

## SAFFLOWER BREEDING, EVALUATION AND GENEPOOL MAINTENANCE IN THE CZECH REPUBLIC

JIŘÍ UHER, Dr. Ing., Associate professor

Mendel University of Agriculture and Forestry at Brno, Faculty of Horticulture, Lednice, the Czech Republic (EU)

### Introduction

Safflower (*Carthamus tinctorius* L.) is an ancient crop, grown for more than 3000 years as dyeing, oilseed producing, and medical plant. In last decades, this plant also establishes as a cut flower – it ranked 50th position between the most grown cut flowers and contain more than 60 ornamental varieties [24]. A longtime cultivation across millenniums in different climates with purposive selections gave birth to enormous number of landraces that differs extremely in morphological and biological characteristics. Contrary to records of gene erosion in last few decades [2, 16], the diversification of regional landraces grown in regions of S. E. Asia and N. Africa is still very large, and in collection of world genebanks have take several thousands specimens.

Large evaluation of morphological data sets in the safflower world germplasm was initiated by Ashri [2, 3]. He was evaluating habitual characters, given by height of the plant, the length, angle, and localization of branching, the leaves shape and spininess, the size and number of the flower heads. He examined the flower colour, the size of outer involucral bracts (OIB) and their spininess, and some seeds characters (number, size and oil content). Later, on the basis of these records, Ashri & al. [4] elevate detailed classificator for safflower published in IBPGR (now Bioversity International), containing of phenological descriptors together with 54 morphological descriptors, and 38 descriptors for plants sensitivity against stress factors, insects, and diseases. Two years later, Vachruseva & Ivanenko [26] outgoing from valuating of middle Asia ecotypes of safflower make descriptor with 36 descriptors for morphological and yield characters, and 15 phenological descriptors. However, the practical use has shown such classificators somewhat complicated, and some later authors [6, 8, 11, 16, 18] have been working rather with their own more reduced classificators. However, simultaneously the more complex projects were proposed, mostly for phenological data [22, 25].

In the Czech Republic, ornamental and oilseed cultivars are maintained by National seed genebank at the Research Institute of Crop Production, Prague (in cooperation with MUAF Brno and RIFC Troubsko), and 37 safflower varieties or landraces have been registered by IS EVIGEZ (National programme for plant genetic resources conservation and utilization). However, the collection is ever evolved. RGZ (Czech National Board on Plant Genetic Resources) safflower classificator [10] consisting of 54 morphological, phenological, and biochemical descriptors, was proposed in the project that take in the account all publications mentioned above, and bring ability for safflower evaluation in the spectre which can be used for evaluation both ornamental and technical advantages of the safflower varieties.

### Objects and methods of investigation

A germplasm collection of safflower, containing 48 ornamental and 20 oilseed varieties, and 72 landraces (Table 1) has been evaluated in the 1994-2006 for 30 morphological characters on the basis of RGZ safflower classificator [10] and, before composition of this, on the modified IPGRI descriptors. Seeds were sown on rows spaced 0.4 m into sandy-loam soil, in the 18th to 22th week, at Lednice (climatic conditions of the Pannonian thermophyticum). The seed quantity (6 g achenes for 2 square meters) agrees with 120 plants for this area, approximately. Recorded data were tested for character correlations, and for selection of the plants for breeding.

