

VARIABILITY OF SEEDS AND DECORATIVE TRAITS AND THE CORRELATIONS AMONG THESE AT DIFFERENT CALENDULA GENOTYPES

VARIABILITATEA UNOR CARACTERISTICI ALE SEMINTELOR ȘI PLANTELOR ȘI CORELAȚIILE DINTRE ACESTE LA DIFERITE GENOTIPURI DE CALENDULA

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Abstract: *Marigolds (Calendula) are considered one of the most versatile and easy to grow flowers in a garden, with ornamental and medicinal importance. In order to identify potential genitors for breeding works, there were studied 45 genotypes of Calendula, represented of six species and different cultivars. Most of them presented valuable ornamental traits and could be used as genitors for obtaining new decorative cultivars by hybridization. The seed's weight influenced positively the rising capacity and was phenotypic correlated with decorative characteristics of the plants, positive with plant height and number of stem per plant, and negative with number of petals per flower. The identified correlations, statistically assured, could be used as selection indices in marigold breeding.*

Key words: *Calendula, hybridization, seed's weight, decorative characteristics.*

Rezumat: *Gălbenelele (Calendula) fac parte dintre cele mai versatile și ușor de întreținut flori de grădină, cu deosebite proprietăți ornamentale și medicinale. În scopul identificării unor potențiali genitori pentru munca de ameliorare, au fost studiate 45 de genotipuri de Calendula, reprezentate de șase specii și diferite cultivaruri. Numeroase genotipuri au prezentat particularități ornamentale valoroase, astfel că pot fi utilizate ca genitori în lucrări de hibridare artificială, pentru obținerea unor noi cultivaruri cu valoare decorativă. Greutatea semințelor a influențat pozitiv răsărirea plantelor și a fost corelată fenotipic cu unele caracteristici decorative ale plantelor, pozitiv cu înălțimea acestora și numărul de tije pe plantă, și negativ cu numărul de petale din floare. Astfel de corelații, asigurate statistic, pot fi utilizate ca indici de selecție în ameliorarea gălbenelelor.*

Cuvinte cheie: *Calendula, hibridare, greutatea semințelor, caracteristici decorative.*

INTRODUCTION

Marigold is included in the *Calendula* gender, *Asteraceae* family, which outtakes approximately 25 annual and perennial species, the most widespread species being: *Calendula officinalis*, *C. arvensis*, *C. alata*, *C. stellata*, *C. tripterocarpa*, *C. suffruticosa* etc. In Romania, the most common species are *C. officinalis* L. and the less well known is *C. arvensis* L. Rustic specie *C. officinalis*

L. is poorly present in the spontaneous flora in the region of Banat, Iași, Cluj and on the Someș riverside (Cociu and Răcz, 1962).

Calendula officinalis L. is used for its decorative aspects in the landscape design, especially the plants with involutes flowers. As cut flowers, *Calendula officinalis* are used in different flower arrangements (Șelaru, 2007). For breeding purposes, it is intended to obtain new cultivars with a high ornamental capacity, with big involutes flowers, highly coloured, especially yellow colour, yellow-orange, or dark orange with compact growth (Gonceariuc, 2001).

Because of the therapeutically properties of *Calendula*, its content of essential oils and pigments, the plant is used in human medicine, veterinary medicine and food industry (Baciu and Sestraș, 2008). Following this aspects, the breeding purposes are to create new genotypes with involutes flowers that will obtain a large number of seeds and essential oils (Diaconu, 1992). *Calendula officinalis* showed good agronomic traits, including tolerance to drought and to high temperature; the seeds contained a mixture of fatty acids (Angelini et al., 1997). Consequently, increasing seed oil content and eliminating certain wild characteristics such as fruit dehiscence represents important further breeding aims work. After Zitterl-Eglseer et al. (2001), breeding work should focus on varieties with a greater number of ray florets in order to improve the quality of herbal medicinal products derived from marigold.

