

Influence of Some Technological Links on the Production and Quality Parameters in Castor-Oil Plants (*Ricinus communis L.*)

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Abstract – Given the multiple uses of castor oil in chemical, aerospace and pharmaceutical industry, it was considered necessary to continue research in the area of improving castor-oil plant production under the specific conditions of transition economy. Crop diversification is a matter of interest for European Union, which by means of the new agricultural policy recommends the extension in the member states of the non-food crops, including the castor-oil plant (*Ricinus communis L.*).

The paper presents the results obtained in the experimental culture of castor-oil plants in 2012, in terms of using two new technological links. Valorizing the experimental results was performed by the analysis of variance and correlations between production and some morphological characteristics.

Keyword – Tillage System, Foliar Fertilization, Castor Oil Fuel, Bonus K-Energy, Dry Matter.

I. INTRODUCTION

Energy products assortment which can be obtained out of the crops biomass is different from one crop to another, but by means of certain procedures, all may lead to an energy form wanted by the consumer.

In their raw form, biomass was used still from “fire discovery” as a heat source, the wood being the first fuel used for burning. The wood resource, excessively used led to forest resource diminishment, with all the resulted consequences for carbon circuit in the nature and the climate change.

In the modern vision of biomass valorization, burning is allowed but only after a specific processing and concentration (grinding, briquetting) meant to some thermal power stations with superior valorization. The main energy used under bio-fuels form comes from oily plants and it acquired bio-diesel denomination. It is obtained from fats (oils) produced by all oily plants, soy, castor-oil plant, rapeseed, sunflower crops being highly important.

II. MATERIALS AND METHODS

In the experiment with castor-oil plant, a trifactorial experiment was settled, according to the randomized

blocks method [7]; the three studied factors were the following:

Factor A - tillage system with two variants:

a₁ - conventional tillage system;

a₂ - tillage system on ridges.

Factor B - the studied castor-oil plant varieties, with two variants:

b₁ - SAFIR variety;

b₂ - VLASCA variety.

Factor C - foliar fertilization with Bonus K-Energy, in three variants:

c₁ - unfertilized control;

c₂ - application of foliar fertilization using a single dose of 5 kg/ha Bonus K-Energy, when castor-oil plants have reached a height of 50 cm;

c₃ - applying two foliar fertilizations using a dose of 5 kg/ha Bonus K-Energy – the first fertilization when castor oil plants have reached a height of 50 cm and the second foliar spraying performed when 50% of plants entered the stage of the main raceme development. The experiment was belonging to the type 2x2x3, with 12 experimental variants arranged in four repetitions [7], the control variant being considered the one in which was practiced the conventional tillage system, without any treatment with Bonus K-Energy foliar fertilizer [2, 3].

III. RESULTS AND DISCUSSIONS

Observations and Determinations Performed During the Growing Season

Experimental data emphasized that there were no significant differences in terms of the date of plant emergence, slight variations being recorded from one experimental variant to the other. Worm temperature requirements for emergence were maintained in very tight limits.

Determination of plant emergence in the field

In order to perform this phenological observation we took into account the time of sowing and the time when 75% of the plants had the two cotyledons visible above the soil surface. Observations were conducted separately for each experimental variant. No significant differences

occurred between the 12 experimental variants as regards plant emergence, these being of only a few days and therefore are insignificant.

In the experimental field, losses of plants in the emergence phase were classified in the appropriate limits of STAS, so that plant losses before emergence can be attributed not only to the temperature, but to other factors as well, among which the evolution of the soil moisture

has in some situations a leading role (table 1). It has to be mentioned that the reddish brown soil on which the castor oil plants are cultivated in our country offers highly favorable emergence conditions, especially if the seedbed is well prepared. This is the most important elements allowing castor oil seeds to be sowed earlier, without affecting significantly the emergence density.

Table 1: Sowing - Emergence Period of Castor Oil Plants According to the Experimental Variant

Variant Number	Experimental Variant	Sowing Date	Number of Days Sowing - Emergence	Sprouted Plants (%)
V ₁ (Mt)	a ₁ b ₁ c ₁	10 april	30	86
V ₂	a ₁ b ₁ c ₂	10 april	28	87
V ₃	a ₂ b ₁ c ₃	10 april	25	91
V ₄	a ₂ b ₁ c ₁	10 april	27	91
V ₅	a ₂ b ₁ c ₂	10 april	23	89
V ₆	a ₁ b ₁ c ₃	10 april	24	91
V ₇	a ₁ b ₂ c ₁	10 april	19	93
V ₈	a ₁ b ₂ c ₂	10 april	22	95
V ₉	a ₁ b ₂ c ₃	10 april	18	87
V ₁₀	a ₂ b ₂ c ₁	10 april	20	85
V ₁₁	a ₂ b ₂ c ₂	10 april	19	86
V ₁₂	a ₂ b ₂ c ₃	10 april	17	90

Biometric determinations on growth and development of castor oil plants

Research continued with biometric measurements on plants within each experimental variant, using for this purpose metric frame and roulette, after previously establishing 5 checkpoints with an area of 1 m² on the field diagonal [2, 3].

