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TOTAL BIOMASS AND GRAIN PRODUCTION OF *Cynara cardunculus* L. SPECIES GROWN UNDER THE CONDITIONS OF SOUTHEASTERN ROMANIA

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Abstract

Cynara cardunculus L. is a perennial plant of Mediterranean origin, which drew attention in particular for the use of biomass or seed oil for energy purposes. This paper presents researches conducted on seed production and productivity elements of Cynara cardunculus L. plants. The paper includes results of researches carried out in 2012-2013, on three Cynara cardunculus L. cultivars (Gobbo di Nizza, C 816 and Porto spineless). Average total biomass production at plants maturity for the two crop years was 16,672.8 kg ha^{-1} dry matter, and the average grain yield was 1,565 kg ha^{-1}.

Keywords: *Cynara cardunculus L., biomass, dry matter, grain yield.*

INTRODUCTION

Cynara Cardunclus L. (cardoon) is a diploid - 2*n* = 34 chromosomes (Fernández et al., 2005), perennial herbaceous plant of Mediterranean origin (Franco, 1984), belonging to the *Asteraceeae* (Archontoulis et al., 2009) family, with a life span of almost 10 years (Gominho, 2001; Archontoulis et al., 2009; Abeliotis et al., 2009) or 10 to 15 years (Archontoulis et al., 2008). Cardoons adaptability to various climatic conditions is a result of the plant ability to achieve a positive balance between its phenological stages and climatic trends, and from its well and deeply developed root system, which allows exploring a large volume of soil (Ierna et al., 2012).

In the Mediterranean Basin, cardoon is mainly cultivated in Spain, Italy, France and Greece (Portis et al., 2005; cited by Ierna et al., 2012). Researches on the species *Cynara cardunculus* L. conducted in Italy highlighted its potential for lignocellulosic biomass, exploited for energy purposes. (Ierna et al., 2012). Cardoons grain production and weight of thousand seeds vary according to the experimental conditions (Gominho et al. 2011; Curt et al., 2002; Fernández and Curt 2004; Ierna et al., 2012). Cardoon seeds are rich in lipids (Sengo et al., 2010) and their oil content varies under different growing conditions (Portis et al., 2010; Piscioneri et al., 2000; Curt et al., 2002).

MATERIALS AND METHODS

Researches were carried out on a chromic luvisol, at the Didactic Farm Moara Domneasca of the University of Agronomic Sciences and Veterinary Medicine of Bucharest.

The field was organized by the method o subdivided parcels with three repetitions, and three cultivars of *Cynara cardunculus* L. were analyzed, respectively:

V_1 - Gobbo di Nizza;

V_2 - C 816;

V_3 - Porto spineless.

Fertilization consisted in applying complex nitrogen and phosphorous fertilizers at a dose of 60 kg ha^{-1} active substance, in early spring, before the plants start growing.

Dynamic biometric measurements were made from the beginning of the growing season up to the senescence stage. Collection of dry biomass production and evaluation of grain yield were carried out after plants reached the stage of senescence.

Starting with the second year of life, cardoon reaches harvest maturity in August.
In 2012 during the period April - August, the average temperature was 18.36 °C, with 2.24 °C above the multi annual average, and in 2013 the average value of the temperature was 19.14 °C, with 2.24 °C higher than the multi annual average. Rainfalls recorded during April - August had a total amount of 283.4 mm in 2012, with 32.7 mm below the multi annual amount o the area. In 2013 during April and August rainfalls amount was 223.3 mm.

Table 1. Climatic conditions in 2012 - 2013 - Weather Station Găneasa –Ilfov

Month	Temperature (t °C)			Rainfalls (mm)		
	2012	2013	Normal	2012	2013	Normal
X	8.9	13.6	11	37.6	16.6	35.8
XI	10.3	6.6	5.3	10.2	5.8	40.6
XII	- 0.17	- 1.7	0.4	101.4	113.6	36.7
I	- 1.1	- 1.7	- 3.0	19.6	70.6	30.0
II	- 4.4	2.2	- 0.9	19.6	50.6	32.1
III	5.8	4.9	4.4	4.2	27	31.6
IV	14.1	13.1	11.2	32.4	19.1	48.1
V	18	19.5	16.5	180.6	44	67.7
VI	22.9	22.6	20.3	14.2	99	86.7
VII	27.0	23.3	22.1	9.2	26.2	63.1
VIII	24.4	24.5	21.7	47.0	35	50.5
IX	19.4	17.4	17.5	42.2	49.6	33.6
Average (^{0}C) Sum (mm)	12.09	12.03	10.54	518.2	557.1	556.5

RESULTS AND DISCUSSIONS

Results of the research conducted on the *Cynara cardunculus L.* species in the second year of life, highlighted the following:

Sprouting, bud development of Cynara cardunculus L. plants

Plant started their development at the beginning of March, through bud swelling on the upper part of the root system (1-3 cm depth).