Table 1  
Commercial varieties, and denominated landraces under evaluation

Variety / landrace	Origin	Variety / landrace	Origin
AC Stirling	Canada	Orangenköpfchen	Germany
AC-1	Canada	Orange Grenade	Netherlands
Alarosa	Spain	Orange Pinsel	Switzerland
Alba	Netherlands	Oranjegeel	Netherlands
Alcaidia	Spain	Oranžový	Czech
Brněnka	Czech	Sabina	Czech
Cremewit	Netherlands	Saffola 317	Spain
C/W 74	U.S.A.	Sepassa P202	Spain
Červená SEVA	Czech	SM 8	Spain
Donkeroranje Select	Netherlands	SM 9	Spain
Draa Basse Tige	Morocco	Sophia	Netherlands
Draa Haute Tige	Morocco	Sironaria	U.S.A.
Duhuanghonghua	China	Selektion Gelb	Germany
ESPO S&G 101	Netherlands	Selektion Weiss	Germany
ESPO S&G 103	Netherlands	Summersun	Germany
Feuerschopf	Germany	S-8 Select R.A.	Morocco
Finch	U.S.A.	Tachenghonghua	China
Girard	Canada	Tanegashima	Japan
Gladki Borowski	Poland	Tangerine	Netherlands
Goldköpfchen	Germany	Taškentskij 51	Russia
Goldschopf	Germany	Toupet Jaune	Switzerland
Inerme du Draa	Morocco	Toupet Orange	Switzerland
Inerme du Marrakech	Morocco	Treibgelb	Germany
Inerme R.A.	Morocco	Treibgold	Germany
Ingrid	Netherlands	Treiborange	Germany
Kanagawa	Japan	Treibweiss	Germany
Kinko	Japan	Vierka	Czech
Lasting Orange	Netherlands	Vogro	Netherlands
Lasting White	Netherlands	Wakayama	Japan
Lasting Yellow	Netherlands	Weishanhonghua	China
Lesaf 34 C	Canada	Weisser Pinsel	Germany
Miljutinskij 114	Russia	White Grenade	Netherlands
Mlochowski	Poland	Xiapuhonghua	China
Montola 2000	Canada	Xinjianghonghua	China
Mogami	Japan	Yangbihonghua	China
Morlin	Canada	Yellow Grenade	Netherlands
Moyen du Draa	Morocco	Zanzibar	Netherlands
Nebraska 8	U.S.A.	Zitronenköpfchen	Germany
Orangefeuer	Germany	Žlutá SEVA	Czech

### Results and discussion

Data for commercial varieties have been discussed earlier [23]: high-rated characters like spinnines absence, appressed branching or vermillion-red flower colour, are linked with the plant height, and the late flowering. Height of plants and branch number, even thought genetically determined, was consistently with a number of records [1, 7, 9, 19, 20] affected with the plant density date of sowing, and number of factors climatic or edafic. The branch number fluctuated dependently on the environmental factors, but there was find correlations between plant height, branch length, spines colour, and earliness of flowering. However, Ashri [2] don't confirm the correlations between branch length, plant height and earliness of flowering, and other authors [16,

18] do not find any correlations between height of the plant and number of flowers; and even, Khidir [12] find a negative correlations. The appressed branching, highly rated by growers, was recorded in two samples. This character is unusual in safflower, and is associated with ideotype for areas where water deficit is no restrictive factor for increasing of plant density, as one of the determinative harvest component [15]. For greenhouse cut-flower culture, however, both of those samples were too late blooming, and again, no such early landraces have been found between hundreds of Iranian, and Chinese genotypes by other authors [16].

High genotypes either incline to other high-rate characters like large flower heads, round involucral bracts, and suppression of spininess. Excepting of spininess character, only Khidir [121] come to like results; Mehtre & al. [18] do not confirm such relationships, and Ashri & al. [5] find them in the Indian samples only. Leaf spininess seems to be linked with increasing bracts length. According to results published by Kupcov [14], Knowles [13], and Ahri [2], in early growth stages remain leaves spineless in all genotypes, whereas number and length of spines have increasing tendency toward the plant apex. Number and size of leaves were not exactly examined, but at soils on different water capacity, differences in leaf number and size were apparent. Salera [20] find leaf size increasing with extending the row spaces. Kupcov [14] and Li & al. [16] find the leaf size also of genetic dependence.

The flower colour seems to be closely associated with OIB morphology and plant spininess (Tabl. 2, Tabl. 3). Generally, strongly spiny varieties are having the florets yellow, on the inert lines was flowers orange or vermillion-red.

Table 2  
**Correlations of the OIB characters with other characters under evaluation**

Characteristic	OIB morphology	OIB size	OIB spininess	Spines localization	Spines color
leaf shape	-0,392**	0,236*	0,460**	0,473**	0,337**
leaf margin	-0,441**	0,301**	0,808**	0,410**	0,165
leaf spininess	-0,619**	0,494**	0,926**	0,661**	0,390**
head shape	0,087	0,043	-0,136	-0,207*	-0,291*
head size	0,239*	-0,063	-0,395**	-0,297**	-0,055
OIB morphology		-0,626**	-0,639**	-0,497**	-0,406**
OIB size	-0,626**		0,513**	0,543**	0,470**
OIB spininess	-0,639**	0,513**		0,644**	0,354**
spines localization	-0,497**	0,543**	0,664**		0,651**
spines color	-0,406**	0,470**	0,354**	0,651**	
fresh flower color	0,407**	-0,297**	-0,373**	-0,355**	-0,315**
dried flower color	0,343**	-0,287**	-0,220*	-0,319**	-0,248*
pollen production	-0,041	0,057	0,076	-0,182	-0,061
flower tube length	0,030	-0,217*	0,228*	-0,393**	-0,435**
petal notching	0,398**	-0,358**	-0,230*	-0,394**	0,335**
plant height	0,493**	-0,473**	-0,323**	-0,632**	-0,669**
branching position	-0,089	0,135	0,103	-0,050	-0,118
branch angle	-0,254*	0,137	0,174	0,131	0,199
branch length	0,015	0,040	0,020	-0,115	-0,225*
branch number	0,248*	-0,256*	-0,049	-0,394**	-0,416**

