ACTA AGRONOMICA ÓVÁRIENSIS

VOLUME 55. NUMBER 1.

Mosonmagyaróvár
2013

UNIVERSITY OF WEST HUNGARY
Faculty of Agricultural and Food Sciences
Mosonmagyaróvár
Hungary

NYUGAT-MAGYARORSZÁGI EGYETEM
Mosonmagyaróvári
Mezőgazdaság- és Élelmiszertudományi Kar
Közleményei

Volume 55. Number 1.

Mosonmagyaróvár
2013

Address of editorial office/A szerkesztőség címe
H-9201 Mosonmagyaróvár, Vár 2.

Publisher/Kiadja
University of West Hungary Press/Nyugat-magyarországi Egyetem Kiadó
9400 Sopron, Bajcsy-Zsilinszky u. 4.

Review – Szemle

Distribution, utilization and cropping possibilities of *Euphorbia lagascae*

RICHÁRD GAÁL – ÁKOS MÁTHÉ – ÁDÁM SZŰCS – VIKTOR JÓZSEF VOJNICH

University of West Hungary
Faculty of Agricultural and Food Sciences
Institute of Environmental Sciences
Mosonmagyaróvár

SUMMARY

Euphorbia lagascae Spreng. is an annual spurge native to south-eastern Spain and Sardinia. The species is characterized by its valuable seed oil content (48–52%) consisting of about 58–62% cis-12,13-epoxyoleic acid, also called vernolic acid with attractive applications for the oleochemistry. As a long-chain fatty acid, vernolic acid can have various utilizations, e.g. dyes, coatings and plasticizer-stabilizer. Polyvinyl chloride can be more resistant to degradation by temperature and light when epoxyoleic acid is used in its composition. Epoxydized oils or their esthers can also be important components of phenolic resins for the electronic industry. The seeds of *Euphorbia lagascae* are also reported to contain piceatannol (a type of phenolic compound), which can increase apoptosis in some cancer cell lines. The large-scale production of the species is hindered by severe seed shattering trait universal in wild accessions. For this reason, breeding and domestication work have been undertaken in Spain, Germany and the Netherlands in recent years.
Keywords: *Euphorbia lagascae, Euphorbiaceae,* vernolic acid, fatty acid, oilseed crop.

INTRODUCTION

Synthesis of seed oils is restricted to unsaturated fatty acids with the chain length of 18 carbon atoms, especially oleic and linoleic acids. However, some plant species are able to produce unusual fatty acids with chain length variations (short, very long, respectively), or with functional groups within the fatty acid molecule (conjugated double bonds, hydroxy or epoxy groups) (*Vogel et al.* 1993). Epoxidation is one of the most common additive reactions with double bonds of unsaturated fatty acids (*Carlson* and *Chang* 1985). So far, six different epoxy fatty acids have been found in seed oils of over 60 species of 12 plant families (*Morris* and *Wharry* 1966, *Krewson* 1968, *Earle* 1970). The majority of examined species supplied fatty acids of little value only, which could not be adapted for commercial application (*Vogel et al.* 1993). It is exclusively in *E. lagascae* and in *Bernardia pulchella* (family *Euphorbiaceae*) and several species of the genus *Vernonia* (*Vernonia galamensis* and *V. anthelmintica,* family *Asteraceae*), that vernolic acid (cis 12,13-epoxy oleic acid) was discovered in more than 50% to 79% of the seed oil (*Kleiman et al.* 1965, *Earle* 1970, *Campbell* 1981, *Perdue et al.* 1989, *Spitzer et al.* 1996).

Anti-carcinogenic characteristics of some species from the *Euphorbiaceae* family are well-known. Quercetin in *Euphorbia hirta* was found to inhibit carcinogenesis in lab animals (*Erlund* 2004). The milky latex of *Euphorbia tirucalli* contain tigliane, inganen, terpenic alcohol, taraxasterol and tirucallol (*Cataluna* and *Taxa* 1999). Piceatannol is a natural stilbene occurring in *Euphorbia lagascae.*

Euphorbia lagascae can be annual, biennial and sometimes perennial. The species has been grown for very different purposes, it can be medicinal and ornamental. It is folkloristically called ”moleplant” for its capacity to repel rodents. Vernolic acid, representing the main fatty acid of *E. lagascae* had been characterized as an isomeric compound of the ricinoleic acid (11-hydroxy monoenoic acid) (*Vidyarthi* 1940). After the isolation of ricinoleic acid, *Gunstone* proved in 1954 that vernolic acid not being a hidroxy but an epoxy fatty acid. This was the first proof of an epoxy fatty acid occurring in seed oils (*Vogel et al.* 1993). *E. lagascae* apart from *Vernonia spp.* is considered to be the most promising natural source of vernolic acid.

The oil content and the anticancer characteristics of *E. lagascae* make this species a valuable raw material for both pharmaceutical and petrochemical industry. However, the large-scale production of the species is hindered by severe seed shattering common in wild accessions. For this reason, breeding and domestication work have been undertaken in Spain, Germany and the Netherlands in recent years.