MATERIAL AND METHODS

In an experimental plot situated at the Botanical Garden of University of Agricultural Science and Veterinary Medicine Cluj-Napoca (UASVM Cluj-Napoca), Romania, 45 genotypes of *Calendula* gender where studied, belonging to six species, as follows: *C. officinalis*, *C. alata*, *C. arvensis*, *C. stellata*, *C. suffruticosa*, *C. tripterocarpa*.

The following characteristics where studied: weight of seeds (mg), emergence capacity of plants (%), height of the plants (cm), no. of stems, no. of flowers/plant and no. of petals in corolla (the traits of plants were analysed at mature plants when these showed their maximum decorative aspect).

The obtained data where computed as averages. The analysis of variance was performed using the ANOVA test, respectively „t” test (Ardelean et al., 2007).

RESULTS AND DISCUSSIONS

The medium values of seed's weight (mg), emergence capacity of seeds (%) and the height of mature plants (cm) are presented in table 1.

Regarding the studied genotypes, the seeds weight presented an ample variation, with values between 5.32 mg at *C. arvensis* F, and 21.06 mg at *C. alata* UK. The seeds with the lowest weight where observed at *C. arvensis* F, *C. arvensis* SLO, Bon Bon Mix, *C. officinalis* L.F.c, *C. officinalis* L.PL, *C. officinalis* I., cv. Prycosnovjenie, cv. Fiesta Hitana, cv. Rozovyi Sjurpriz, cv. Pacific, cv. Plamen, *C. officinalis* AZ, all with negative signification compared with the experiment average (12.27 mg).

Table 1

Mean values of analyzed traits and variability coefficient for *Calendula* genotypes