There are not discovered the totally spineless yellow varieties in evaluation (one with notably suppressed spininess was selected for breeding of ornamental variety 'Brněnka', registered by MUAF in the 1998), whereas strongly spiny genotypes with the deep orange flowers are more usual, and also the earlier authors [13, 16, 21] mentioned them frequently. All the white flowered strains belongs to relatively uniform group of early, weakly spiny genotypes, although Kupcov [14] and Knowles [13] reported about strongly spiny and spineless white-flowered varieties as well, and

Li & al. [16] find out the most of white flowered landraces to showing a strongly spininess. The vermillion-red flowers have been found in two nearly spineless genotypes only. One of them, a highly heterogeneous Iranian race from IPK Gatersleben, was selected for bulk-method breeding of the medium-early variety 'Vierka' for dried flower production. The infrequent find red flowers also Ashri [3] in germplasm collection containing nearly 2000 lines originating from all the safflower growing areas in the world. However, high ratio of red flowering landraces was recorded by Li & al. [16] in their collections from Afghanistan, Iran, Israel, Egypt, Ethiopia and China.

Table 3  
**Correlations of the flower characters with other characters under evaluation**

Characteristic	Fresh.flower color	Dried flower color	Pollen production	Flower tube length	Petal notching
leaf shape	-0,323**	-0,258*	0,034	-0,037	-0,236*
leaf margin	-0,210*	-0,050	0,022	0,290*	-0,099
leaf spininess	-0,364**	-0,195	0,042	0,182	-0,265*
head shape	0,268**	0,299**	-0,205*	0,187	0,292**
head size	0,285**	0,232*	0,016	-0,221*	0,129
OIB morphology	0,407**	0,343**	-0,041	0,030	0,398**
OIB size	-0,298**	-0,286**	0,057	-0,217*	-0,358**
OIB spininess	-0,373**	-0,220*	0,072	0,228*	-0,230*
spines localization	-0,355**	-0,319**	-0,181	-0,393**	-0,394**
spines color	-0,315**	-0,248*	-0,061	-0,435**	-0,335**
fresh flower color		0,811**	-0,252*	0,156	0,348**
dried flower color	0,811**		-0,102	0,237*	0,334**
pollen production	-0,252*	-0,102		-0,115	0,077
flower tube length	0,156	0,237*	-0,115		0,242*
petal notching	0,348**	0,334**	0,077	0,242*	
plant height	0,384**	0,383**	0,036	0,499**	0,545**
branching position	0,076	0,075	-0,022	0,333**	0,065
branch angle	-0,117	-0,194	-0,111	-0,010	-0,207*
branch length	0,145	0,118	-0,119	0,311**	0,057
branch number	0,197	0,195	-0,021	0,656**	0,286**

$\alpha = 0.01: 0.267^{**}$ ;  $\alpha = 0.05: 0.205^*$

#### Acknowledgement

Seeds for evaluation were provided by seed companies Benary (Hannover-Münden, D), Walz Samen (Stuttgart, D), Hans Meisert Samenzucht (Hannover-Buchholz, D), Kieft Bloemzamen (Venhuizen, NL), Hammer Bloemzaden (Zwijndrecht, NL), Leen de Mos Bloemzaden (s'Gravenvoerde, NL), Wyss Samen & Pflanzen (Zuchwil-Solothurn, H), Petunia Černý (Jaroměř, CZ), Seva Valtice (CZ), and by genebanks of VÚRV Piešt'any (SK), Research St. Agriculture Canada (Lethbridge, Canada), and IPK Gatersleben (D). Other samples were given by Institute of Botany CAS (Beijing, China) and Medicinal Plant Research Station (Tsukuba, Japan). The evaluation proceed by support of Mze ČR E - 97/01 - 3160 - 0200 and MSM 435100002 MŠMT ČR projects.

