DEVELOPMENT OF ALLIUM ASCHERSONIANUM, AN ISRAELI NATIVE SPECIES, AS A NEW ORNAMENTAL CROP

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Abstract

About 40 Allium species and cultivars are cultivated as garden and cut flowers in the Netherlands, Japan, Israel and a few other countries. Recently, the Israeli native species Allium aschersonianum, which is indigenous to the Jordan Valley and the Negev desert has shown promise for use as cut flowers and potted plants. In 1996-2000, we studied the natural life cycle of the species and developed experimental systems for its propagation. As with other geophytes, A. aschersonianum becomes reproductive after reaching a critical mass sufficient for floral development. Bulbs of A. aschersonianum initiate inflorescence during the third year of their development from seeds, but high-quality flowers can be obtained only from 3-year-old bulbs that are greater than 8/9 cm in circumference. Floral initiation occurs within the parent bulb in September, and flower formation continues for 2 months. When the bulb is planted in November, elongation of the flower scape begins after the development of 3-4 leaves and flowering occurs in January-February. We have developed systems for vegetative propagation which involve enhancing the initiation of the axillary meristems and the subsequent development of numerous daughter bulbs.

1. Introduction

There are approximately 700 Allium species, found mainly in the Northern Hemisphere (Hanelt, 1990). This highly polymorphic genus includes edible, medicinal and ornamental species. About 20 species are cultivated in the Netherlands, Japan, Israel and a few other countries for use as garden and cut flowers (De Hertogh and Zimmer, 1993). In Israel, two species - A. aflatunense and A. sphaerocephalon – are grown for cut flower production. In addition, two indigenous species – A. amapeloprasum and A. neapolitanum – have been selected from natural populations and are grown as cut flowers, and several other native Israeli species – A. nigrum, A. telavivense and A. rothii – have potential as ornamental plants. Recently, A. aschersonianum W. Barbey has shown promise as a cut flower and potted plant; it is a desert geophyte, distributed in the western Irano-Turanian region and found in Israel in the Jordan Valley, the Negev desert and the Dead Sea area (Kollmann, 1986). The adult bulb of A. aschersonianum is ovoid, the root system is ephemeroidal and superficial, and the inflorescence is spherical and many-flowered (Kollmann, 1986). Morphologically, this species is similar to the Central Asian species, which have become popular ornamental plants in Europe, and it belongs to the same subgenus, Melanocrommyum. In contrast to the Central Asian species, which require prolonged low period for optimum floral development, floral development of A. aschersonianum does not require low temperatures, and flowering occurs naturally in January-February.

Allium species, like most ornamental geophytes, are propagated vegetatively, from
axillary bulbs or bulblets on stolons, by division of rhizomes, and from topsets (Kamenetsky, 1993). The species vary in the propagation rates of their axillary daughter bulbs. Thus, commercial strains of *A. moly*, *A. rosenorum* and *A. stipitatum* produce many daughter bulbs, whereas multiplication of most wild plants (e.g. *A. oreophilum*, *A. giganteum* and *A. macleanii*) is rather low. Some species from the subgenus *Melanocrommyum* (e.g., *A. aschersonianum* and *A. rothii*) form only one renewal bulb each year to replace the parent bulb (Kamenetsky, 1993, 1994; Kamenetsky *et al.*, 2000), which makes cloning difficult.

Artificial methods of scaling and chipping have been successfully developed for the members of the *Amaryllidaceae* such as *Hippeastrum* and *Narcissus* (Hank, 1993; Sandler-Ziv *et al.*, 1997). *Allium* species can also be multiplied artificially by autumn scaling, as demonstrated for *A. cristophii* and *A. giganteum* (Alkema, 1976).

For the successful commercial cultivation of *A. aschersonianum* for flower production, in-depth studies are needed, addressing, e.g., developmental morphology and physiology, bulb propagation, and forcing requirements. In addition, selections of genotypes from natural populations must be carried out for pot plant and cut flower production.

### 2. Materials and methods

#### 2.1. Plant material

Seeds of *A. aschersonianum* were collected from the natural populations in the Jordan Valley in May 1995, 1996 and 1997, and sown in November in a net house at the Jordan Valley Experimental Station. For phenological observations and morphogenetic studies, we used 3-year-old bulbs, measuring 8-9 cm in circumference. Each year in April, after the above-ground shoots had withered, bulbs were harvested and kept under ambient conditions in a storage house. After planting in November, the bulbs were grown on raised beds in a net house at the Jordan Valley Experimental Station. Standard agricultural practices were employed throughout.