Distribution

At the time of the first botanical characterization about *E. lagascae, Sprengel* (1821) was unable to determine the region of origin. The first accurate description originates from *Nyman* (1854–1855) who stated the species to be indigenous in southern Spain (Granada, Murcia). *Willkomm* (1893) specified the provinces of Granada and Valencia as the principal distributional area in Spain (*Vogel et al.* 1993).

Today, the range of main distribution of the species covers the southeastern parts of Spain (Valencia, Murcia and Andalusia) but the herb is also present in the arid southeast and the coastal region of Cadiz (*Krewson* and *Scott* 1966, *De Bolos* and *Vigo* 1990). In Spain, the most northern distributional area of the species is Catalonia (*Rovira* 1987). *E. lagascae* is also indigenous to Sardinia (*Tutin et al.* 1968, *Pignatti* 1982) *(Figure 1.).*

Figure 1. Natural occurrence of *Euphorbia lagascae*

The species colonizes spontaneously on devastated cultivated lands and road margins with loamy soils rich in nitrogen and often of saline origin, however it avoids silicic soil types (*Krewson* and *Scott* 1966). *E. lagascae* requires specific edaphic and climatic conditions for its permanent colonization of given locations. This is particularly true for the neutral to moderately alkaline soils with mainly clayish structure as well as semiarid climates with temperate but not too cool winters. At lighter soils, water might become a growth limiting factor, since seed ripening happens to occur during the low-rainfall period of the year (*Vogel et al.* 1993). The species germinates in autumn after the first rains, flowers in March or April, and becomes ripe from April to May.

Botanical description

Taxonomy

Genus: *Euphorbia*
Family: *Euphorbiaceae*
Subfamily: *Euphorbioideae*
Tribe: *Euphorbieae*
Subtribe: *Euphorbiinae*
Taxon: *Euphorbia lagascae* Spreng.

Euphorbia lagascae Spreng. is an annual species containing 2n = 16 chromosomes (*Perry* 1943, *Singh* 1968). The species produces a central primary shoot, which can reach the height of 60–110 cm. On the base of the primary shoot, two vigorous cotyledonary shoots are connected. Leaves are inserted on the primary and the two secondary (cotyledonary) shoots. Shape of the leaves is oblong-lanceolate with a length/width ratio of 3–4:1. On the upper part of primary and cotyledonary shoots, the generative organ, called the pseudoanthium can be found, which in the genus *Euphorbia* is called cyathium. Cyathium is usually placed amongst a threefold pseudo-whorl. This whorl consists of three leaves, which extrude each one side branch. Each of these side branches bifurcate up to seven times carrying a cyathium in each bifurcation point (*Troll* and *Heidenhain* 1952). The whorl leaves of the cyathium, also called bracts, have an oval-lanceolate shape with a length/width ratio of 1–1,5:1 (*Vogel et al.* 1993). The cyathium itself is a reduced inflorescence, which resembles a solitary flower by interlacement of five bracts (whorl leaves) to form an involucrum (*Schmidt* 1907, *Weberling* 1981). Four stuffed extranuptial nectaries functioning for insect attractions can be found at the upper edge of the involucrum. In the central part of the cyathium is the female flower to be found consisting of a tripartite, uniovulate ovary. The ovary is surrounded by male flowers, (five groups with two male flowers each) each represented by one anther (*Goebel* 1931). Both male and female flowers are exempt from any perianth (*Vogel et al.* 1993)

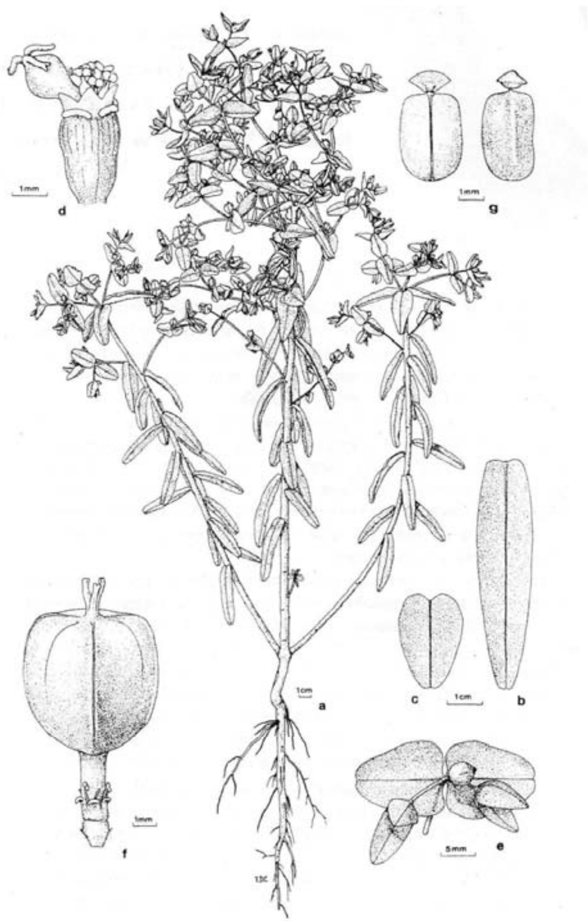
The cyathia of the genus *Euphorbia* usually behave as allogamous, but self-fertile. The stigma of the inflorescence is receptive before the pollen is viable (protogyny). According to *Bodman* (1937) the female flower of the genus *Euphorbiaceae* bend down geotropically towards the missing nectary prior to protrusion of the first anthers out of the involucrum. At the end of the flowering, the anthers fall off and the ripening capsule assumes again to a standing-up position (*Bodman* 1937)

