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THE FIRST REPORT OF POLYCARPIC GENOTYPE IN GALBANUM (FERULA GUMMOSA) POPULATIONS

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Ferula gummosa Boiss. (galbanum) is recognized as a monocarpic species according to the available data. Following off a research on Iranian galbanum accessions diversity, we found some genotypes that are not monocarpic. The clung parts of the older roots behind the fresh roots, represented the existence of two or three generations of growth in wild populations of galbanum. These polycarpic genotypes were transferred to pots and established in greenhouse conditions. The domesticated plants showed unlimited regeneration power. About 10 to 15 lateral meristematic buds were produced on the roots of this genotype. The vegetative meristematic buds were planted on different rooting media as fine sand and soil. Also these buds were cultured on MS medium for micro propagation. Here we report the existence of polycarpy in some genotypes of galbanum for the first time. This is very important finding which can help to propagate this species with seed production limitation and consequently in conservation of species in nature.

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Key words: Polycarpic genotype; galbanum; *Ferula gummosa*; propagation; conservation

اولین گزارش از بررسی و معرفی پلی کارپی در توده های باریجه Ferula gummosa

علی عمارلو: استادیار گروه زیست فناوری پژوهشکده فناوریهای نوین زیستی دانشگاه زنجان

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اطلاعات موجود حاکی از منوکارپیک بودن گیاه دارویی- مرتعی باریجه می باشد. اما در جریان مطالعات مستمر و بررسیهای میدانی و مرتعی این گیاه در رویشگاه‌های طبیعی آن در استان زنجان، موارد نادری از صفت پلی کارپی در برخی از توده های مورد مطالعه مشاهده گردید. نمونه های یاد شده همراه با پایه های منوکارپیک، به شرایط گلدانی منتقل و به مدت پنج سال مورد بررسیهای جامع علمی قرار گرفت. نتایج و مشاهدات، بیانگر بروز صفت منحصربفرد پلی کارپی در این گونه بوده و پایه یاد شده (ژنوتیپ پلی کارپ) در بررسیهای گلخانه ای و بویژه در مطالعات کشت بافت پایداری ژنوتیپی خود را در استمرار مریستم زایی نشان داد. بر اساس آخرین اطلاعات منتشر شده ، معرفی این ژنوتیپ برای اولین بار صورت میگیرد. این یافته علمی می تواند در تسهیل تکثیر این گیاه که در حالت طبیعی با محدودیتهای بیولوژیکی خاصی مواجهه می باشد و همچنین افزایش سن بهره برداری اقتصادی از پایه های پلی کارپیک باریجه، بسیار حائز اهمیت باشد.

INTRODUCTION

There are two extremes of life-history strategies in plants and animals – semelparity (monocarpy) and iteroparity (polycarpy) (Charlesworth 1980). The semelparous species devote most of their energy and resources to maximizing the number of offspring in a single cycle of reproduction, and die soon after reproducing. Semelparity may be advantageous when

the prospects for long-term survival are low. Iteroparous species, in contrast, reproduce multiple times, a strategy that may be an advantage when prospects for long-term survival are good (Humphries and Stevens, 2001; Amasino, 2009).

The family Apiaceae includes approximately 455 genera and 3700 species (Pimenov, 2004). Of this number, 41 % are monotypic and 26 % comprise only two or three species. As a result, 67 % of all genera account for only 13 % of all species (Pimenov and Leonov, 1993; Kurzyna-Mlynik, 2008). The Asian countries with the greatest Apiaceae diversity include China, Turkey, Iran, Russia, and Kazakhstan (BİLGİLİ et al., 2016).

The genus *Ferula* L. (Apiaceae) contains about 180-185 perennial herbaceous species occurring from Central Asia, where it has its main center of endemism, westward throughout the Mediterranean region to Northern Africa and the Macaronsian region (Leonov, 2004; Sagiroglu and Duman, 2007; Dettori et al., 2016). *Ferula* is represented by 96 species in Flora of the USSR (66 endemic), 53 species in Flora Iranica (33 endemic), and 18 species in Flora of Turkey (9 endemic) (Korovin 1951; Duman and Sagiroglu 2005; Sagiroglu and Duman, 2007). With experience, most of the species of *Ferula* can be identified from flowering material (Chamberlain and Rechinger 1987). However, the delimitation of species requires examination of complete specimens with roots, stems bases, basal leaves, inflorescence, flowers, and ripe fruits, and should be based on observations of living plants (Korovin 1947). It is not surprising, that both the infrageneric classification of *Ferula* and its phylogenetic position remain disputed (Kurzyna-Młynik et al., 2008).