No.	Genotype	Seeds weight		Emergence capacity %	Plant height	
		mg	CV%		cm	CV%
1	122GE 2822-0002	12.02 ⁻	29.2	56.7 ⁻	33.56 ⁰⁰⁰	28.5
2	123GE Hortus Hudae	17.36 ^{xxx}	32.0	50.0 ⁻	37.60 ⁰⁰	19.0
3	121GE2822-0001	18.21 ^{xx}	46.9	68.6 ⁻	55.00 ^{xxx}	16.5
4	124GE2822-04	12.87 ⁻	41.3	51.4 ⁻	39.15 ⁰⁰	28.5
5	<i>C. officinalis</i> L.D.a	19.05 ^{xxx}	24.1	78.3 ^{xx}	36.13 ⁰⁰⁰	31.4
6	<i>C. officinalis</i> L.B	11.27 ⁻	26.4	78.0 ^{xx}	31.06 ⁰⁰⁰	48.0
7	<i>C. officinalis</i> F.a	14.06 ^x	20.3	76.7 ^{xx}	36.19 ⁰⁰⁰	28.8
8	<i>C. arvensis</i> F	5.32 ⁰⁰⁰	27.3	33.8 ⁻	44.35 ⁻	17.0
9	<i>C. officinalis</i> SLO	10.85 ⁻	27.2	63.3 ⁻	42.11 ⁰	18.9
10	<i>C. arvensis</i> SLO	9.17 ⁰⁰	46.1	65.0 ⁻	67.72 ^{xxx}	13.8
11	cv. prolifera Nr. 215	11.61 ⁻	41.9	56.7 ⁻	49.88 ⁻	34.2
12	cv. prolifera Nr. 214	12.74 ⁻	31.7	61.7 ⁻	59.65 ^{xxx}	35.2
13	Bon-Bon Orange	18.21 ^{xxx}	33.9	68.3 ⁻	52.12 ^x	30.3
14	Bon Bon Mix'	7.69 ⁰⁰⁰	31.4	51.8 ⁻	41.71 ⁻	38.2
15	<i>C. officinalis</i> UK	16.83 ^{xx}	33.8	61.1 ⁻	30.64 ⁰⁰⁰	40.5
16	<i>C. officinalis</i> L.D.b	11.69 ⁻	50.3	31.7 ⁻	44.95 ⁻	37.7
17	<i>C. officinalis</i> L.F.b	16.21 ^{xxx}	25.4	76.7 ^{xx}	50.54 ⁻	34.2
18	<i>C. officinalis</i> L.D.c	12.11 ⁻	48.6	56.7 ⁻	43.29 ⁻	48.5
19	cv. Pacific-Riesen	14.59 ^x	30.6	61.7 ⁻	41.43 ⁻	36.0
20	cv. Radio	16.32 ⁻	58.0	63.3 ⁻	45.89 ⁻	31.0
21	cv. Rech.f.	17.31 ⁻	68.3	66.7 ⁻	61.15 ^{xxx}	29.6
22	<i>C. arvensis</i> L.	9.79 ⁻	54.2	70.0 ^x	58.12 ^{xxx}	32.6
23	<i>C. stellata</i> Cav.	11.27 ⁻	54.7	53.3 ⁻	60.53 ^{xxx}	27.0
24	<i>C. suffruticosa</i> Vahl.	10.76 ⁻	58.3	60.0 ⁻	65.89 ^{xxx}	23.0
25	<i>C. tripterocarpa</i> Rupr.	11.04 ⁻	57.1	53.3 ⁻	84.06 ^{xxx}	12.6
26	<i>C. officinalis</i> L.F.c	10.20 ⁰⁰⁽⁰⁾	21.9	48.3 ⁻	51.45 ^x	29.7
27	<i>C. officinalis</i> L.D.d	13.25 ⁻	45.4	48.3 ⁻	71.24 ^{xxx}	14.0
28	<i>C. officinalis</i> L.D.e	11.60 ⁻	41.6	41.7 ⁻	31.72 ⁰⁰⁰	32.0
29	<i>C. officinalis</i> L.PL	8.74 ⁰	74.2	33.3 ⁻	43.85 ⁻	41.4
30	<i>C. officinalis</i> L.D.f	16.83 ^(x)	46.1	48.3 ⁻	46.87 ⁻	35.6
31	<i>C. officinalis</i> D.g	10.93 ⁻	33.2	50.0 ⁻	47.67 ⁻	38.5
32	<i>C. officinalis</i> I	8.60 ⁰⁰	54.4	37.8 ⁻	35.85 ⁰⁰	32.0
33	<i>C. officinalis</i> D.h	10.84 ⁻	59.8	18.7 ⁰⁰	29.00 ⁰⁰	49.5
34	cv. Prycosnovjenie	7.15 ⁰⁰⁰	65.7	17.1 ⁰⁰	38.88 ⁻	27.2
35	cv. Pacific Beauty	10.61 ⁻	46.3	40.0 ⁻	40.00 ⁻	46.9
36	cv. Gaicha Gril	9.70 ⁻	53.2	26.7 ⁰	43.16 ⁻	34.7
37	cv. Fiesta Hitana	9.41 ⁰⁰⁰	30.6	46.7 ⁻	28.79 ⁰⁰⁰	34.5
38	cv. Zelenoye Serdtse	9.93 ⁻	55.8	23.3 ⁰	31.57 ⁰	53.2
39	cv. Rozovyi Sjurpriz	8.59 ⁰⁰⁰	42.7	23.3 ⁰	22.00 ⁰⁰⁰	61.7
40	<i>C. alata</i> UK	21.06 ^{xxx}	34.0	31.1 ⁻	62.40 ^x	17.1
41	<i>C. suffruticosa</i>	19.12 ^{xxx}	32.5	33.3 ⁻	60.60 ⁻	27.3
42	<i>C. officinalis</i> A	10.18 ⁻	46.0	53.3 ⁻	29.44 ⁰⁰⁰	34.8
43	cv. Pacific	9.20 ⁰⁰	39.2	36.7 ⁻	55.91 ^x	24.9
44	cv. Plamen	8.19 ⁰⁰⁰	42.4	40.0 ⁻	26.00 ⁰⁰⁰	66.7
45	<i>C. officinalis</i> AZ	9.39 ⁰⁰⁰	29.8	30.0 ⁻	44.11 ⁻	34.2
Mean of experiment(Control)		12.27	42.6	49.8	45.63	32.8

