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STUDIES ON THE EFFECT OF GENOTYPE ON GROWTH AND SEED YIELD IN SOME *Camelina sativa* L. VARIETIES CULTIVATED UNDER CONTROLLED ENVIRONMENTAL CONDITIONS

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Abstract

The recently emerged interest in using renewable vegetable sources as feedstock for biofuel production requires the identification of effective solutions aimed to follow the principles of sustainable development. Biofuels from the first generation were produced from sugarcane, starch and oils derived from agricultural products, but they may not be sustainable because are competing with the agricultural production. Currently, studies are focused on the obtaining of a second generation of biofuels that originate from plants other then food crops, from agricultural residues and from municipal wastes. Being economically attractive and having certain agro-technical advantages, the Camelina sativa seed oil is considered a sustainable source for obtaining second generation biofuels. The aim of the present research was to record the effect of genotype in 3 foreign varieties of Camelina sativa (CALENA, GP 204 and GP 202) and in 3 autochthonous ones (CAMELIA, one local population Fundulea and one hybrid line) as regards both the growth characteristics and the yield components in a greenhouse experiment, in order to evaluate their potential performance and adaptability in field conditions. Periodic phenological observations were performed on the occurrence of flowering, on the pod maturation and genotypic differences of the biometric measurements such as plant height, number of branches, number of pods per plant, number of seeds in pods and thousand seed weight are discussed.

Key words*: Camelina sativa L., greenhouse experiment, varieties.*

INTRODUCTION

The recent interest in using renewable vegetal sources as feedstocks for biofuel production requires the identification of effective solutions aimed at pursuing the principles of sustainable development. The concept of sustainable development was implemented in 1987 by the World Commission on Environment and Development (WCED) following the Brundtland Report. The sustainable development is the one that meets the needs of the present without compromising the ability of future generations to meet their own requirements.

Being attractive from economic point of view and having certain agro-technical advantages, *Camelina sativa* crop is considered a sustainable source to be used for obtaining the second generation of biofuels (Dobre and Jurcoane, 2011, Imbrea et al., 2011; Moraru, et al., 2013; Robinson, 1987). *Camelina sativa* is an annual plant that belongs to the *Brassicaceae* family, originating from southeastern Europe and southwestern Asia. *Camelina sativa* exhibits unique characteristics which make possible its introduction in culture as a sustainable source for obtaining second-generation biofuels (biokerosene), compared to other oilseed species such as soybean, rapeseed and sunflower (Ciubota-Rosie et al., 2013; Bonjean and Le Goffic, 1999; Budin et al., 1995; Downey, 1971).

Among the special features that deserve to be mentioned are: adaptability to low temperatures, reduced consumption of inputs (fertilizers, water, pesticides), short vegetation period (85-105 days, recovery of degraded land and reduction of gaseous emissions with greenhouse effect (Dobre et al., 2014a; Dobre et al., 2014b; Putnam et al., 1993).
In this context, the paper presents an analysis of the evolution of 6 *Camelina sativa* varieties in a greenhouse experiment.