Crop plants development and biomass evaluation

At the beginning of the vegetation period, plants development takes place more slowly, depending on climatic conditions and variety. Rosette formation or the growth of 5 to 6 leaves (Archontoulis et al., 2009), under the conditions of Moara Domnească, corresponded to mid April. Inflorescences begin to form once stems elongate.

Flowering period lasts about 4 weeks and begins with the advent of lilac colored flowers on the inflorescence in the center of the corymb.

The average biomass production at harvest, for the two years, was 16,672.8 kg ha^{-1} (Table 2). The variety with the highest dry biomass production both in 2012 and 2013 was V_3 - Porto spineless, recording in the two years analyzed an average production of the total biomass of 20,368.5 kg ha^{-1}, the positive difference compared to the average of the three varieties being very significant.

Grain production is closely correlated with the number of inflorescences per plant. In 2012 there was an average grain production of the three varieties of 1,478.4 kg ha^{-1}, and in 2013 the average grain production was 1,652.67 kg ha^{-1}, with 174.27 kg (Table 3) above the average grain production recorded in the previous year.

Cardoon variety with the highest grain yield recorded was Porto spineless, with an average of 2,282.2 kg ha^{-1} for the two crop years. The lowest average grain yield for the two crop years, of 1,103.8 kg ha^{-1}, was recorded for Gobbo di Nizza variety, the negative difference compared to the average of the experience being distinctly significant. Increased production in Porto spineless variety is very significant compared to the average of the three studied *Cynara cardunculus* L. varieties.

The number of capitula per plant depends on the variety and the climatic conditions, especially on the amount of rainfalls and their distribution during growing period. The average number of capitula per plant was 6.85 in 2012, and 8.11 in 2013, while the average number for the two crop years was 7.48 capitula per plant (Table 4).

Table 5 presents the average grain yield per plant for each variety, in the two analyzed crop years. In 2012 the grain yield per plant was 78.68 g and in 2013 it was 153.6 g per plant.

The variety with the highest grain yield per plant was Porto spineless, with an average production for the two crop years of 163.85 g per plant, the positive difference compared to the average of the cultivated varieties being very significant.

Table 2. Total biomass production (dry matter) of *Cynara Cardunculus* L. in the second year of life, during 2012 – 2013 at Moara Domneasca (Ilfov)

Variety	Year 2012		Year 2013		Average 2012 - 2013		
	kg ha^{-1}	%	kg ha^{-1}	%	kg ha^{-1}	%	Diff.
V_1	13,063	82.9	14,793	84.1	13,928.0	83.5	- 2744.8^{000}
V_2	15,190	96.4	16,254	92.4	15,722.0	94.3	- 950.8 ^{00}
V_3	19,022	120.7	21,715	123.5	20,368.5	122.2	3,695.7***
Average	15,758.3	100	17,587.3	100	**16,672.8**	100	C
V_1 - Gobbo di Nizza; V_2 - C 816; V_3 - Porto spineless					LSD 5% = 468.36 kg LSD 1% = 709.17 kg LSD 0.1% = 1,140.58 kg		

Table 3. Grain yield of *Cynara Cardunculus* L. in the second year of life, during 2012 – 2013 at Moara Domneasca (Ilfov)

Variety	Year 2012		Year 2013		Average 2012-2013		
	kg ha^{-1}	%	kg ha^{-1}	%	kg ha^{-1}	%	Diff.
V_1	1,087.0	73.5	1,120.5	69.3	1,103.8.0	70.5	- 461.2^{00}
V_2	1,226.0	82.9	1,392.5	79.6	1,309.3.0	83.7	- 255.7^{0}
V_3	2,122.3	143.5	2,442.0	151	2,282.2	146	717.2***
Average	1,478.4	100	1,651.7	100	1,565	100	C
V_1 - Gobbo di Nizza; V_2 - C 816; V_3 - Porto spineless					LSD 5% = 253.22 kg LSD 1% = 383.66 kg LSD 0.1% = 616.65kg		