By determining the castor oil plants height, the averaged values recorded showed quite large variations among experimental variants, ranged between 74.6 cm and 112.1 cm (table 2). The minimum value was recorded for the control variant V₁ (a₁b₁c₁), which that did not benefit from foliar fertilization, and the applied tillage corresponded to the conventional system for castor oil plant cultivation. It can be noted that the maximum plant height (112.1 cm) corresponds to the variant V₈ (a₁b₂c₂), being influenced by the genotype, the tillage system on ridges and by the system of plant fertilization.

Differences between experimental variants are obvious when analyzing the insertion height of the main raceme. Comparing to the control variant V₁ (a₁b₁c₁), where the main raceme developed at a height of 60.3 cm, in the remaining experimental variants the insertion height exceeded 69.2 cm; the highest values were recorded for variants that benefited of two new technological links introduced in castor oil plant culture, the maximum being

obtained in variant V₁₁ (a₂b₂c₂), respectively 89.5 cm. We can thus draw the conclusion that by practicing the ridges system of cultivation the plant root system is better developed, helping to a better anchor of the plants in the soil. The foliar treatment with Bonus K-Energy induces in plants a stronger ability of vegetative growth, thus allowing the mechanical harvesting of the culture, without the risk of seed losses.

Castor plant morphological features are within limits which gives them precocity and suitability to mechanical harvesting: plant hight between 74.6-112.1 cm, insertion of the main raceme at 60.3-89.5 cm, number of stem nodes ranging from 6.5 to 13.5 and absence or weak branching of the stem.

Determinations on the production components in castor oil plants

Measurements were made when the plant reached the technical maturity, namely when the seed moisture reached 13%. The moisture dynamics began since the stage of physiological maturity, marked by basal leaf drying, drying of capsules, strengthening of seeds, the appearance of gloss and of pigments on seeds, the characteristic colors bring genotype-specific. Humidity dynamics was followed every 2 days for 10 plants from each experimental variant [6].

Table 2: Castor Oil Plant Growth and Development in the Experimental Field

Variant Number	Experimental Variant	Plant Height (cm)	Insertion Main Raceme (cm)	Number of Branches/Plant	Number of Stem Nodes
V ₁ (Mt)	a ₁ b ₁ c ₁	74,6	60,3	0	6,5
V ₂	a ₁ b ₁ c ₂	74,9	75,9	0	8,7
V ₃	a ₂ b ₁ c ₃	99,5	70,4	1,6	9,2
V ₄	a ₂ b ₁ c ₁	96,9	69,2	0	6,9

V ₅	a ₂ b ₁ c ₂	104,8	78,3	1,2	9,3
V ₆	a ₁ b ₁ c ₃	100,5	77,1	1,5	10,4
V ₇	a ₁ b ₂ c ₁	94,3	69,9	0	9,2
V ₈	a ₁ b ₂ c ₂	112,1	82,0	1,2	12,0
V ₉	a ₁ b ₂ c ₃	107,8	87,7	1,7	13,4
V ₁₀	a ₂ b ₂ c ₁	98,1	86,0	0	10,2
V ₁₁	a ₂ b ₂ c ₂	110,5	89,5	1,3	12,7
V ₁₂	a ₂ b ₂ c ₃	108,0	88,4	1,0	13,5

In order to assess the production components, determinations were performed on 10 plants from each variant regarding the length of the main raceme, the number of capsules formed on the main raceme and the number of seeds. After setting these parameters, weighings were performed for each production component, the results being expressed in grams.

Main raceme length was of about 26.0 cm in the case of the control, which was unfertilized and under the conventional tillage system, the rest of the experimental variants significantly exceeding the value recorded in the control variant. Maximum raceme length, of 42.4 cm, was obtained in the variant V₁₂ (a₂b₂c₃) (table 3). It is noticeable the decisive influence of the two technological links on this component of efficiency.