According to literature data, the sexual reproduction of *Ferula gummosa* is the only practical and natural way for plant reproduction. The vegetative multiplication starting from the rhizomes has not previously been reported for this species. Based on literature data, galbanum (*Ferula gummosa* Boiss.) is a monocarpic species. Following off research on Iranian galbanum cultivars diversity, we found some genotypes that are not monocarpic. The focus of this work is on the selection and introduction of a special genotype of *F. gummosa* with polycarpic characteristics.

MATERIAL AND METHODS

Study sites

Ferula species was found growing in some parts of Zanjan province especially in North (Taham-Chilandar-Chavarzagh Montaines) and Southern (Anguran) as shown in Fig. 1. The collected plant materials were identified as *F. gummosa* L.

Fig. 1. The map of studied area in Zanjan province . The habitats of *Ferula* spp., were shown with red circle.

Ecological and morphological characterization

The studies were carried out in natural habitats of Zanjan province (Fig. 2) during 2007-2017, and photographs were taken using Canon –Power shut, A810 camera. Most *F. gummosa* specimens are growing in northern and western slopes of the mountainous areas, with an altitude of about 2,500 to 3,000 m above sea level. The amount of precipitation is about 300-400 mm and more as snow. The plant starts the life cycle from late April to mid-July. The habitat soil is very light and rugged and galbanum roots can penetrate to a depth of 1 to 2 meters. More than 500 individuals in different life cycle stages were selected randomly and tagged from each population in order to observe the various morphological parameters of the species and to record the variability in floral and vegetative traits. The populations were evaluated for morphological traits like number of shoots per plant, root tuber dimensions, plant height, basal leaf length, pinnae number, pinnae length, pinnule length, number of flowering stems per plant, flowering stem length, sheath number per plant, sheath length, number of umbels, umbel diameter, the number of umbels per flowering stem, umbellules per umbel, number of flowers, fruit morphology and fruit numbers.

In vitro evaluations

Some of individuals were transferred to pots and placed in greenhouse conditions. Adapted plants were studied for morphological and biological characters including: number of basal leaves, length of branches, number of lateral buds and plant growth period. All traits were evaluated on two types of studied plants (mono and polycarpic specimens), table 1.

The vegetative meristematic buds, both in mono and polycarpic genotypes were cultivated on different rooting media as fine sand and soil. Also these asexual buds were cultured on MS medium *(*Murashige and Skoog, 1962*)* for micropropagation research.

RESULTS

Different biological growing states of *F. gummosa* are presented in Fig. 2. The monocarpic root of this plant and different parts of a root in dormant state are shown in figs. 3 & 4.

According to literature review, galbanum (*F. gummosa* Boiss.) is a monocarpic species. Based on habitats studies, the root of these monocarpic plants have one meristematic bud on root apex (Fig. 3-A). These monocarpic plants grow 5-7 years in vegetative state and then flower, produce fruit and seeds, then die off. (Fig. 4-B). But during our research on Iranian galbanum accession diversity, we found some genotypes (about 0.1 %) that were not monocarpic. The clung parts of older dead roots behind fresh root, represented existence of two or three generations of growth in galbanum wild populations (Fig. 5).

These polycarpic genotypes (figs. 6 & 7) were transferred to large pots in suitable conditions and established in greenhouse. The domesticated plants showed unlimited generations power. In addition to the main bud, about 10 to 15 lateral meristematic buds were established on the roots of this genotype. The vegetative meristematic buds were sown on different rooting media as fine sand and soil. Also these asexual buds were cultured on Murashige & Scoog (1962) medium for micro-propagation.

CONCLUSIONS

The results of our research revealed new finding on life form of *Ferula gummosa* which was previously recognized as a monocarpic plant species. We identified polycarpic genotypes. This is an important result which is very helpful in plant propagation and conservation programs for this well-known Iranian medicinal plant.

Table 1. Morphological traits of two types of galbanum. **statistically significant differences on a 99% significance level ($p = 0.01$), – statistically insignificant differences.
Significant differences between two types of studied plants were observed in length of leaves blades, number of lateral buds and plant growth period.