Table 4. Number of capitula per plant in *Cynara cardunculu*s L. crop

Variety	Year 2012		Year 2013		Average 2012-2013		
	No/p	%	No/p	%	No/p	%	Dif.
V_1	6.11	89.2	6.33	78.1	6.22	83.2	-1.26
V_2	6.33	92.4	7.67	94.5	7	93.6	-0.48
V_3	8.11	118.4	10.33	127.4	9.22	123.3	1.74
Average	6.85	100	8.11	100	7.48	100	C
V_1 - Gobbo di Nizza; V_2 - C 816; V_3 - Porto spineless							

Table 5. Seed weight per plant

Variety	Year 2012		Year 2013		Average 2012-2013		
	g	%	g	%	g	%	Diff.
V_1	61.8	78.6	114.8	74.7	88.3	74.8	-29.7^{00}
V_2	69.36	88.2	133	86.5	101.18	85.7	-16.8
V_3	104.7	133	223	145.2	163.85	138.8	45.9***
Average	78.62	100	153.6	100	117.98	100	C
V_1 - Gobbo di Nizza; V_2 - C 816; V_3 - Porto spineless					LSD 5% = 17.56 g LSD 1% = 26.61 g LSD 0.1% = 42.77 g		

Seed weight per capitulum (Table 6) in 2012 had an average of 11.37 g, and 19.02 g per capitulum in 2013, the average seed weight of the two years being of 15.18 g per capitulum. The variety with the highest seed production per capitulum was Porto spineless, with an average of 17.25 g per capitulum in the two crop years.

Regarding the weight of thousand seeds of the studied *Cynara cardunculus* L. varieties, this had an average value of 33.87 g in 2012, and 42.2 g in 2013 (Table 7). For the variety Porto spineless the positive difference compared to the average of the three varieties is distinctly significant, while Gobbo di Nizza recorded a significant negative difference.

Table 6. Seed weight per capitulum (g)

Variety	Year 2012		Year 2013		Average 2012-2013		
	g	%	g	%	g	%	Diff.
V_1	10.14	89.2	18.14	95.4	14.14	93.1	-1.04
V_2	10.96	96.4	17.34	91.2	14.15	93.2	-1.03
V_3	12.91	13.5	21.59	113.5	17.25	113.6	2.07
Average	11.37	100	9.02	100	15.18	100	C
V_1 - Gobbo di Nizza; V_2 - C 816; V_3 - Porto spineless							

Table 7. Weight of thousand seeds (WTS)

Variety	Year 2012		Year 2013		Average 2012-2013		
	g	%	g	%	g	%	Diff.
V_1	30.9	91.2	40.1	95	35.5	93.4	2.5^{0}
V_2	33.1	97.7	41.1	97.4	37.1	97.6	0.9
V_3	37.6	111	45.3	107.3	41.45	109.0	3.45**
Average	33.87	100	42.2	100	38.0	100	C
V_1 - Gobbo di Nizza; V_2 - C 816; V_3 - Porto spineless					LSD 5% = 1.92 g LSD 1% = 2.91 g LSD 0.1% = 4.68 g		

CONCLUSIONS

Results of the research conducted in 2012 and 2013 on the *Cynara cardunculus* L. species show the following:

- Average biomass production for the two crop years was 16,672.8 kg ha^{-1}.

- The maximum biomass production was achieved in 2013 in Porto spineless variety, respectively 21,715.0 kg ha^{-1}.
- The maximum grain yield was achieved in Porto spineless variety, with an average for the two crop years of de 2,282.2 kg ha^{-1}.
- Yield components, respectively number of capitula per plant, seed production per capitulum and weight of thousand seeds (WTS) had maximum values in the variety Porto spineless.

Figure 1. Flowering *Cynara cardunculus* L. plants, Moara Domneasca Experimental Field (July 25, 2013)

Figure 2. *Cynara cardunculus* L. plants, Moara Domneasca Experimental Field (August 8, 2013)

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