Heavier seeds were obtained at 123GEHortus Hudae, 121GE2822-0001, *C. officinalis* L.D.a, *C. officinalis* F.a, Bon-Bon Orange, *C. officinalis* UK, *C. officinalis* L.F.b, cv. Pacific-Riesen, *C. officinalis* L.D.f, *C. suffruticosa*, *C. alata* UK, with superior differences, and statistically assured related to the average of the experiment. The highest percent of seed emergence was recorded at *C. officinalis* L.D.a with the value of 78.3%, *C. officinalis* L.B with 78.0% and *C. officinalis* L.F.a, *C. officinalis* L.F.b with 76.7%.

The plant height oscillated between 22.00 cm (cv. Rozovyi Sjurpriz) and 84.06 (*C. tripterocarpa* Rupr.), the average height of the plants for experiment being 45.63 cm.

Table 2

Results obtained for important decorative traits analyzed at *Calendula* genotypes

No.	Genotype	No. of stems		No. of flowers		No. of petals	
		No	CV%	No	CV%	No	CV%
1	122GE 2822-0002	11.41 ^{xxx}	23.0	12.18 ^{ooo}	51.6	30.26 ^{ooo}	13.4
2	123GE Hortus Hudae	9.33 ⁻	20.5	7.07 ^{ooo}	45.2	35.40 ^{ooo}	32.7
3	121GE2822-0001	10.37 ^{xxx}	22.9	20.60 ⁻	52.2	20.37 ^{ooo}	18.4
4	124GE2822-04	4.85 ^{ooo}	17.8	11.70 ^{ooo}	27.7	21.63 ^{ooo}	17.4
5	<i>C. officinalis</i> L.D.a	16.38 ^{xxx}	41.0	7.43 ^{ooo}	66.7	28.66 ^{ooo}	43.7
6	<i>C. officinalis</i> L.B	3.89 ^{ooo}	69.9	4.06 ^{ooo}	106.1	25.11 ^{ooo}	66.4
7	<i>C. officinalis</i> F.a	10.58 ^{xxx}	35.5	16.46 ⁻	51.0	38.17 ^{ooo}	8.0
8	<i>C. arvensis</i> F	4.59 ^{ooo}	19.0	32.24 ^{xxx}	27.5	20.06 ^{ooo}	13.9
9	<i>C. officinalis</i> SLO	8.97 ⁻	20.8	16.50 ^{ooo}	23.1	26.89 ^{ooo}	7.6
10	<i>C. arvensis</i> SLO	7.36 ^{ooo}	19.8	19.77 ⁻	28.7	15.87 ^{ooo}	7.7
11	cv. prolifera Nr. 215	5.59 ^{ooo}	22.5	5.50 ^{ooo}	51.9	42.85 ^{o(o)}	42.4
12	cv. prolifera Nr. 214	13.43 ^{xxx}	33.8	11.00 ^{ooo}	53.9	115.51 ^{xxx}	60.5
13	Bon-Bon Orange	11.95 ^{xxx}	36.6	16.83 ^{ooo}	36.5	41.66 ^{ooo}	25.8
14	Bon Bon Mix'	6.79 ⁻	57.0	2.86 ^{ooo}	71.1	97.64 ^{xx}	54.4
15	<i>C. officinalis</i> UK	4.91 ^{xxx}	56.5	2.00 ^{ooo}	86.6	19.91 ^{ooo}	79.8
16	<i>C. officinalis</i> L.D.b	10.00 ⁻	47.8	6.00 ^{ooo}	78.6	26.47 ^{ooo}	45.8