MATERIALS AND METHODS

The research was conducted in in the unit-greenhouse for automation research of the Center for quality research of the agro-food products (HORTINVEST), Bucharest. The characteristics of the compartment distributed to our experiment were: 160 m², with the scope to obtain seedlings on culture bench and the facilities: heating, shielding, air-conditioning, electric set up, tide type irrigation, microaspersion, 4 assimilation lamps; two LED lighting devices (red and blue) were added to supplement the light during 16 hours/day.
The biological material being tested was represented by several varieties of *Camelina sativa*: 'GP 202', 'GP 204' (provided by Camelina Company Espana), '*Calena*' (Austria) and 'Camelia' (NARDI Fundulea Romanian genotypes) (Toncea et al., 2013), one Fundulea local population (wild camelina population) and one hybrid line named FP-5-02 (obtained by controlled hybridization between international comercial camelina genotypes with pollen from the Fundulea local population). For the new hybrid line, named FP-5-02 the amelioration program (started in 2012) has been conducted in amelioration laboratory from NARDI Fundulea (50 km from Bucharest) and field's trails of UASVM Bucharest (Moara Domneasca, 15 km far from Bucharest) and in present moment are in pending approval stage from Romanian National Homologation Authority). The purpose of this work was to improve the camelina oil content and productivity by breeding a new variety adapted to Romanian alternative cultivation conditions.
For each **6** variety of camelina studied were provided five repetitions.
The seeds were sown in 11x11x11 cm square pots (1 seed/pot) placed in appropriate trays, at a density of 15 plants/m². Each pot was filled with 1 l substrate consisting of Kekkila DSM 2 W peat, which is a light ”breathable” peat (well milled) with addition of perlite, pre-fertilized with a base fertilizer (NPK 14-16-18), with the Ph adjusted to 5.5/5.9. Before potting the substrate was sterilized by autoclaving at 100ºC for 20 min. Prior to seeding the substrate was soaked up with as much water as it could take in. Date of seeding: 20 November 2014.
As a fertilizer, a complex chemical fertilizer named Azofoska was chosen, that has the following characteristics: N:P:K 13.6-6.4-19.1 containing in addition small quantities of Mg, S, B, Fe, Mn, Mo, Zn. A first fertilizing was applied at seeding, by using 150 ml of the fertilizer solution (5 g/10 l) for every pot. The application of the next watering depended on temperature, humidity and air flow in the greenhouse compartment.
The photoperiod/temperature regimen was of 16 h light, 24ºC and 8 h dark, 20ºC, light intensity of 4700 lux. The ventilation was middle and the RH was of 55-57%.
As the weather conditions recorded during the first 30 days after sowing (1-st decade of November-1-st decade of December 2014) among which we mention continuous cloudiness, natural light intensity at low levels throughout the all day and low temperatures recorded in this date range led us to add to the artificial light, besides the 4 assimilation lamps provided at HORTINVEST greenhouse, an equipment of 2 LED panels with specific band lights in red and blue color. Each of the two LED panels were made in the following sizes: 650 mm x 350 mm x 120 mm, and insured with continuous illumination of 2000 lx each for 14 hours.
Light-emitting diodes (LEDs) represent a promising technology for the greenhouse industry that has technical advantages over traditional lighting sources. Designs of LED arrays allow waste heat to be placed within the greenhouse when and where desired during cold weather, or vented from the greenhouse during warm weather. LEDs can be manufactured to emit photon colors that match the absorbance peaks of important plant pigments, such as the red and far-red-absorbing

forms of phytochrome, or the red and blue peaks of leaf photosynthetic action spectra.
In order to prevent fungal diseases a 0.1% solution of PREVICUR, a systemic fungicide, was prepared and was applied when necessary. The first treatment to prevent disease occurrences was administered to seedlings that were in the stage of the development of the first leaflet pairs (12 days after sowing).

RESULTS AND DISCUSSIONS

A.) The evaluation of the results on germination rate

The results recorded for germination rate in the 4th day of sowing were 100% for genotypes: GP204, Calena, Camelia, local Romanian population (Fundulea) and the newly created hybrid named FP-5-02; the genotypes - GP202 registered a value of only 80%. The non-germinated seeds of GP202 variety germinated only after 10 days from sowing.

B.) Evaluation of results on the development of the first pair of leaves

As regards the dynamics of the leaves development, there were not significant differences among the 6 genotypes, these being evaluated at:

- 12 days after sowing for the 1st pair of leaves);
- 18 days after sowing for the 2nd pair of leaves;
- 22 days after sowing for the 3rd pair of leaves);
- 28 days after sowing for the 4th pair of leaves.

A general characteristic of the Camelina plantlets in the first stage of growing is the development of abnormally long and thin hypocotyls, making them prone to bend down, In this stage the presence of a *Pythium* attack was noticed. The respective plants were discarded and treatments with 0.1% Previcur were applied every 5-10 days. Due to the fact that the thin hypocotyls cannot maintain the plants upright, a mechanical support was provided (Figure 1). Besides the fertilizer applied at seeding, a second application was done after 2 weeks of seeding. The hypocotyls continued to remain thin, while the epicotyls developed normally.