From the ovary a tripartite capsule is developed. At ripening, each of the three carpels split up from the bottom to the tip. Consequently, the included seeds will be shot away (*Vogel et al.* 1993). *E. lagascae* possess a loculicidal capsule. The capsule wall (pericarp) in wild plants differs remarkably from the one found in indehiscent cultures. In plants growing wild, the capsule wall usually consists of three pericarp layers: the epicarp made of schlerenchyma cells, the mesocarp with a palisade parenchyma, and the endocarp with a compacted collenchyma tissue.

During ripening, tensions are obviously built up between these three tissues, which evoke an opening of the capsule. The improved indehiscent variants do not include the mesocarp layer with the palisade parenchyma. As a result, they have significantly thinner fruit wall which results in lower fruit wall weight. Consequently, in absence of the mesocarp layer such tensions are not generated, which result in capsule indehiscence (*Pascual-Villalobos et al.* 1994).

Shape of the seeds is longish and rectangular, their surface is brownish-glossy. At their upper edge, a special formation, a yellow caruncle can be found. The caruncle supports the release of the seed from the placenta giving them super-fine energy to catapult away (*Pax* and *Hoffmann* 1931). Seed composition of the species is characterized by its high seed oil content of about 48–52%, consisting of about 58–62% vernolic acid.

The morphological characteristics of *Euphorbia lagascae* Spreng. is shown by *Figure 2*.



a – whole plant, b – leaf of primary and secondary (cotyledonary) shoots, c – whorl leaf (bract) of the cyathium, d – cyathium, e – capsule with bracts, f – ripe capsule, g – seed with caruncle (front and side view)

Figure 2. Morphological characteristics of *Euphorbia lagascae* Spreng. (*Vogel et al.* 1993)

Utilization

Euphorbia lagascae has been grown for very different purposes. The seed oil is a marketable product however its industrial use is still little less known. Along with medicinal uses, studies dates back to 1976 by Nobel Prize M. Calvin suggested to use it for biofuels, oil composition of wild spurge being very close to that of diesel oil. Ten years later, *Hirsinger* (1989) corroborated this hypothesis.

Vernolic acid *(Figure 3.)* is the most important natural epoxy fatty acid in the seed oil *Euphorbia lagascae.* The oil is of significant interest in lubricant and polymer industries as a biodegradable replacement of petrochemical oils or as an oil with new properties (*Verdolini et al.* 2004). The seed oil consists of over 60% vernolic acid allowing a relatively easy recovery of this versatile starting material for the synthesis of a wide range of (fine) chemicals (*Cuperus* and *Derksen* 1996). *Cuperus* and *Derksen* (1996) examined several synthesis routes for the production of selected special chemicals in which the vernolic acid epoxy group serves as a key functionality.

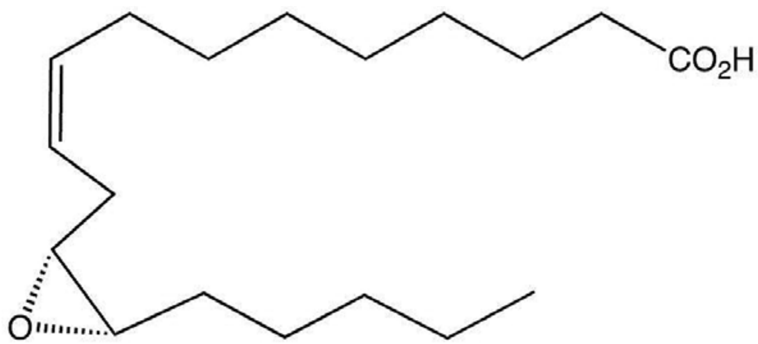


Figure 3. Structural formula of vernolic acid

Utilization in the chemical industry

Bombykol ((10E,12Z)-hexadeca-10,12-dien-1-ol) *(Figure 4.)* has been identified as a sex pheromone of the silkworm *(Bombyx mori)* and can be used in pest control. Bombykol can be synthesized starting from vernolic acid. First the epoxy group was ring-opened, resulting in a diol product.

