factor dispersive analysis. The factors “year” Factor A, “irrigation regime” factor B and their interaction A and B were examined. The force of factors` impact was estimated with the method of Plohinski [11]. It was determined as a part of the intergroup variation in the common variance. It was worked with the sum of the squares and with the formula:

$$h_x^2 = \frac{D_x}{D_y},$$

Where D_x - sum of the factor`s squares *x*, D_y - total sum of the squares (SS).

Data was processed statistically with the computer program MS Excel.

III. RESULTS AND DISCUSSION

Meteorological characteristics of the experimental years

The three experimental years were very different from each other. In regard of the precipitation provision they were moist, average moist, and dry, respectively for 2010, 2011 and 2012. Precipitations for the three years were distributed uneven during the vegetation, and its quantity in 2012 was extremely insufficient for the cultivation of celery. In 2010 their sum was 287.5 mm, in 2011 - 198.3 mm, and in 2012 – 78,2mm. Regarding the temperature, the following tendency was observed – the three years differed significantly from each other: 2010 was average warm, 2011–warm, and 2012 – hot (extreme). The sums of the average daily temperatures of air were: 2010 - 3048.6 °C, 2011- 3185.0°C and 2012- 3414.8°C (table 1).

Table I: Probability of meteorological factors in the region of Plovdiv during V – IX

factor		experienced years			
		rate	2010	2011	2012
ΣT°	°C	3041.1	3093.6	3185.0	3414.8
	P %	(for 88 years)	2.2	19.1	39.3
N	mm	221.4 mm	287.5	198.3	78.2
	P %	(for 88 years)	13.3	60.0	90.0
ΣT° – temperature sum; **N** – precipitations **P%** –probability of weather factors					

In 2010 there were the best conditions for the celery development – relatively big quantity of precipitations, lower temperatures and a lower deficit of air density with water vapors. 2011 was determined as average, and as most unfavorable – 2012. In the last year there were counted the smallest quantities of precipitations, regarding the whole three-year period, high air temperature values and low relative moist.

Irrigation Regime

During the first vegetation year 7 times of watering were realized, and in the second and third – 14. In 2012, during the first stage of the celery`s growth, two times of watering were given, which secure the beginning and the middle of the period, and in its end the soil moisture was provided with around 100 mm of precipitations. In the period of intensive growth of root crops in the same year, the realized times of watering were 3, at precipitation sum of 27 mm. For the third stage period there were two times of watering, they were realized at the beginning of the stage, and after that the water deficit was compensated by the fallen precipitations, which were over 120 mm until the end of the period.

For the second experimental year – from the moment of seedlings graft to the beginning of root crops forming (1 phenophase), the given times of watering were 3 at precipitation sum 16.5 mm. In the second stage of growth there were four times of watering. Precipitations in this period were near 34 mm, 28.6 mm from them fell one day after the second time of watering and were not used by the plants. From the intensive growth to the gathering of plants there were accounted 66 days, in 55 of them there were 3.4 mm of precipitations. This water deficit was compensated through handing 7 times of watering.

2012 was the driest and the hottest from the three years. Nevertheless, the number of watering times was equal to this of the previous year. Plants that were cultivated in such unfavorable conditions had difficulty in their growth, in their root system and root crop, and in their leaf mass. In a result, they remained quite small, with low consummation of water and with extended growth stages, in comparison with the other two years. From the moment of graft to the moment of root crops forming there were 9 times of watering. During this period (continuing 87 days) there were barely 21.4 mm of precipitations. During the intensive root crop growth the times of watering were 3, and during the last stage – 2. They were distributed in the beginning and middle, and in the end of the stage the moisture deficit in soil was compensated by precipitation sum over 32 mm.

In this year the plants had water stress, in result of the big drought, and the yields were extremely low. For low yields in result of water stress reported Pascale et al 2003.

Analysis of the Results

Data extraction options years and average period had been presented graphically in Fig. 1 and those for biometric indicators (average weight of a mass of roots and leaves of an root) are plotted in Table 2. The results of the dispersion analysis of the impact of Factors A, B and AhV on individual biometric indicators are shown in Tables 3, 4 and 5. The indicator "mass of root crop" (Table 3) was observed greatest impact factor B - irrigation, with proven reliability on $p \leq 0.001$ climate indicator and a dominant influence by 94%.The second is the factor A - year, with effect from 5% and 1% is the interaction of two factors.

