Detection of QTLs for Yield in Globe Artichoke

Daniel Leskovar
d_leskovar@tamu.edu

Texas A&M AgriLife
Research & Extension Center
Texas A&M University, Uvalde, TX

IICAR-CONICET
Facultad de Cs. Agrarias, UNR
Zavalla, SF, Argentina

Eugenia Martin
eamartin@unr.edu.ar

Vanina Cravero
vcravero@unr.edu.ar

Aldana Zayas
aldana.zayas@unr.edu.ar

Enrique Cointry
ecointry@unr.edu.ar

Cynara cardunclus L. (allogamous *Asteraceae*) includes two domesticated taxa, globe artichoke and cultivated cardoon, as well as the wild cardoon, commonly considered to be the wild ancestor of both domesticated forms. Globe artichoke is an important horticultural crop in Argentina and the United States. The edible part are the heads (capitulum) consumed as fresh or canned, which are important sources of antioxidants due to the high content of phenolic compounds.

The aim of this work was to identify QTLs controlling the genetics basis of yield-related traits in globe artichoke as a first step to MAS.

Materials & Methods

Plant Material. 115 F_1 progeny derived from an inter-botanical variety cross and both parents were grown at the Experimental Field Station of the Universidad Nacional de Rosario in 2014 (*Figure 1*).

Morphological Analysis. Seven agronomic traits were evaluated (*Table 1*).The normal distribution of the traits was verified by a Shapiro-Wilks test. The t-Student test was performed to compare the means values between parents. The correlation between traits was determined by the Pearson´s coefficient.

Molecular Analysis & QTLs association. A total of 247 SSRs were used to evaluate the genotypes. The markers were tested for an expected Mendelian segregation in the F_1 by a $\chi 2$ test. Only SSRs showing a fully consistent with monogenic segregation ($\chi 2 \leq \chi 2_{\alpha=0.1}$) were used for QTLs association. Association between SSR locus and traits was determined by a one-way ANOVA ($p \leq 0.05$). The proportion of total phenotypic variance explained by each QTL was estimated by R^2 values.

Wild Cardoon

Estrella del Sur

F_1 progeny

Figure 1. Inter-botanical variety cross and its progeny.

Morphological Traits	
Head per plant	NHP
Fresh weight of main head (g)	WMH
Diameter of main head (cm)	DMH
Length of main head (cm)	LMH
Fresh weight of 2nd heads (g)	W2H
Diameter of 2nd heads (cm)	D2H
Length of 2nd heads (cm)	L2H

Table 1: Morphological traits evaluated

Results

All the morphological traits showed normal distribution (W > 0.94) and both parental genotypes were significantly different (*Figure 2*, *Table 2*). The correlation analysis revealed that diameter and length of the main and secondary heads were the most important factors influencing fresh weigh (*Table 3*). A total of 70 SSRs showed Mendelian segregation and were used for QTLs association. SSR markers linked to QTL and % of total phenotypic variation explained by each QTLs (R^2) are shown in *Table 4*.

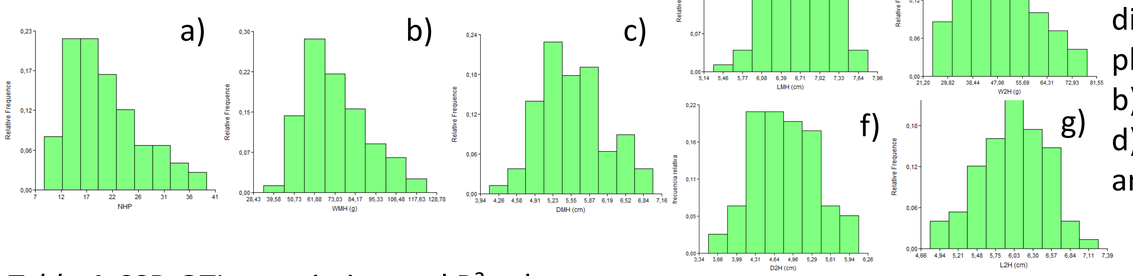

Figure 2. Frequency distribution of F_1 phenotypes for a) NHP, b) WMH, c) DMH, d) LMH, e)W2H, f) D2H, and g) L2H.

	Genotypes										
	WC			ES				F_1			
Traits	Mean	SE	SD	Mean	SE	SD		Mean	SE	min	max	W
NHP	17.0	1.08	2.16	4.0	0.41	0.82	*	20.2	0.76	9.0	39.0	0.94
WMH (g)	22.9	1.54	3.07	147.3	8.06	16.13	*	73.5	2.05	34.1	123.0	0.97
DMH (cm)	4.3	0.09	0.18	7.2	0.09	0.18	*	5.6	0.07	4.1	7.0	0.97
LMH (cm)	4.5	0.10	0.21	8.5	0.83	1.65	*	6.8	0.06	5.3	7.8	0.96
W2H (g)	14.3	1.62	3.24	62.3	4.21	8.43	*	47.4	1.53	24.5	78.2	0.95
D2H (cm)	3.8	0.18	0.35	5.7	0.21	0.42	*	4.8	0.07	3.5	6.1	0.97
L2H (cm)	4.1	0.19	0.39	6.0	0.79	1.57	*	6.0	0.06	4.8	7.3	0.98

Table 2: Mean values, standard error (SE), and standard deviation(SD) for each trait of Wild Cardoon (WC), Estrella del Sur FCA globe artichoke (ES) and the F_1. Significant mean differences between parentals are indicated (*p>0.05).

Table 4: SSR-QTL association and R^2 values.

SSR	Traits	R2 (%)	p-Value	SSR	Traits	R2 (%)	p-Value
CELMS-02	WMH	6	0.045	CyEM_02	D2H	6	0.0355
	W2H	6	0.0499	CELMS-36	D2H	11	0.0119
	D2H	8	0.0164	CyEM_188	DMH	10	0.0075
CELMS-10	W2H	18	0.0027	CyEM_234	WMH	8	0.0104
	D2H	11	0.0173		DMH	8	0.0151
	L2H	8	0.0437		W2H	8	0.008
CyEM_244	L2H	6	0.0335		D2H	8	0.0141
CyEM_293	W2H	13	0.002		L2H	6	0.0338
	D2H	10	0.0062	CyEM_53	W2H	8	0.0134
CELMS-57	WMH	18	0.0013		D2H	6	0.0341
	DMH	17	0.002	CyEM_86	D2H	6	0.0333

Table 3: Correlation analysis. High positive values indicated by arrows.

	NHP	WMH	DMH	LMH	W2H	D2H	L2H
NHP	1						
WMH	0.59	1					
DMH	0.49	0.89	1				
LMH	0.60	0.82	0.71	1			
W2H	0.38	0.55	0.39	0.5	1		
D2H	0.48	0.56	0.45	0.49	0.93	1	
L2H	0.42	0.43	0.27	0.57	0.84	0.79	1

Conclusion

We have detected 22 new QTLs controlling yield-related traits in *Cynara cardunclus* L., providing evidence that there are several loci controlling globe artichoke yield. The SSRs linked to this trait should be used for marker assisted improvement of the species.