Evaluated traits	Monocarpic galbanum	Polycarpic galbanum	Significant based on t-test
Number of basal leaves	8	9	-
Length of blades of leaves (cm)	15	8	**
Number of lateral buds	1	10	**
Plant growth (days)	60	75	**

Fig. 2. General ontogenesis of *F. gummosa* in different biological growing stages. A, plant in vegetative state; B, flowering stage; C & D, formation of seed on flowering shoot; E, end of seasonal growing state at late of spring and seed maturation and F, a view of habitat of *Ferula* spp.

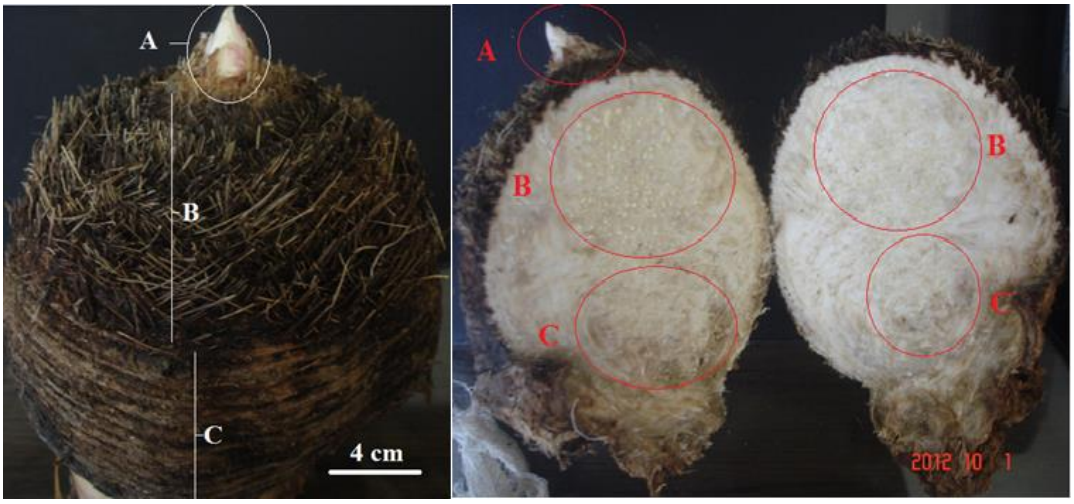

Fig. 3. The complete view of a monocarpic root of *F. gummosa* (left), A: the end meristematic part, B: the guard part of meristem with remain of leaves, C: the main body of root; and two splits of a root in right. Gum-secreting cells in the body (B) can be seen clearly.

Fig. 4. The monocarpic galbanum roots (A) and dead flowered plants after 5-7 years growth (B).

Fig. 5. A polycarpic genotype of *F. gummosa* with two (A & B) in left and three (A, B, C) generations in right. The clung parts of older roots behind fresh root, represented existence of two or three generations of growth in galbanum wild populations.

Fig. 6. Adaptation of a polycarpic galbanum to nursery condition (A). The removed galbanum plant from pot (B) and a polycarpic genotype with 10 to 15 lateral meristematic buds (C).

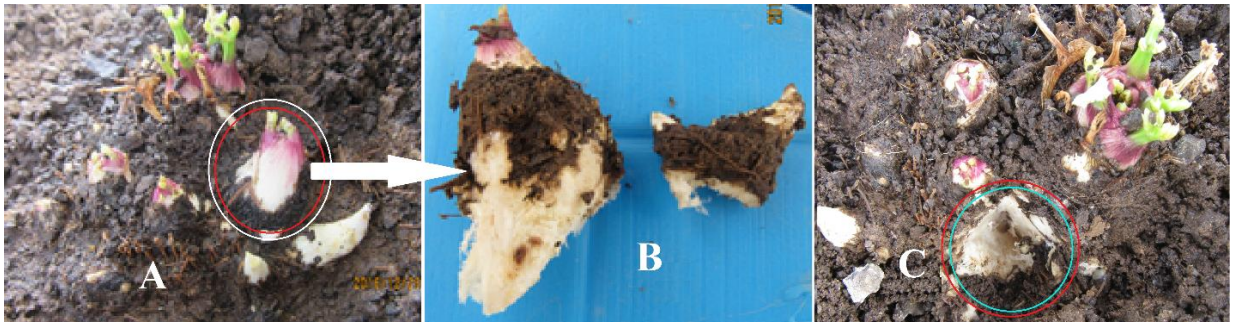

Fig. 7. A polycarpic galbanum with lateral mature meristematic bud (A), a removed lateral bud (B) and footprint of bud (C).