#### References

1. Abel G.H. Effects of irrigation regimes, planting dates, nitrogen levels, and row spacing on safflower cultivars // Agronomy Journal. – 1976. – V. 68, N 3. – P. 448-452.
2. Ashri A. Divergence and evolution in the safflower genus, *Carthamus* L. // Final Research Report P.L. 480, U.S.D.A. Project No.A10-CR-18, Grant FG-IS-234. – The Hebrew University of Jerusalem, Rehovot, 1973. – 180 p.

3. Ashri A. Evaluation of the germplasm collection of safflower, *Carthamus tinctorius* L.
5. Distribution and regional divergence for morphological characters // Euphytica. – 1975. – V. 24, № 3. – P. 651-659.
4. Safflower descriptors / Ashri A., Anishetty N.M., Bozzini A., Davis A.M., Heaton T.C., Klisiewicz J.M., Knowles P.F., Rajan S., Singh R.B., Yu S.X. – IBPGR: Rome, 1983. – 22 p.
5. Ashri A., Urie A.L., Zimmer D.E. Evaluation of the germplasm collection of safflower, *Carthamus tinctorius* L. 7. Variability of capitulum width and outer involucral bracts dimensions // Euphytica. – 1976. – V. 25, № 1. – P. 225-229.
6. Evaluation of safflower germplasm for ornamental use / Bradley V.L., Guenthner R.L., Johnson R.C., Hannan R.M. // Perspectives on new crops and new uses. Jannick J. (ed.) – ASHS Press: Alexandria: VA, 1999. – P. 433-435.
7. Esenval E. The effect of phosphorus, nitrogen, and row-spacing on the yield and some plant characters of the safflower (*Carthamus tinctorius* L.) // Sesame and Safflower Newsletter. – 1986. – V. 2. – P. 96-98.
8. Gutierrez-Más J.C., Visglerio G.G., Mérida-Silva J. Identification de cultivares de cartamo, *Carthamus tinctorius* L.: Importancia taxonomica de caracteres // Information Tecnica Economica Agraria. – 1987. – V. 69. – P. 76-85.
9. Hiremath S.M., Chittapur B.M., Hosmani N.M. Effect of population and plan-ting geometry on the seed yield of late sown safflower under rainfed condition // Karnataka Journal of Agricultural Sciences. – 1993. – V. 6, № 3. – P. 294-296.
10. Hofbauer J., Uher J., Faberova I. Klasifikator (descriptor list) *Carthamus tinctorius* L. – Genetické zdroje 74: RGZ: VURV Praha, 2001. – 8 p.
11. Jaradat A.A., Shahid M. Patterns of phenotypic variation in a germplasm collection of *Carthamus tinctorius* L. from the Middle East // Genetic Resources and Crop Evolution. – 2007. – V. 53. – P. 225-296.
12. Khidir M.O. Genetic variability and interrelationship of some quantitative characters in safflower // Journal of Agricultural Sciences. – 1974. – V. 83, № 3. – P. 197-202.
13. Knowles P.F. Centers of plant diversity and conservation of crop germplasm safflower // Economic Botany. – 1969. – V. 23, № 5. – P. 324-329.
14. Kupcov A.I. Geograficheskaya izmenchivost vida *Carthamus tinctorius* L. // Trudy po priklad. botanike, genetike i selekcii. – 1932. – V. 9, № 1. – P. 99-181. (in Russian)
15. Leon R., Knowles P.F. Inheritance of apressed branching in safflower // Crop Science. – 1964. – V. 4, № 3. – P. 441.
16. Li D.J., Zhou M.D., Ramanatha-Rao V. Characterization and evaluation of safflower germplasm – Geological Publishing House: Beijing, 1993. – 260 p.
17. Li D.J., Mündel H.H. Safflower. *Carthamus tinctorius* L. Promoting the conservation and use of underutilized and neglected crops. 7. – IPK Gatersleben: IPGRI Rome, 1996. – 83 p.
18. Evaluation of exotic safflower germplasm collected in China for agromorphological characters / Mehtre S.P., Akashe V.B., Koli B.D., Veer D.M., Patil M.V.V. // Sesame and Safflower Newsletter. – 1995. – V. 10. – P. 79-84.
19. Nasr G.D., Kathkuda N., Tannir L. Effects of N-fertilization and population rate-spacing on safflower yield and other characteristics // Agronomy Journal. – 1978. – V. 70, № 7-8. – P. 683-684.
20. Salera E. Influenza dell' "repoca di semina e della densità d'invesimento sulla produzione del cartamo (*Carthamus tinctorius* L.) // Agricoltura Ricerca. – 1995. – V. 160, № 4. – P. 35-42.
21. Seegeler C.J.P. Oil plants in Ethiopia, their taxonomy and agricultural significance – Central Agriculture Publishing Doc.: Wageningen, 1983. – 368 p.
22. Safflower plant development stages / Tanaka D.L., Riveland N.R., Bergman J.W., Schneiter A.A. // Proc. 4<sup>th</sup> ISC – Safflower: a multipurpose species with unexploited potential and world adaptability. Corleto A., Mündel H.-H. (eds.). – Adriatica Editrice: Bari, 1997. – P. 179-

180.