Figure 1. Plantlets of *Camelina sativa* (Calena genotype) sustained upright by a support (original image-December 08.2014)

C.) Evaluation of results on the dynamics of plant growth

Plants from the 6 Camelina varieties studied under greenhouse conditions were evaluated by biometric measurements made at different time intervals in order to quantify the growth dynamics of the main stem height (cm) (Figure 2), the number of stem ramifications and the total biomass (g), weighted before harvesting the pods (Table 1).

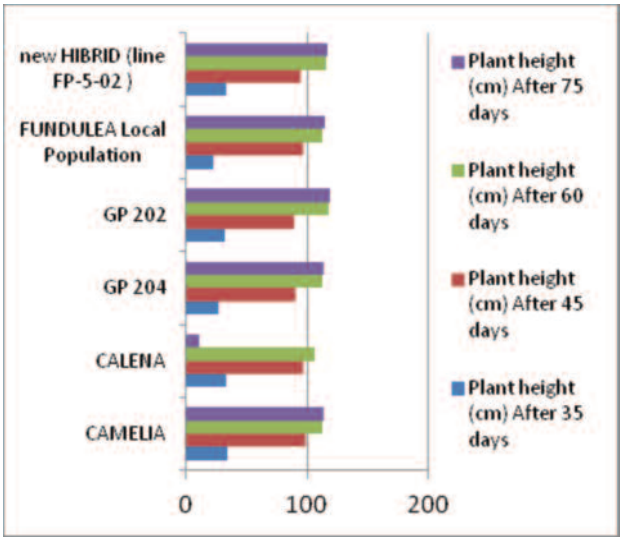

Figure 2. Evolution of plant height in the 7 *Camelina sativa* varieties (cm)

By analyzing the average value for the 5 repetitions/Camelina studied genotype of the growth dynamics presented in Table 1 it was noted that three varieties exceeded the average values calculated at 113 cm total height (GP 202 followed by the local population and the new hibrid line FP-5-02, 3 genotypes exceeded

the average value of 19 floriferous branches/plant (Fundulea local population, GP 204 and the new hibrid line FP-5-02), and three genotypes exceeded the average of total plant biomass calculated at 26.45 g (GP 204, Fundulea local population and GP 202).

Table 1. Evaluation of plant growth parameters from six *Camelina sativa* varieties (average value for the 5 repetitions / each Camelina studied genotype)

Genotype	Plant height (cm)	No. of branches/ plant	Biomass weight (g)
CAMELIA	113.00	17.80	25.37
CALENA	105.60	17.66	19.33
GP 204	113.75	20.00	**31.69**
GP 202	**118.20**	17.40	28.42
FUNDULEA Local Population	115.00	**21.40**	30.52
new HIBRID (line FP-5-02)	117.40	19.75	23.34
AVERAGE VALUE	**113.83**	**19.00**	**26.45**

D.) Evaluation of production components (seeds)

Determination of seed production (g), obtained from each genotype was performed by harvesting the plants, counting the total pods/plant, average number of seeds/pod, and by weighing the total seed/plant and the weight of 1000 seeds. The percent of total seed weight/biomass and the total seeds/plant were estimated by mathematical calculations (Table 2).

In assessing the recorded production values, the followings exceeded the calculated averages (value for the 5 repetitions / Camelina studied genotype) (Figure 3).

- the total weight of seeds/plant (3.20 g) for the new HIBRID (line FP-5-02) followed by Camelia genotype;
- average seed/pod (13.12) for the new HIBRID (line FP-5-02) and Camelia genotype;
-weight of 1000 seeds/plant (1.04 g) for GP 204 genotype followed by the new HIBRID (line FP-5-02).

Table 2. Evaluation of production parameters in six *Camelina sativa* varieties (average value for the 5 repetitions / Camelina genotype studied)

Genotype	No. of pods/plant	Seed weight/ plant (g)	Total seed weight/ biomass (%)	Average seeds /pod	Number of seeds/ plant	1000 seed weight (g)
CAMELIA	236	3.38	13.32	14.6	3313	1.02
CALENA	248	3.26	16.86	12.75	3228	1.01
GP 204	241	3.15	11.48	11.48	2763	1.14
GP 202	251	3.01	10.60	12.62	3168	0.95
FUNDULEA Local Population	238	2.95	9.66	11.9	2864	1.03
new HIBRID (line FP-5-02)	235	3.42	15.37	15.34	3288	1.08
AVERAGEVALUE	**241.5**	**3.20**	**12.90**	**13.12**	**3104**	**1.04**