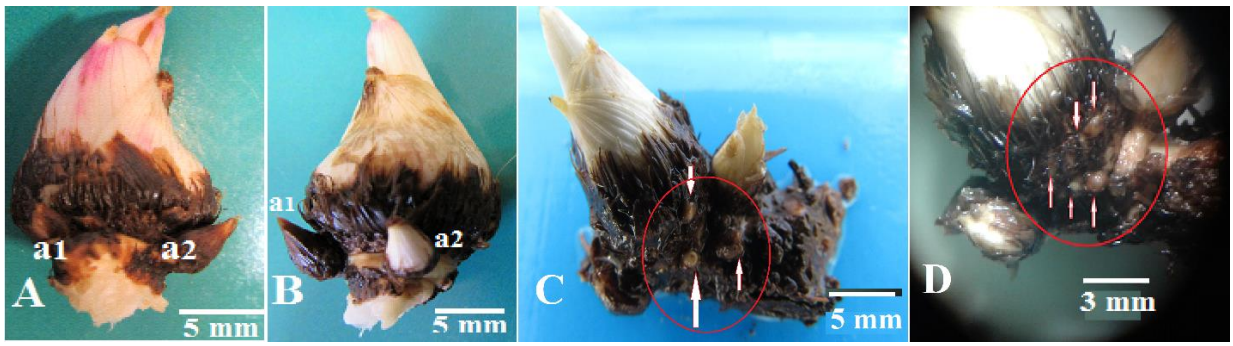

Fig. 8. Production of 2- 8 small secondary buds (a_1 & a_2) by lateral meristematic bud (A).

Fig. 9. The removed lateral bud and secondary buds (A) used for culture in soil (B), fine sand(C) and tissue culture media (D & E).

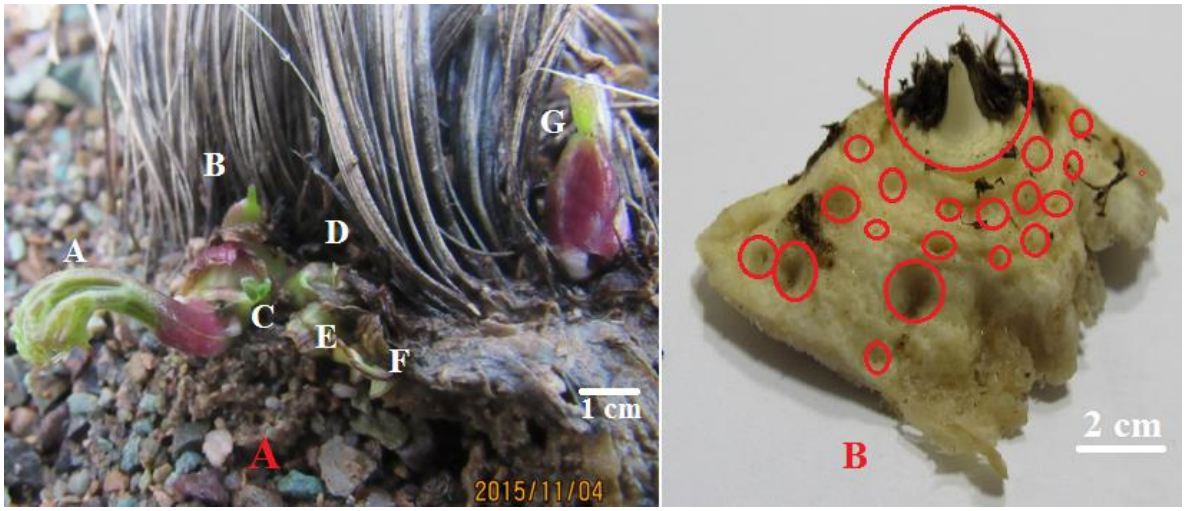

Fig. 10. The potential of production of more than 6-10 secondary lateral buds (A) and a profile of surface of a polycarpic galbanum root without epiderm that shows a main bud (large circle) and unlimited meristematic buds (small circles) (B).

Fig. 11. The polycarpic genotype with a growth of apical meristem (A) and some normal domesticated monocarpic galbanum plants in controlled conditions (B).

FUTURE WORKS

We planned to study more specimens from the different area in the distribution range of *Ferula gummosa* to identify more possible genotypes with the same potential.

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