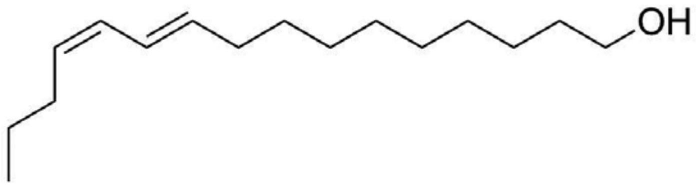


Figure 4. Structural formula of bombykol

This diol could be selectively cleaved to the aldehyde without affecting the carbon-carbon double bond and leaving hexenal as a side-product, that in itself may find useful applications in the flavor industry. Protecting the carboxylic acid group and isomerization of the double bond yielded a reactive intermediary product [12-oxo-10(E)-dodecenoic acid] which contained a carboxylic ester and also an aldehyde functionality in conjugation with the carbon-carbon double bond. Subsequent Wittig olefination reaction leads to the 10(E), 12(Z)-product, which is selectively reduced to bombykol (*Cuperus* and *Derksen* 1996).
Traumatic acid (Dodec-2-enedioic acid) *(Figure 5.)* is a wound healing agent in plants ("wound hormone") that stimulates cell division near a trauma site to form a protective callus and to heal the damaged tissue. Traumatic acid can be used as an intermediate in prostaglandine synthesis. The first part of the synthesis is identical to the synthesis of bombykol. Mild oxidation of the reactive aldehyde 12-oxo-10(E)-dodecenoic acid leads to the formation of a carboxylic acid functionality while leaving the carbon-carbon double bond unaffected. Traumatic acid can be utilized as a base for certain pharmaceuticals. (*Cuperus* and *Derksen* 1996).

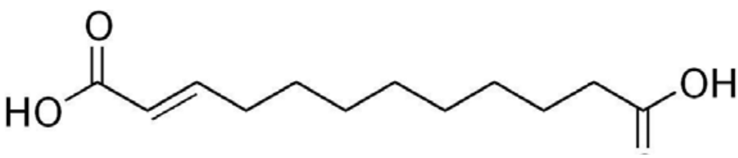


Figure 5. Structural formula of traumatic acid

Pharmaceutical utilization

Piceatannol *(Figure 6.)* is a stilbenoid, considered to be an anti-carcinogenic compound.

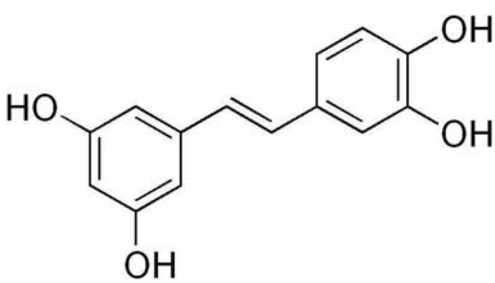


Figure 6. Structural formula of piceatannol

Duarte et al. (2008) successfully isolated piceatannol, two coumarins and two 12-deoxyphorbol diterpene esters by chromatographic methods, from the methanol extracts of the defatted seeds of *Euphorbia lagascae*. The structures of these compounds were elucidated by a combination of physical and spectral data (IR, MS and high-resolution (1)H-NMR and (13)C-NMR spectroscopy utilizing COSY, HMBC, HMQC and NOESY experiments). The stilbene, piceatannol, was screened for its antileishmanial activity against promastigotes as an extracellular form of *Leishmania donovani, Leishmania infantum* and *Leishmania major* and amastigotes of *Leishmania donovani* as an intracellular form. Piceatannol was moderately active against the extracellular forms of the three tested *Leishmania* species, and more active than the reference compound against the intracellular form of *Leishmania donovani* (*Duarte et al.* 2008)

Cropping possibilities

Domestication

First field tests were accomplished in the USA (*White* and *Wolff* 1968, *White et al.* 1971). In Europe, the first plant performance tests were performed in Göttingen in 1986. In Spain, in the Murcia region first cultivations started in 1988 to collect data for agronomical techniques and potential of *E. lagascae* for future oil crop production (*Vogel et al.* 1993). *Breemhaar* and *Bouman* (1995) performed experiments in the Netherlands on mechanical harvesting and cleaning *E. lagascae.*

Sowing and harvesting

First field trials with *E. lagascae* in the region of Murcia, Spain were meant to explore the chances of cultivation of this species over winter. Under Spanish growing conditions with winter temperatures rarely dropping below zero degree of Celsius, sowing in autumn is accomplishable. In Murcia, sowing was performed on 12^{th} of October (autumn trial), the second field experiment was sown on 3^{rd} of March (spring trial). After spring sowing, flowering started after about 90–100 days, while after autumn sowing it took almost the double time (*Vogel et al.* 1993).

In a trial conducted by *Breemhaar* and *Bouman* (1995) about one hectare of *E. lagascae* was sown on 22^{nd} of April at a rate of 12.5 kg ha^{-1}. Since the crop characteristics of Euphorbia are very similar to green peas, the trials performed in 1993 and 1994 were harvested with pea harvester type FMC 879 and FMC 979. Harvesting dates were 10^{th} and 17^{th} of August. The trial performed by Research Station for Arable Farming and Field Production of Vegetables (PAGV) showed that the most appropriate date to harvest *E. lagascae* is when the third branches start to shed their seeds (*Borm* and van *Dijk* 1993). According to *Breemhaar* and *Bouman* (1995) seed shedding occurred at the second branch, however by the second harvest date (17^{th} of August) it had just reached the third branch.

In another experiment performed by *Pascual-Villalobos et al.* (1992) 14 accessions of Euphorbia were tested in 2 locations in both autumn and spring trials. Accessions included in the autumn trial were equal to the ones used in spring trial. Sowing dates were 18^{th} of October 1990 for location 1 and 24^{th} of October 1990 for location 2. Harvesting dates were the following: spring trial was harvested in July 1990, the autumn trial of 1990 was harvested during May–June 1991.