The number of capsules increases in a direct proportion with the length of raceme. In the variants V₁₁ (a₂b₂c₂) and V₁₂ (a₂b₂c₃) a number of 70.5 (V₁₁) and 73.5 capsules (V₁₂) was recorded, the rest of the variants also exceeding the control which had only 19.5 capsules developed on the main raceme. We can thus say with certainty that the number of capsules is clearly influenced by the three factors included in the study: the cultivated genotype, the tillage system and the practiced fertilization scheme [2, 3, 5].

The weight of the capsules from the main raceme reached maximum values also in the two experimental variants mentioned above: V₁₁ (50.28) and V₁₂ (52.12).

The number of seeds developed in the main raceme was closely related to the number of formed capsules. Thus, the plants from the experimental variants V₉ (a₁b₂c₃), V₁₁

(a₂b₂c₂) and V₁₂ (a₂b₂c₃) developed over 200 seeds in the raceme, as follows: 206.1 seeds in V₉, 212.7 in V₁₁ and 220.5 seeds V₁₂. The other experimental variants also exceeded the control, which had only 58.5 seeds formed in the main raceme.

The weight of the seeds from the main raceme was higher for all three variants mentioned above: 52.3 g in V₉, 53.98 g in V₁₁ and 55.96 g V₁₂.

Again, the experimental factors included in the study are directly influencing both the formation or production components and their technological value. In control variant V₁ there was a high number of hollow seeds, which although had a normal developed pericarp, the inside was empty. The number of hollow seeds for this variant was of 65.3, with a seed mass of 6.10 g (table 4).

Determinations on the productive potential of castor oil plants

The castor oil plants have been harvested throughout the maturation of the racemes. Therefore, two separate production data sheets were prepared, namely: a sheet where it was recorded the production of the main and of the secondary racemes which reached maturity simultaneously with the main raceme and another sheet for recording the total production, by cumulating the yields from the first sheet with those of the racemes that reached maturity later.

The actual harvesting was started when the seeds reached 14-16% humidity, which was determined by using a T₁ moisture analyzer, this device operating on the principle of seed mass electrical conductivity [4, 6].

Table 3: Measurements of the Production Components in Castor Plants

Variant Number	Experimental Variant	Main Racem Length (cm)	Number of Capsules/Primary Raceme	Capsules of Main Raceme Weight (g)
V ₁ (Mt)	a ₁ b ₁ c ₁	26,0	19,5	13,82
V ₂	a ₁ b ₁ c ₂	30,7	24,8	17,58
V ₃	a ₂ b ₁ c ₃	32,5	30,7	21,77
V ₄	a ₂ b ₁ c ₁	29,7	22,0	15,60
V ₅	a ₂ b ₁ c ₂	34,8	36,9	26,17
V ₆	a ₁ b ₁ c ₃	39,6	52,3	37,09
V ₇	a ₁ b ₂ c ₁	27,5	30,0	21,27
V ₈	a ₁ b ₂ c ₂	34,6	59,8	42,41
V ₉	a ₁ b ₂ c ₃	38,2	68,7	48,72
V ₁₀	a ₂ b ₂ c ₁	37,3	53,9	38,22
V ₁₁	a ₂ b ₂ c ₂	38,9	70,9	50,28
V ₁₂	a ₂ b ₂ c ₃	42,4	73,5	52,12

Table 4: Production Components Performance of Castor Oil Plants

Variant Number	Experimental Variant	Number of Seeds/ Main Raceme	Seeds Weight/Main Raceme (g)	Number of Dry Seeds/Main Raceme	Dry Seeds Weight/ Main Raceme (g)
V ₁ (Mt)	a ₁ b ₁ c ₁	58,5	14,84	65,3	6,10
V ₂	a ₁ b ₁ c ₂	74,7	18,88	20,3	1,89
V ₃	a ₂ b ₁ c ₃	92,1	23,37	14,7	1,37
V ₄	a ₂ b ₁ c ₁	66,0	16,75	54,8	5,12
V ₅	a ₂ b ₁ c ₂	110,7	28,09	30,2	2,82
V ₆	a ₁ b ₁ c ₃	156,9	39,82	27,6	2,57
V ₇	a ₁ b ₂ c ₁	90,0	22,84	59,9	5,59
V ₈	a ₁ b ₂ c ₂	179,4	45,53	19,4	1,81
V ₉	a ₁ b ₂ c ₃	206,1	52,30	10,3	0,96
V ₁₀	a ₂ b ₂ c ₁	161,7	41,04	48,9	4,57
V ₁₁	a ₂ b ₂ c ₂	212,7	53,98	19,3	1,80
V ₁₂	a ₂ b ₂ c ₃	220,5	55,96	15,6	1,45

The optimum moment of harvesting was established by taking into account the seed moisture dynamics. This process began when the capsules of the main raceme turned brown, the spines become rigid, and the seed was hard and with a shiny exocarp. The production data have been centralized in synthetic tables, and subsequently have been statistically processed according to the method of experiment settlement in randomized blocks.