#### 2.2. Studies of the life cycle

Phenological observations of at least 50 plants were carried out every week during the seasons of active growth and once monthly during the summer. The parts of the bulbs are named according to Mann (1960). The annual life cycle was studied in the 1998/99 and 1999/00 growing seasons. Once a month, six plants were sampled at random from the stored stock or from the plants in the field, and the weights and sizes of their parts were recorded.

#### 2.3. Propagation Technique

In order to increase rate of vegetative propagation and to promote the development of several daughter bulbs from a single parent, the cutting method was used. On 25 October 1999, selected 4-year-old mother bulbs, measuring 10-11 cm in circumference, were cleaned, dried and divided vertically into four segments (chips). These bulb segments were treated for 15 min with 0.2% Benlet (Du Pont de Nemours, France) and 0.5% Marpan (Machteshim, Israel) to prevent fungal infection, placed in moist vermiculite (8-10% moisture) and incubated at 20-22°C for 5 weeks. The segments were planted in an experimental plot on 1st December and grown on raised beds with volcanic tuff in a net house at the Jordan Valley Experimental Station. Standard agricultural practices were employed throughout.
3. Observations and discussion

3.1. Growth cycle

A complete growth cycle of *Allium* species begins with seed germination, continues with a juvenile period of vegetative growth and ends in the generative period and senescence. Neither juvenile nor adult plants of *A. aschersonianum* produce daughter bulbs, and their natural reproduction occurs only by seed propagation.

The black rounded seeds of *A. aschersonianum* germinate in September-November, with emergence of the cotyledon, which pushes the embryonic rootlet downward. One to two days later, the upper part of the cotyledon develops an inverted-U shape loop which is pushed upwards through the soil surface by the elongation of the two sides of the cotyledon. Later, the epigeal part of the cotyledon remains green for several weeks without any other leaf formation. As in other *Melanocrommyum* species, this part is the sole assimilating organ during the whole season (Druselmann, 1992). At the end of the season, the storage leaves develop at the underground growing point and form a small bulb 0.5-0.7 cm in diameter at a depth of 5-20 cm. This mechanism allows rapid elongation of the subterranean part of the seedling and formation of bulblet at a depth sufficient to protect it from desiccation during the dry hot summer (Glimcher, 1951; Kamenetsky, 1994).

The juvenile stage may continue for 2-3 years (Fig. 1). During the juvenile and early adult periods, the number of leaves, the length of the floral stalk and the number of florets in the inflorescence increases (Table 1). The transition of the apical meristem to the reproductive stage may occur in bulbs as young as 2 years. However, these plants are too small to support normal bloom and, therefore, the young reproductive bud aborts inside the bulb (Kamenetsky et al., 2000). About 30% of the 3-year-old bulbs produce weak flowers, but high-quality flowering of most of the bulbs occurs in the fourth year of development from seed.

Generally, the duration of the juvenile stage of the *Allium* plant ranges from a few months to several years (Kamenetsky and Fritsch, 2001). During this phase, the leaf form changes from the thread-like cotyledon to the species-specific final form, and the size of the bulb increases. The juvenile apical meristem produces only leaves and cannot be induced to bloom (Baitulin et al., 1986; Kamenetsky, 1994). In horticultural practice, shortening the juvenile period is very important for profitable production of bulbs and cut flowers, since a long juvenile period demands several years of plant cultivation, and so increases the cost of bulb production. Further study on shortening the juvenile periods of *Allium* species, and especially that of *A. aschersonianum*, which is still propagated only from seeds, is required.

3.2. Annual life cycle and florogenesis

*A. aschersonianum* is a perennial polycarpic plant. The generative plant is sympodial and its monocarpic shoot develops once a year in the axil of the uppermost leaf (Fig. 1). The life of the monocarpic shoot lasts for 18 months and includes 12 months of intrabulb development within the parent bulb and 6 months of above-ground growth.

Morphogenesis of the monocarpic shoot begins in October-November, when two or three scale primordia are initiated in the axil of the uppermost leaf of the parent plant; and a new developing bulb replaces the parent bulb during following season (Fig. 2). In the apical meristem of the renewal bulb, initiation of leaf primordia begins in January and continues until June-July. The apical meristem becomes reproductive in August-September, and the inflorescence differentiates in October-November.

After planting, the root system elongates rapidly to 40-50 cm within 2 weeks. Leaf sprouting occurs in November, and the maximal leaf length is 35 cm. The scape appears between the leaves in February; flowering begins in February-March and lasts for about
25-30 days, while the leaves begin to dry, and wither completely during the flowering period. Seed maturation takes more than 1 month. The roots dry off in March-April, and in May-June the plant enters a "dormancy" period (Fig. 2).