Harvesting was performed using the following three procedures:

1. Uprooting the plants after the beginning of seed dehiscence *(Figure 7.)*
2. Drying the plants in the field using black plastic cover
3. Collecting the shattered seed from the plastic cover underneath (*Pascual-Villalobos et al.* 1992)

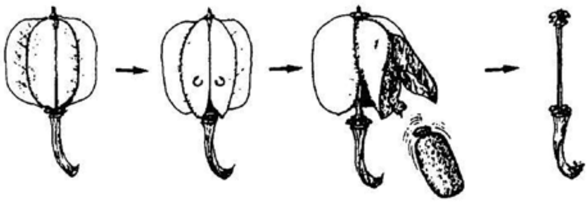


Figure 7. Process of capsule (seed) dehiscence in *E. lagascae* (*Röbbelen et al.* 1994)

According to the results of *Pascual-Villalobos et al.* (1992) the average oil content was about 44%, 63% of it was vernolic acid, however some accessions could be highlighted for having higher contents (48% and 69%, respectively). Seed yield (kg ha^{-1}) was determined upon calculating from the number of capsules m^{-2} and thousand seed weight.

Plant protection tests

The first herbicide tolerance tests were conducted in Spain at the end of 80s, as chemical weed control was felt to be compulsory before field tests. Therefore, a pre-test was accomplished under glasshouse conditions including the components described in *Table 1.*

Table 1. Test on herbicide tolerance of *Euphorbia lagascae* Spreng. (*Vogel et al.* 1993)

Herbicide	**Application**	**Rate** (kg ha^{-1})	**Crop damage***	**Weed reduction** (% of control)	**Dicot. weeds (%) dead**	**Seed yield** (rel.)
Dicuran[1]	Pre-emerg.	1.25	0	36.7	–	125
		2.5	0	71.0	–	60
		5	0	80.2	–	101
Pyramin[2]	Pre-emerg.	2	0	57.8	–	94
		4	0	86.8	–	110
		8	0	94.7	–	113
Basagran[3]	Post-emerg.	2	0	–	68.3	77
		4	0	–	90.8	86
		8	0	–	96.4	126
Goltix[4]	Post-emerg.	5	5	–	75.0	130
		10	7	–	83.3	97
		20	9	–	84.1	0
Tribunil[5]	Post-emerg.	1.5	2	–	77.8	158
		3	7	–	75.0	96
		6	7	–	88.2	95

[1] 700 g/l Chlortoluron; [2] 65% Chloridazon; [3] 480 g/l Bentazon; [4] 70% Metamitron; [5] 70% Methabenzthiazuron

* 0 = no damage; 9 = severe damage

The field test was conducted in Göttingen in 1986. The herbicides were applied at pre-emergence 2 days after sowing or at post-emergence when plants had reached 4–8 leaves. Concentrations were applied as specified by the producer and in addition with the half and double dose, respectively. Controls remained unsprayed and unweeded. As shown in *Table 1.,* Dicuran (700 g/l Chlortoluron) and Pyramin (65% Chloridazon) exerted no damage to the crop, however with 20 kg/ha Goltix (70% Metamitron) all crop plants perished (*Vogel et al.* 1993).

During another trial conducted by *Breemhaar* and *Bouman* (1995), 0.6 l Stomp (pendimethalin) and 3.2 l Propachlor (propachlor) ha^{-1} at pre-emergence were applied. Weeds were controlled mechanically with rear-mounted tractor. During flowering the crop was sprayed against botrytis with Ronilan (vinclozolin) when necessary (*Breemhaar* and *Bouman* 1995).

Diseases and pests

During the cultivations performed by *Vogel et al.* (1993) in Spain, the only disease invariably found was rust caused by *Melampsora euphorbiae* (Schub.) Castagne. Occurrence of *Melampsora euphorbiae* on *E. lagascae* has been reported for the first time by *Pascual-Villalobos* and *Jellis* (1992). The symptoms appeared first on the adaxial surface of the leaves, where the yellowish uredinia were surrounded by a chlorotic area. Under favourable conditions for disease spread, defoliation occurs and finally blackish telia appear on stems and older leaves. Chemical control was successful with spraying a 0.2% solution of Plantvax-EC (active ingredient: oxycarboxin) once a week at outburst of the disease and later every 10–12 days. *Vogel et al.* (1993) observed *Phytium ssp.* on the roots of some plants as a possible cause of the disease, however no treatment against this agent was tried out.

Among pests the following most common ones were observed: leaf bugs *(Nezara viridula),* the black bean louse *(Aphis fabae),* a green louse species of the genus Acirtosiphum (possibly *A. pisum*), and the Euphorbia moth *(Celerium euphorbiae).* Because of low grades of infestation, no treatment was applied.