17	<i>C. officinalis</i> L.F.b	10.50 ^{xx}	40.5	16.89 ^{o(o)}	63.5	27.89 ^{ooo}	32.6
18	<i>C. officinalis</i> L.D.c	9.18 ⁻	60.7	14.53 ^{o(o)}	77.0	24.44 ^{ooo}	52.0
19	cv. Pacific-Riesen	8.11 ⁻	38.9	10.24 ^{ooo}	91.2	51.35 ⁻	105.5
20	cv. Radio	7.89 ⁻	41.9	16.08 ^{oo}	64.0	49.29 ⁻	31.6
21	cv. Rech.f.	9.45 ⁻	34.4	32.10 ^{xxx}	48.1	25.65 ^{ooo}	4.9
22	<i>C. arvensis</i> L.	8.79 ⁻	36.6	73.07 ^{xxx}	33.4	24.83 ^{ooo}	6.0
23	<i>C. stellata</i> Cav.	9.22 ⁻	33.9	83.03 ^{xxx}	32.6	25.00 ^{ooo}	5.3
24	<i>C. suffruticosa</i> Vahl.	9.31 ⁻	29.4	98.00 ^{xxx}	26.7	25.06 ^{ooo}	8.1
25	<i>C. tripterocarpa</i>	11.53 ^{xxx}	19.2	96.53 ^{xxx}	19.0	24.66 ^{ooo}	6.3
26	<i>C. officinalis</i> L.F.c	9.14 ⁻	47.8	16.86 ^o	61.2	33.00 ^{ooo}	41.4
27	<i>C. officinalis</i> L.D.d	9.10 ⁻	31.3	17.24 ^{oo}	33.8	51.69 ⁻	18.0
28	<i>C. officinalis</i> L.D.e	7.44 ⁻	53.6	26.16 ⁻	60.2	22.88 ^{ooo}	46.2
29	<i>C. officinalis</i> L.PL	7.40 ⁻	55.7	13.85 ^{ooo}	65.6	176.30 ^{xxx}	43.8
30	<i>C. officinalis</i> L.D.f	9.52 ⁻	49.1	23.52 ⁻	65.5	31.52 ^{ooo}	61.0
31	<i>C. officinalis</i> D.g	7.50 ⁻	54.0	17.07 ^o	52.8	31.90 ^{ooo}	46.5
32	<i>C. officinalis</i> I	6.85 ⁻	50.5	8.69 ^{ooo}	64.3	60.31 ⁻	33.6
33	<i>C. officinalis</i> D.h	5.50 ^o	67.8	3.50 ^{ooo}	109.5	25.33 ^{ooo}	50.8

34	cv. Prycosnovjenje	10.75 ^x	24.2	13.75 ^o	63.1	14.00 ^{ooo}	62.6
35	cv. Pacific Beauty	7.58 ⁻	56.6	10.75 ^{ooo}	56.5	82.08 ^x	58.7
36	cv. Gaicha Gril	9.19 ⁻	44.3	12.61 ^{ooo}	52.2	194.00 ^{xxx}	41.5
37	cv. Fiesta Hitana	6.29 ^o	62.8	3.43 ^{ooo}	107.1	159.57 ^{xx}	78.7
38	cv. Zelenoye Serdtse	7.29 ⁻	48.7	3.00 ^{ooo}	101.8	181.86 ^(x)	97.0
39	cv. Rozovyi Sjurpriz	5.71 ⁻	83.8	3.14 ^{ooo}	90.8	107.00 ^(x)	68.8
40	<i>C. alata</i> UK	9.80 ⁻	19.6	54.20 ^{xx(x)}	40.4	23.20 ^{ooo}	3.6
41	<i>C. suffruticosa</i>	8.60 ⁻	39.9	58.00 ^{xxx}	36.2	22.80 ^{ooo}	3.7
42	<i>C. officinalis</i> A	8.69 ⁻	62.9	18.19 ⁻	55.5	24.25 ^{ooo}	50.2
43	cv. Pacific	8.00 ⁻	31.6	10.82 ^{ooo}	58.7	60.45 ⁻	36.7
44	cv. Plamen	5.50 ^{ooo}	40.7	2.17 ^{ooo}	103.8	126.75 ^{xx}	88.6
45	<i>C. officinalis</i> AZ	9.89 ⁻	49.4	15.89 ⁻	69.0	29.89 ^{ooo}	19.5
Mean of experiment (Control)		8.54	41.2	21.46	59.2	52.08	38.7