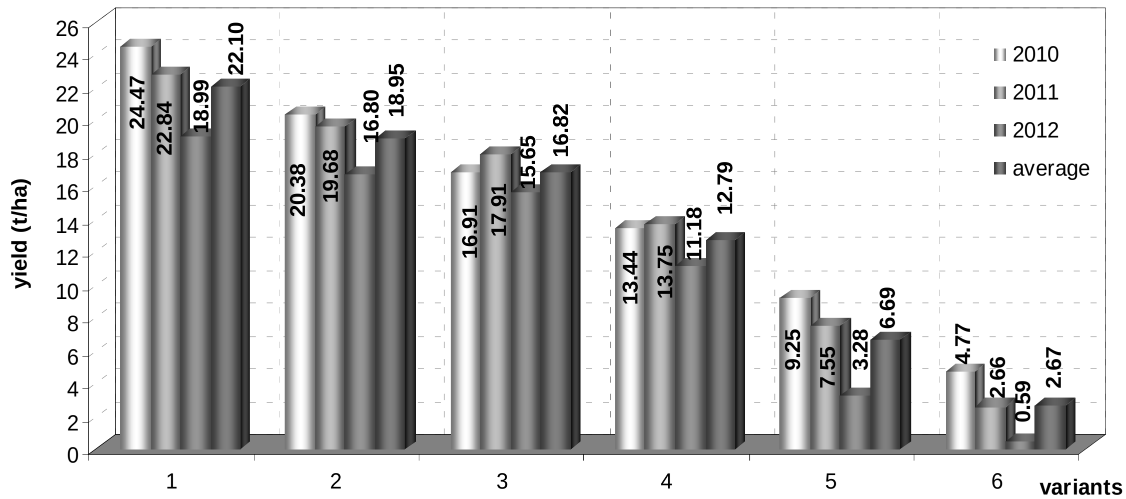


Figure 1. Yield of roots options and years

Table II: Data for biometric indicators variants and years

average weight of an one root						foliage of an one root			
year		2010	2011	2012	average	2010	2011	2012	average
variants	1	152.9	142.8	118.7	138.1	42.0	42.0	54.1	46.0
	2	127.1	123.0	105.0	118.4	32.8	38.2	49.0	40.0
	3	105.7	112.0	81.5	99.7	29.0	27.2	38.2	31.5
	4	84.0	86.0	70.0	80.0	29.4	27.3	30.5	29.1
	5	57.8	47.2	20.5	41.8	28.9	22.2	24.1	25.1
	6	13.1	10.6	3.7	9.1	3.9	5.9	1.7	3.8

Table III: Influence of the factors: A -year and B – irrigation regime on extraction of root

Sourse of variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Year (A) **	7838.99	2	3919.50	260.75	0.001	3.17
Variants of irrigation (B)***	140534.41	5	28106.88	1869.83	0.000	2.39
Interaction (AxB) *	1573.38	10	157.34	10.47	0.05	2.01
Errors	811.72	54	15.03			

The results of the biometric indicator "foliage" were shown with the greatest impact of 90% on climate indicators are variants of irrigation, followed by interaction year - variants of irrigation 6% and year factor was statistically significant with $p \leq 0.05$ (Table 4).

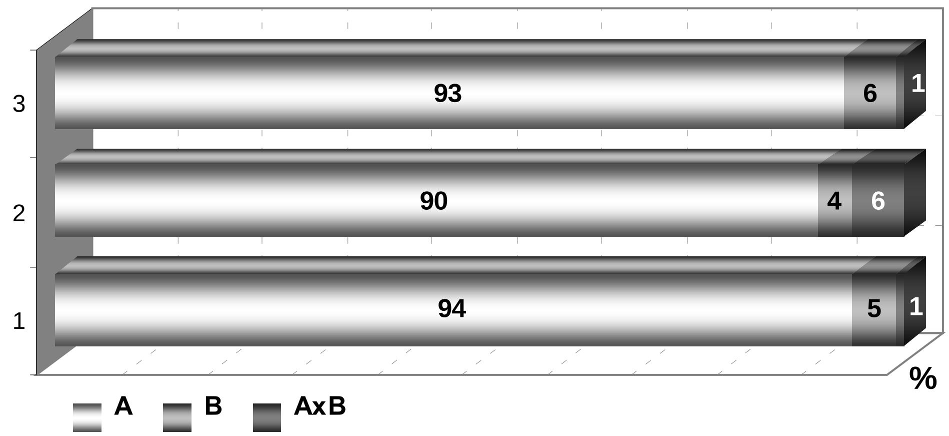
Table IV: Influence of the factors: A – year and B-irrigation regime on foliage

Sourse of variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Year (A) **	506.34	2	253.17	93.60	0.001	3.17
Variants of irrigation (B)***	12902.74	5	2580.55	954.07	0.000	2.39
Interaction (AxB)*	865.91	10	86.59	32.01	0.06	2.01
Errors	146.06	54	2.71			

From the results for the indicator "yield" is significantly prevalence weight again factor irrigation. Dominant, with 93% of the power is the assessment of the impact of the irrigation system on the yield, while the nature of the year and the interaction of these two factors is significantly less - 6% and 1% (Table 5). The relative distribution of the effects of the factors year and irrigation, and their interaction were shown in fig.2.

Table V: Influence of the factors: A –year and B- irrigation regime on the yield

Sourse of variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Year (A) *	204.34	2	102.17	610.02	0.08	3.17
Variants of irrigation (B)***	3290.36	5	658.07	3929.18	0.000	2.39
Interaction (AxB) **	35.35	10	3.54	21.11	0.002	2.01
Errors	9.04	54	0.17			



1. for weight of the root
2. for weight of the leaves
3. for the yield

Figure 2. Strength of influence (%) of the factors

IV. CONCLUSIONS

On the basis of the two- factor dispersive analysis were conducted that factor B-in irrigation regime has a dominant influence on all the three variables: the mass of roots and leaves and extraction, which is statistically proven at a very high level of reliability (p≤0.001). Strongest impact had the factor "irrigation regime" with strength of influence (94 %).

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