Breeding trials

The major difficulty that makes this species hard to commercialize is the severe capsule dehiscence, which is a disadvantageous trait common to all accessions. That means improving this plant by breeding is inevitable. For this reason, *Pascual-Villalobos et al.* (1992) applied a useful technique called induced mutagenesis. Previously, some mutants had already been selected by *Vogel* and *Röbbelen* (1989) after chemical mutagen treatment. Non-shattering genotypes have been selected frequently as spontaneous mutants from natural populations, e.g. shattering-resistant *Lupinus luteus* (*Von Sengbusch* and *Zimmermann* 1937), *Vicia faba* (*Sirks* 1931), *Vicia sativa* (*El-Moneim* 1993) and *Onobrychis viciifolia* (*Knoll* and *Baur* 1942). Mutation breeding has been successful to induce shattering-resistant mutants of *Brassica juncea* (*Rai* 1959) and soybean (*Humphrey* 1954).

Induced mutagenesis

After choosing the appropriate accession, 500 g of ungerminated seeds were presoaked for 12 h at room temperature (20–22 °C) in a thin layer on wet filter paper. Seed lots of each 50 to 100 g were submersed in solutions of ethyl methanesulphonate or EMS ($CH_3SO_3C_2H_5$) for 2 to 6 h using a concentration between 0.4 and 1% EMS at pH 7. Seeds were thoroughly post-washed in running tap water for 12 h and surface-dried. The second mutagenic treatment was applied in essentially the same way. In both cases, controls were used, i.e. equal amounts of seeds were treated the same way except for the use of EMS (*Pascual-Villalobos et al.* 1994)

M_1 generation (the first generation after chemical treatment) was grown from treated seed in the glasshouse at Göttingen (Germany) and bulk harvested. M_2 and subsequent generations were grown in the open field at Torreblanca Experimental Station (Murcia, Spain). Screening for indehiscence was done by visual observation at ripening in M_2 and M_3 generations.

M_3 and M_4 generations were sown in the open-field in spring at Torreblanca Experimental Station two locations and two sowing dates (autumn and spring) were used (*Pascual-Villalobos et al.* (1994). *Table 2.* shows the genetic gain for indehiscence in *E. lagascae.*

Table 2. Genetic improvement in *Euphorbia lagascae* as a result of mutation breeding (*Pascual-Villalobos et al.* 1994)

Generation	**Progenies tested** (number)	**Indehiscent plants** (%)		**Indehiscent capsules per plant**[a] (%)		**Total plants scored**[b] (number)	**Plants selected** (number)
		mean	range	mean	range		
M_2	–	2.2×10^{-5}		100.0	–	45384	1
M_3	1	3.5		100.0	–	113	6[c]
M_4	6	6.5	0–17.5	100.0	–	1047	134
M_5	19	38.5	0–100	50.5	11–100	1222	128
M_6	76	52.4	0–100	77.8	7.3–100	4225	515
M_7	386	82.3	0–100	67.4	4.8–100	15795	23

[a] Only in indehiscent plants; [b] Including dehiscent and indehiscent plants; [c] Four plants from the evaluated progeny and two new unrelated indehiscent mutant phenotypes

Az *Euphorbia lagascae* elterjedése, hasznosítása és termesztési lehetőségei

GAÁL RICHÁRD – MÁTHÉ ÁKOS – SZŰCS ÁDÁM – VOJNICH VIKTOR JÓZSEF

Nyugat-magyarországi Egyetem
Mezőgazdaság- és Élelmiszertudományi Kar
Környezettudományi Intézet
Mosonmagyaróvár

Összefoglalás

Az *Euphorbia lagascae* Spreng. egy egyéves kutyatejféle, mely Délkelet-Spanyolországban és Szardínián őshonos. A faj magjának mintegy 48–52% olajtartalmára jellemző, hogy 58–62%-ban egy értékes, cisz-12,13 epoxi-olajsavat, ún. vernolsavat tartalmaz. A vernolsav a vegyipar területén széleskörű hasznosítási lehetőségekkel rendelkezik. Hosszú szénláncú zsírsavként festékek, bevonatok, lágyító-stabilizáló szerek gyártása során alkalmazható. A polivinil-klorid (PVC) ellenállóbb a hőmérséklet és fény általi degradációnak, amennyiben epoxi-olajsav szerepel az alkotórészei között. Az epoxidált olajok és észtereik fontos komponensei lehetnek az elektonikai iparban alkalmazott fenolgyantáknak is. Ismereteink szerint az *Euphorbia lagascae* magja egy értékes fenolvegyületet, piceatannolt is tartalmaz, mely néhány rákos sejtvonalnál megnövelheti az apoptózis mértékét. A bíztató eredmények ellenére a nagyüzemi termesztési lehetőségek a fajra jellemző magpergés következtében korlátok közé szorulnak. A hátrányos tulajdonság minimalizálásának céljából az utóbbi években Spanyolországban, Németországban és Hollandiában nemesítési és honosítási munka kezdődött el.
Kulcsszavak: *Euphorbia lagascae, Euphorbiaceae,* vernolsav, zsírsav, olajnövény.

Acknowledgements

The authors acknowledge the support of M. J Pascual-Villalobos.
This research was supported by the European Union and co-financed by the European Social Fund in frame of the project ”TALENTUM – Development of the complex condition framework for nursing talented students at the University of West Hungary” project ID: TÁMOP-4.2.2/B-10/1-2010-0018.