Compared with the experimental average, related statistical data for no. of stems was observed at 17 genotypes (table 2). The lowest no. of stems was observed at *C. arvensis* F. (4.59) and the highest no. of stems was recorded at *C. officinalis* L.D.a (16.38). In all the 45 studied genotypes, the highest no. of flowers was observed at *C. suffruticosa* Valh. (98.00) and the lowest no. of flowers/plant *C. officinalis* UK of 2.00, between the two values existing a large amplitude. Regarding the no. of petals in corole, 40 genotypes were statistically related, with a limits between 14.00 (at cv. Prycosnovjenje) and 194.00 (at cv. Gaicha Gril).

It was identified different genotypes, which could be used as genitors for obtaining new cultivars by hybridization: 122GE 2822-0002, *C. officinalis* L.D.a, cv. prolifera Nr.214, Bon-Bon Orange, *C. tripterocarpa* Rupr. (for high no of steams/plant); Rech.f., *C. arvensis* L, *C. stellata* Cav. (for a high no of flowers/plant);, Cv. prolifera Nr. 214, *C. officinalis* L.PL, cv. Gaicha Gril (for high no of petals in corolla: 121GE2822-0001, cv. prolifera Nr.214, cv. Rech.f., *C. officinalis* L.D.d. (for height plants).

In the experiment, among the analyzed characteristics there were computed phenotypic correlations, majority of them being statistically assured, positive or negative (table 3).

Table 3

**Phenotypic correlation between the main characteristics analyzed
at 45 *Calendula* genotypes**

Correlated characters	Seed germination	Plant height	No. of stems	No. of flowers	No. of petals
Seed weight	0.420 ^{xxx}	0.226 ^x	0.433 ^{xxx}	0.095 ⁻	- 0.337 ^{oo(o)}
Seed germination		0.220 ^x	0.294 ^{xx}	0.115 ⁻	- 0.362 ^{ooo}
Plant height			0.377 ^{xxx}	0.689 ^{xxx}	- 0.282 ^{oo}
No. of stems				0.234 ^x	- 0.156 ⁻
No. of flowers					- 0.325 ^{oo}

$r\ 5\% = 0.205$; $r\ 1\% = 0.267$; $r\ 0.1\% = 0.338$

Positive correlations, highly significant where identified between: seed weight and seed germination; seed weight and no. of seams; plant height and no. of steams; plant height and no. of flowers/plant. There was confirmed previous data (Baciu and Sestraș, 2008), that the seed's weight assures a better germination. The result illustrated that the seed's weight is positive correlated with the no. of steams per plant. In the experiment, no. of petals per flower was negatively correlated with the weight of seeds, seed germination, plant height and no. of flowers/plant.

CONCLUSIONS

The large variability recorded at the *Calendula* genotypes studied in the Botanical Garden of UASVM Cluj-Napoca, allowed identification of potential genitors for marigold breeding and obtaining new cultivars.

The identified correlations between different characteristics can be used as selection indices for different breeding purposes. The negative correlation between the no of petals and different plant characteristics suggests the fact that once with the rise of seed weight, germination capacity, plant height and no of flowers/plant, the no of petals in corolla is decreasing. These correlations could be an impediment in marigold breeding in order to create new cultivars with high ornamentals traits, as are many flowers per plant and with many petals per flower.

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