The seed production of the studied cultivars was strongly influenced by the new technological links introduced to the cropping of castor oil plants, compared to the control variant, where it was practiced the conventional tillage system, without foliar fertilization. This resulted in a production of only 1530 kg/ha, while the other experimental variants recorded production increases which were highly significant statistically, the production differences ranging between 200 and 1930 kg/ha (table 5). The highest yield efficiency was recorded in the experimental variants in which the two technological links were combined, respectively the growing system on ridges and the application of two foliar fertilizations in key phases of castor oil plants cropping.

Seed production is closely correlated with plant size, height of insertion of the main raceme and the number of

stem nodes for the studied cultivars of castor oil plants. Close links also exist among the other studied morphological characteristics: plant height, main raceme insertion height and number of stem nodes.

Determining the physical indices of quality in castor oil seeds

Introducing foliar fertilization as a new technological link for castor oil plants growing resulted in statistically very significant gains both in terms of the development of production components (raceme length, number of capsules in raceme, the average number of seeds in it), but also in terms of the achieved efficiency and of the physical and chemical indicators of quality [4, 6] (HW, WTS, oil content), compared with the conventional cropping system. After harvesting, average samples of seeds were extracted and were brought to the laboratory in the Phytotechny Department of UASVM from Bucharest, to determine the main physical indices that give the seed quality: weight of 1000 seeds, hectoliter weight, seed shells percentage and percentage of oil content in seeds. Seed samples were transported in hermetically sealed bags and labelled according to each analyzed experimental variant.

Table 5: The Average Seed Production Recorded in the Experiment

Variant Number	Experimental Variant	Seed Production (Kg/ha)	Output Gap (Kg/ha)	Semnification
V ₁ (Mt)	a ₁ b ₁ c ₁	1530	-	-
V ₂	a ₁ b ₁ c ₂	2260	730	***
V ₃	a ₂ b ₁ c ₃	2567	1037	***
V ₄	a ₂ b ₁ c ₁	1898	368	***
V ₅	a ₂ b ₁ c ₂	2365	835	***
V ₆	a ₁ b ₁ c ₃	2754	1224	***
V ₇	a ₁ b ₂ c ₁	1730	200	***
V ₈	a ₁ b ₂ c ₂	2680	1150	***
V ₉	a ₁ b ₂ c ₃	2986	1456	***
V ₁₀	a ₂ b ₂ c ₁	2000	470	***
V ₁₁	a ₂ b ₂ c ₂	3253	1723	***
V ₁₂	a ₂ b ₂ c ₃	3460	1930	***

DL 5% = 1,38; DL 1% = 1,84; DL 0,1% = 2,40

Weight of 1000 seeds (WTS) was determined by using an electronic balance for two repetitions of 500 seeds each. According to this method, the seeds were randomly numbered and firstly were grouped by 10, then by 100 and after that by 500 seeds. The two groups of 500 seeds were weighed separately and the results were added up, the sum of the two weighings giving the value of this physical index of quality, expressed in grams [4, 6].

The hectoliter weight (HW) - represents the weight of a 100 l volume of seeds expressed in kilograms and was determined by using a hectoliter balance of 1 liter volume

of seeds [4, 6]. Following this criterion (table 6), the seed weight in all experimental variants exceeded the control in which the hectoliter weight was of 44.0 kg/hl. By using the tillage system with ridges and applying foliar fertilizations significantly influenced this indicator of seed quality, resulting in recorded values that exceeded 49 kg/hl, the highest value, of 56.3 kg/hl, being obtained in the variant V_{12} ($a_2b_2c_3$). It is obvious that the use of the two technological links influences the accumulation of reserve substances in seeds, with a direct impact on seed quality [4, 6].