References

Bodmann, H. (1937): Zur Morphologie der Blütenstände von Euphorbia. Österr. Bot. Z. **86.,** 241–279.
Bolós, O. de – Vigo, J. (1990): Flora dels Paísos Catalans. Crucifers-Amaranthacies. Vol. **II.,** *Euphorbia lagascae,* p. 575. Editorial Barcino, Barcelona.

Borm, G. E. L. – van Dijk, N. (1993): De invloed van oogsttijdstip op oliegehalte, vetzuursamenstelling en zaadopbrengst van een zevental oliehoudende gewassen. Research Station for Arable Farming and Field Production of Vegetables (PAGV), Lelystad, Interne Mededeling 961, 35.

Breemhaar H. G. – Bouman A. (1995): Harvesting and cleaning *Euphorbia lagascae,* a new arable oilseed crop for industrial application. Industrial Crops and Products. **4.,** (3) 173–178.

Campbell, T. A. (1981): Agronomic potential of stokes aster. Amer. Oil Chem. Soc. Monograph **9.,** 287–295.

Carlson, K. D. – Chang, S. R. (1985): Chemical epoxidation of a natural unsaturated epoxy seed oil from *Vemonia galamensis* and a look at epoxy oil markets. J. Am. Oil Chem. Soc. **62.,** (5) 934–939.

Cataluna, P. – Taxa, S. M. K. (1999): The traditional use of the latex from *Euphorbia tirucalli* Linnaeus *(Euphorbiaceae)* in the treatment of cancer in South Brazil. Acta Horticulturae, **501.,** 289–296.

Cuperus, F. P. – Derksen, J. T. P. (1996). High Value-Added Applications from Vernolic Acid. In: *J. Janick* (ed.), Progress in new crops. ASHS Press, Alexandria, VA. 354–356.

Duarte, N. – Kayser, O. – Abreu, P. – Ferreira, M. J. (2008): Antileishmanial activity of piceatannol isolated from *Euphorbia lagascae* seeds. Phytotherapy Research, **22.,** (4) 455–457.

Earle, F. R. (1970): Epoxy oils from plant seeds. J. Amer. Oil Chem. Soc. **47.,** 510–513.

El-Moneim, A. (1993): Selection for non-shattering common vetch, *Vicia sativa* L. Plant Breeding, **110.,** 168–171.

Erlund, I. (2004): Review of the flavanoids quercetin, hesperetin, and naringenin. Dietary sources, bioactivities, bioavailability, and epidemiology. Nutrition Research **24.,** 851–874.

Goebel, K. (1931): Organographie der Pflanzen. 2. Erg.bd., Blütenbildung und Sprossgestaltung. Fischer Verlag, Jena.

Gunstone, F. D. (1954): Fatty acids. Part II. The nature of the oxygenated acid present in *Vernonia anthelmintica* (Willd.) seed oil. J. Chem. Soc. **II.,** 1611–1616.

Hirsinger, F. (1989): New annual oil crops. In: *Röbbelen, G. – Downey, R.K. – Ashri, A. (eds.),* Oil Crops of the World, their Breeding and Utilization. McGraw Hill, Inc., New York, USA, 518–532.

Humphrey, L. M. (1954): Effects of neutron irradiation on soybeans, II. Soybean Dig., **14.,** 18–19.

Kleiman, R. – Smith, C. R. Jr. – Yates, S. G. – Jones, Q. (1965): Search for new industrial oils, XII. Fifty-eight Euphorbiaceae oils, including one rich in vernolic acid. J. Am. Oil Chem. Soc. **42.,** 169–172.

Knoll, J. – Baur, G. (1942): Avena-Arten. In: *Roemer* and *Rudorf* (Editors), Handbuch der Pflanzenzüchtung, **III.,** Verlag Paul Parey, Berlin, pp. 405-414.

Krewson, C. F. – Scott, W. E. (1966): *Euphorbia lagascae* Spreng., an abundant source of epoxyoleic acid; seed extraction and oil composition. J. Amer. Oil Chem. Soc. **43.,** 171–174.

Krewson, C. F. (1968): Naturally occurring epoxy oils. J. Amer. Oil Chem. Soc. **45.,** 250–256.

Morris, L. J. – Wharry, D. M. (1966): Naturally occurring epoxy acids. IV. The absolute optical configuration of vernolic acid. Lipids **1.,** 41–46.

Nyman, C. F. (1854–1855): Sylloge Florae Europeae. Oerebroae.

Pascual-Villalobos, M. J. – Röbbelen, G. – Correal, E. (1994): Production and evaluation of indehiscent mutant genotypes in *Euphorbia lagascae.* Industrial Crops and Products **3.,** 129–143.

Pascual-Villalobos, M. J. – Correal, E. – Vogel, R. – Röbbelen, G. – von Witzke-Ehbrecht, S. (1992): First sources of complete seed retention in *Euphorbia lagascae* L.

Pascual-Villalobos, M. J. – Jellis, G. J. (1992): Occurrence of *Melampsora euphorbiae* on *Euphorbia lagascae* in south-east Spain. Plant Pathol. **41.,** 370–371.