In their natural habitats, the geophytes of the genus Allium are subjected to a wide range of climatic conditions. Seasonal changes in temperature and rainfall have activated various adaptation mechanisms, manifested in variations in underground organ structure, annual cycles and floral development. This process is related to the geographical spread of the genus from temperate zones to arid regions (Kamenetsky, 1992). Bulbous species of the genus are distributed mainly in areas with marked seasonal changes and have a more or less differentiated renewal bulb within which the vegetative and reproductive organs of the following season are formed (Pastor and Valdes, 1985; Kamenetsky, 1994). Like many other desert bulbous plants (Evenari and Gutterman, 1985), A. aschersonianum lacks specific xerophytic adaptations such as succulent or sclerophyllous leaves; but it successfully survives in severe conditions owing to an effective life strategy adapted to the specific environment. During a long summer "dormancy", important physiological processes occur inside the renewal bulb: the apical meristem produces leaf primordia, and floral initiation occurs in September, after the hottest period of the climatic cycle.

Further physiological studies are required to determine whether a high summer temperature is a necessary condition for flower initiation in A. aschersonianum or, on the contrary, whether florogenesis can start only when the soil cools down.

3.3. Development of the propagation techniques

Cutting of the bulbs of A. aschersonianum into four segments (chips) in October, following incubation led to intensive root elongation. Adventive roots, which had been initiated in the basal plate of the bulb during the summer, lengthened to 3-4 cm within 3 weeks and to 8-10 cm within 6 weeks. At the same time, new meristems were initiated at the basal plate, in the axils of leaf primordia (Fig. 3 a, b). After planting and following 5 months of cultivation, these meristems formed numerous axillary bulbs. Newly formed bulbs produced by one parent plant varied in number and size. Thus, after harvesting in April 2000, three to six daughter bulbs were found on one bulb segment, and they ranged from 2 to 5 cm in circumference (Fig. 3 c).

Artificial vegetative propagation by bulb cutting (chipping and twin-scaling) is a well known technique, applied to ornamental bulbs from the Liliaceae family. Here we present the possibility of using of this technique with the bulbous Allium species. It was shown in the present study that during certain stages of intrabulb floral development, the developing inflorescence may be destroyed by bulb cutting and the growth of lateral bulbs can be induced. This method, when improved, will be ecologically acceptable and useful for other ornamental bulbs with limited vegetative propagation.

4. Conclusion

The ornamental value of the most popular ornamental Allium species is based on their striking multi-flowered inflorescences (e.g., Allium giganteum, A. aflatunense and A. karataviense). A. aschersonianum, with beautiful large deep purple inflorescences, is morphologically similar to popular ornamental Alliums but, at the same time, it is naturally adapted to desert areas, with very hot summers and mild winters. Unlike Central Asian species (De Hertogh and Zimmer, 1993; Zimmer and Weckeck, 1989), A. aschersonianum does not require low temperatures for floral stalk elongation and flowering, and, therefore, can be successfully introduced into horticultural practice in warm climate zones.

The study of the growth cycle, annual life cycle and florogenesis, presented in this report, provide bases for flowering manipulations by means of variations of storage and growth temperatures. At the same time, the development of inexpensive and effective
techniques for vegetative propagation enable us to clone the outstanding types of *A. aschersonianum* and to introduce them into horticultural practice.

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**References**


Table 1. Development of *A. aschersonianum* during juvenile and early adult period

<table>
<thead>
<tr>
<th>Parameters of growth and development</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Years 5-6</th>
</tr>
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<tbody>
<tr>
<td>Number of leaves</td>
<td>1</td>
<td>1-2</td>
<td>2-4</td>
<td>4-5</td>
<td>5-6</td>
</tr>
<tr>
<td>Bulb circumference at the end of the season (cm)</td>
<td>0.5-0.7</td>
<td>4-6</td>
<td>7-10</td>
<td>9-12</td>
<td>11+</td>
</tr>
<tr>
<td>Length of floral stalk (cm)</td>
<td>-</td>
<td>-</td>
<td>15-35</td>
<td>50-70</td>
<td>60+</td>
</tr>
<tr>
<td>Number of florets in inflorescence</td>
<td>-</td>
<td>-</td>
<td>40-50</td>
<td>70-110</td>
<td>110-180</td>
</tr>
</tbody>
</table>

Fig. 1 Development of *Allium aschersonianum* during 4-years cycle from seedling to reproductive plant
Fig. 2 Annual cycle of *Allium aschersonianum*. Inner cycle presents intrabulb development of monocarpic shoot.

Fig. 3 Vegetative propagation of *Allium aschersonianum* by the cutting method:
A – Bulb segment 2 weeks after cutting. Fast development of roots and leaves is visible
B – Bulb segment 3 weeks after cutting. Plantlet, including several leaves, is developing on the basal part of the segment.
C – Formation of several daughter bulbs during cultivation