23. Uher J. Comparison of safflower varieties (*Carthamus tinctorius*) in view of floricultural utilization // Zahrádnictví. – 1995. – V. 22, № 3. – P. 89-94.
24. Uher J. Safflower in world floriculture: a review // Sesame and Safflower Newsletter. – 2005. – V. 4, № 3. – P. 76-80.
25. Uslu N. Description of development stages in safflower plant // Proc. 4<sup>th</sup> ISC: Safflower: a multipurpose sp. with unexploited potential and world adaptability. Corleto A., Mündel H.-H. (eds.). – Adriatica Editrice: Bari, 1997. – P. 248-251.
26. Vakhrusheva T.E., Ivanenko E.N. Klassifikator vida *Carthamus tinctorius* L. (Saflor krasilnyj). – NIIR imeni N.I. Vavilova: Leningrad, 1985. – 16 p. (in Russian)

## **СПОНТАННАЯ МУТАЦИОННАЯ ИЗМЕНЧИВОСТЬ КОЛИЧЕСТВЕННЫХ ПРИЗНАКОВ И ЕЁ ГЕНЕТИЧЕСКИЕ АСПЕКТЫ НА ПРИМЕРЕ МАХРОВОСТИ ЦВЕТКОВ РОЗ**

К.И. ЗЫКОВ, кандидат технических наук;

З.К. КЛИМЕНКО, доктор биологических наук

Никитский ботанический сад – Национальный научный центр

### **Введение**

Махровость цветков роз, т.е. количество лепестков в них, является одним из важных декоративных признаков садовых роз, знание закономерностей мутационной изменчивости которых необходимо при их селекции. Ранее [2] на примере двух признаков (размера и интенсивности антоцианового окрашивания цветков) было установлено, что их мутационная изменчивость может быть преимущественно направленной в сторону повышения или понижения количественной выраженности этих признаков. Первое часто наблюдается у исходных сортов, генеалогически близких к мелкоцветковым дикорастущим видам или имеющим ациановые (не содержащие антоцианов) цветки, а также у сортов, трансгрессивно унаследовавших пониженную выраженность указанных признаков, второе – у современных, значительно удалённых от указанных видов («эволюционно продвинутых») крупноцветковых или интенсивно антоцианово окрашенных сортов, а также у трансгрессивно унаследовавших повышенную выраженность этих признаков. То, что касается трансгрессивного наследования, справедливо также и для признака “интенсивность аромата цветков”, исследовавшегося нами ранее [2].

Нами [2] на основании данных по трём указанным выше признакам предложена гипотеза, объясняющая изменение количественных признаков у естественных почковых мутантов (спортив) инактивированием или элиминированием вследствие мутаций доминантных аллелей двух систем аддитивных полимерных генов, первые из которых ( $\Sigma M_i$ ) способствуют, а вторые ( $\Sigma E_i$ ), наоборот, препятствуют фенотипическому проявлению количественных признаков. При повреждении первых из них (доминантных аллелей) выраженность признака снижается, а при повреждении вторых, наоборот, повышается.

Если  $k$  – количество активных генов  $M_i$  в генотипе исходной формы, а  $l$  – количество таких же генов  $E_i$ , то возможны три типа исходных сортов:  $k$  приблизительно равно  $l$  ( $k \approx l$ ),  $k$  значительно больше  $l$  ( $k >> l$ ) и  $k$  значительно меньше  $l$  ( $k << l$ ). Чем больше генов  $M_i$  и  $E_i$  в генотипе, тем большее вероятность того, что какой-либо из них будет инактивирован (частично или полностью) вследствие мутаций, поэтому количественная выраженность признаков у спортив по сравнению с исходной должна изменяться преимущественно в сторону ослабления (при  $k >> l$ ), усиления (при  $k << l$ ) или с равной вероятностью в обоих направлениях (при  $k \approx l$ ).