D.) Periodic assessment of plant health

A good phytosanitary state as regards the pests and diseases was maintained until the flowering stage by applying 6-7 treatments with a 0.1% solution of Previcur to prevent the fungal diseases and 5 alternating treatments for the control of harmful pests (mites, thrips and whiteflies) with Mospilan (0.03%) and Actara. In order to support a vigorous growth of *Camelina sativa* plants, the complex Azofoska fertilizer was applied at 2 weeks intervals, until about 20% of plants have formed inflorescences (Figure 4).

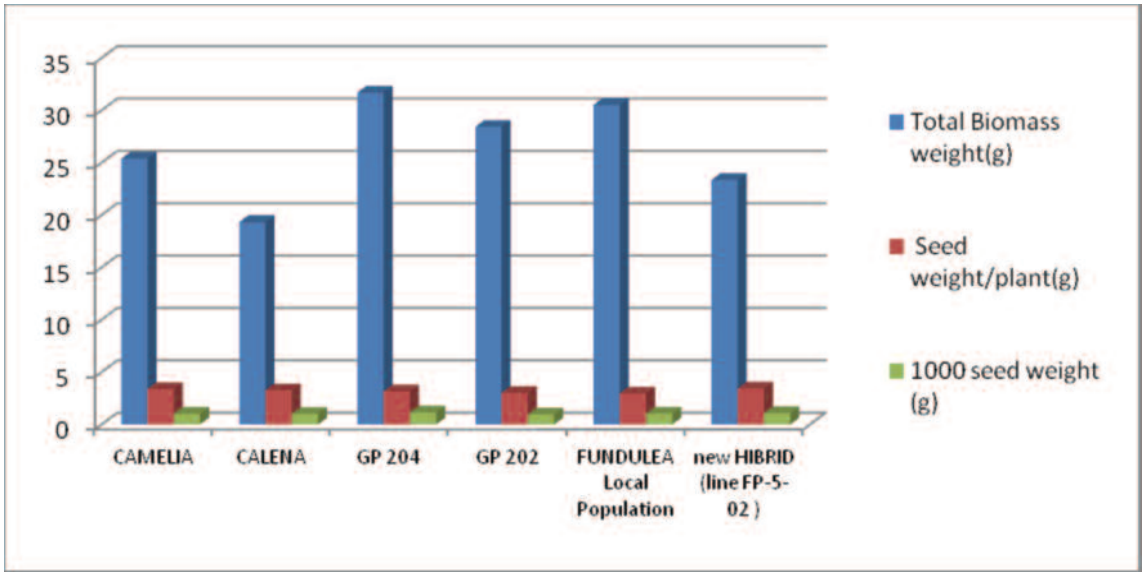

Figure 3. Production elements recorded in plants from the six *Camelina sativa* varieties (average value for the 5 repetitions / Camelina genotype studied)

Figure 4. Camelina plants in flowering stage (original-HORTINVEST greenhouse experiment, January 15.2015)

CONCLUSIONS

The obtained results recorded for the production parameters in *Camelina sativa* grown in controlled environmental conditions suggest that these are comparable to the ones obtained in the field (Dobre, and Jurcoane, 2011).

Analysing the production parameters obtained for the six *Camelina sativa* studied varieties the best good results were achieved by the new hybrid line (FP-5-02), which is pending approval for introduction in culture in Romania for: seed weight/plant (3.42 g) and for average seeds/pod (15.34), and other good results over the average values were recorded for the other 3 parameters analyzed (total seed weight/ biomass, number of seeds/plant, 1000 seed weight).

Except for plant height obtained values for all other production parameters analyzed were higher for the new camelina created hybrid line (FP-5-02), compared to the local population Fundulea used as pattern genitor in the controlled hybridization process.

After evaluating the productive performance recorded at the 6 varieties of crop plants, in the second decade of March (2015) were performed biochemical analyzes for the oil content of the seed samples and the rest was

used as a source of biological material to set up in the field of comparative batches, the results of these experiments will be reported in the future.

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