Pax, F. – Hoffmann, K. (1931): Euphorbiaceae. In: *A. Engler* and *K. Prantl (eds.),* Die natürlichen Pflanzenfamilien, 19c, 11–233. Engelmann Verlag, Leipzig.

Perdue, R. E. – Jones, E. Jr. – Nyati, C. T. (1989): *Vernonia galamensis:* a promising new industrial crop for the semiarid tropics and subtropics. In: *G. E. Wickens, N. Haq* and *P. Day (editors),* New Crops for Food and Industry. Chapman and Hall, London, 197–202.

Perry, B. A. (1943): Chromosome number and phylogenetic relationships in the Euphorbiaceae. Amer. J. Bot. **30.,** 527–543.

Pignatti, S. (1982): Flora d'Italia. Edagricole, Bologna.

Rai, U. K. (1959): Thickened pods – a morphological recessive mutant in X-ray treated Brassica juncea. Sci. Cult. **24.,** 534.

Rovira, A. M. (1987): Aportations á la flore des comarques transibériques, II. Collect. Bot. (Barcelona) **17.,** 97–105.

Röbbelen G. D. – Theobald D. – Pascual-Villalobos M. J. (1994): Variability, selection and performance of *Calendula officinalis* and *Euphorbia lagascae* for industrial seed-oil uses. In: Alternative Oilseed and Fibre Crops for Cool and Wet regions of Europe. Proceedings of a workshop, 7–8 April 1994 at Wageningen, CPRO-DLO, The Netherlands, 60–73.

Schmidt, H. (1907): Über die Entwicklung der Blüten and Blütenstände von *Euphorbia* L. und *Diplocyanthium* n.g. Beih. Bot. Centralbl. **22.,** 21–69.

Singh, J. (1968): Chromosome number, chromosome doubling (*Euphorbia lagascae* S.) and some physiological studies in three Euphorbia species. Diss. Dep. Hort. Forestry, Kansas State Univ., Manhattan, Kansas.

Sirks, M. J. (1931): Beiträge zu einer genotypischen Analyse der Leckerbohne (*Vicia faba* L.). Genetica, **13.,** 210–631.

Spitzer, V. – Aitzetmüller, K. – Vosmann, K. (1996): The Seed Oil of *Bernardia pulchella (Euphorbiaceae)* – A Rich Source of Vernolic Acid. J. Am. Oil Chem. Soc. **73.,** 1733–1735.

Sprengel, K. P. J. (1821): Neue Entdeckungen im ganzen Umfang der Pflanzenkunde. **2.,** 115–116.

Troll, W. – Heidenhain, B. (1952): Studien über die Infloreszenzen von *Euphorbia cyparissias.* Ber. Dtsch. Bot. Ges. **65.,** 377–382.

Tutin, T. G. – Heywood, V. H. – Burger, N. A. – Moore, D. M. – Valentine, D. H. – Walters, S. M. – Webb, D. A. (1968): Flora Europaea. Cambridge University Press, Cambridge.

Verdolini, F. – Anconetani, A. – Laureti, D. – Pascual-Villalobos, M. J. (2004): Indehiscence Expression and Capsule Anatomy in Vernola. Crop Science, **44.,** 1291-1298.

Vidyarthi, N. L. (1940): Seed oil of *Vernonia anthelmintica.* Proc. Ind. Sci. Congress Sec. III, 79–80.

Vogel, R. – Pascual-Villalobos, M. J. – Röbbelen, G. (1993): Seed oils for new chemical applications, 1. Vernolic acid produced by *Euphorbia lagascae.* Angew. Bot. **67.,** 31–41.

Vogel, R. – Röbbelen, G. (1989): Breeding of *Euphorbia lagascae* Spreng., a possible new oil crop for industrial uses. Poster 15–4. In: Book of Poster Abstracts. Proc. 12th Congr. EUCARPIA, Göttingen, Paul Parey Sci. Publ., Berlin.

Von Sengbusch, R. – Zimmermann, K. (1937): Die Auffindung der ersten gelben und blauen Lupinen *(L. luteus* und *L. angustifolius)* mit nichtplatzenden Hülsen und die damit zusammenhängenden Probleme der Süsslupinenzüchtung, Züchter, **9.,** 57–65.

Weberling, F. (1981): Morphologie der Blüten und der Blütenstände. Ulmer Verlag, Stuttgart.

White, G. A. – Willingham, B. C. – Skrdla, W. H. – Massey, J. H. – Higgins, J. J. – Calhoun, W. – Davis, A. M. – Dolan, D. D. – Earle, F. R. (1971): Agronomic evaluation of prospective new crop species. Econ. Bot. **25.,** 22–43.

White, G. A. – Wolff, I. A. (1968): From wild plants to new crops in USA. World Crops, **6.,** 70–76.

Willkomm, M. (1893): Supplementum Prodomi Florae Hispanicae. Schweizerbart, Stuttgart.

Address of the authors – A szerzők levélcíme:

GAÁL Richárd
Nyugat-magyarországi Egyetem
Mezőgazdaság- és Élelmiszertudományi Kar
H-9200 Mosonmagyaróvár, Vár 2.
E-mail: gaal_richard@mtk.nyme.hu