Table 6: Determination of Physical Indices of Quality in Castor Oil Seeds

Variant Number	Experimental Variant	Weight of 1000 Seeds (g)	Percentage of Shells (%)	Hectoliter Weight (kg/hl)
V_1 (Mt)	$a_1b_1c_1$	302	23,45	44,0
V_2	$a_1b_1c_2$	324	23,80	51,5
V_3	$a_2b_1c_3$	332	23,95	55,2
V_4	$a_2b_1c_1$	322	22,90	49,2
V_5	$a_2b_1c_2$	336	23,20	53,9
V_6	$a_1b_1c_3$	348	23,90	55,8
V_7	$a_1b_2c_1$	314	22,15	49,3
V_8	$a_1b_2c_2$	338	23,00	54,9
V_9	$a_1b_2c_3$	343	23,05	56,0
V_{10}	$a_2b_2c_1$	319	23,15	50,1
V_{11}	$a_2b_2c_2$	345	22,20	54,4
V_{12}	$a_2b_2c_3$	348	24,00	56,3

Out of the homogenized yield of seeds, an average sample of 100 grams was taken, the seeds were decorticated and weighed, thus obtaining the percentage of shells resulted after decortications [4, 6]. It can be noted that there are not wide differences between the analyzed experimental variants, therefore we can say that this indicator is not greatly influenced by the cropping techniques.

Seed oil content was determined on average samples of 250 g seeds which were previously decorticated, tightly packed and labeled for each experimental variant; the samples were sent to ISTIS for determinations [6]. The results were analyzed and statistically interpreted in terms of conferring significance degrees for each experimental variant [7] [8].

Table 7: Average Oil Production Registered in the Experiment

Variant Number	Experimental Variant	Oil Production (%)	Difference of Oil Production (%)
V_1 (Mt)	$a_1b_1c_1$	50,3	-
V_2	$a_1b_1c_2$	53,2	2,9
V_3	$a_2b_1c_3$	55,8	5,5
V_4	$a_2b_1c_1$	52,6	2,3
V_5	$a_2b_1c_2$	54,3	4,0
V_6	$a_1b_1c_3$	55,9	5,6
V_7	$a_1b_2c_1$	51,7	1,4
V_8	$a_1b_2c_2$	54,8	4,5
V_9	$a_1b_2c_3$	55,9	5,6
V_{10}	$a_2b_2c_1$	53,9	3,6
V_{11}	$a_2b_2c_2$	56,0	5,7
V_{12}	$a_2b_2c_3$	56,8	6,5

After determining the percentage of oil content in the seeds (table 7), it was found that the lowest percentage of oil, of 50.3%, was recorded for the control variant ($a_1b_1c_1$). This variant was established in classical tillage system and

did not receive any treatment with foliar fertilizers. The rest of the experimental variants very significantly exceeded the control, the production increases being statistically significant in the case of variant V_7 ($a_1b_2c_1$)

with a production increase of 1.4%, up to very significant, the highest values being recorded for variant V_{11} ($a_2b_2c_2$) and V_{12} ($a_2b_2c_3$), variants that benefited of two and respectively tree foliar treatments with Bonus K-Energy.

Therefore, we may conclude that in order to achieve higher returns in terms of quantity and quality and consequently an increased economic efficiency, it is recommended to combine the two technological links, taking into account the minimum inputs required for the technology of castor oil plants cultivation.

IV. CONCLUSION

Balanced application of foliar fertilizers in critical stages of growth will greatly favour the level and quality of agricultural productions. For these reasons we introduced in the castor oil plants technology of cultivation this new method of fertilization by using a new formula, specially designated to improve yields and increase the production efficiency for biofuel crops.

Bonus K-Energy (10-5-38 +3MgO) fertilizer contains a unique balance of macro and micronutrients, ment to increase the plant production of sugars and fats. This fertilizer also contains special adjuvants for a better adherence on the leaf surface to improve the absorption and to prolong the action.

Tillage system on ridges is practiced for hoe plants (corn, soy, etc.) and consists in leaving the soil fallow, except for fertilizer and herbicide applications, from the harvesting of the precedent crop up to the new sowing. By using the tillage system with ridges, yields are higher than those obtained by using the conventional system and consequently the economic efficiency is superior, as only 60-70% of the conventional system energy is used, due to the reduction of approx. 40% of the tilling and the increase of the labor productivity.

Introducing of foliar fertilization as a new technological link in the castor oil plants cultivation resulted in statistically very significant gains both in terms of forming the components of production (raceme length, number of capsules in raceme, the average number of seeds in it), but also in terms of achieved efficiency and of the physical and chemical indicators of quality (HW, WTS, oil content) in comparison with conventional cultivation system.

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