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# 'Adagio': A Slow-Bolting Arugula

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Arugula (*Eruca sativa* Mill., Brassicaceae) is a fast-growing, cool-season crop that flowers under long days and high temperature. Arugula, also known as rocket (English), roquette (French), rucola (Italian), or rughetta (Italian), is a low-growing annual with dull-green, deeply cut leaves. It contains glucosinolates, such as allyl sulfonocyanate, which give this vegetable a distinct spicy, pungent flavor. During the vegetative stage, the leaves of arugula are large and arranged in a rosette. When the plant bolts, it produces a primary stem, which then branches out into secondary and tertiary stems. Stems eventually end up on raceme-type influorescences with small, creamy white flowers. Stems produce leaves at the nodes, which become increasingly smaller from the base to the top of the stem. Leaves are parted, with two major lobes on each side and a larger lobe at the tip.

Arugula is widely cultivated and consumed in Mediterranean countries, where its pungent qualities are appreciated. In Italy, arugula is consumed alone as a salad green, as a cooked green, and is now very popular as a pizza topping (Padulosi and Pignone, 1997). Arugula is now cultivated in the United States and can be found in select supermarkets as a specialty green and in farmers' markets as part of mesculun mixes. It grows well in many U.S. growing zones and offers the possibility of long-term availability, because it is well adapted to greenhouse culture. However, early bolting is a serious impediment to production. A search for a late-bolting germplasm was carried out by Morales and Janick (2002), who studied variability in flowering from the collection of the National Plant Germplasm System of the United States and in cultivars from Italy. As a result of this study, development of a late-bolting arugula was initiated. We report the release of a late-bolting arugula derived from Italian germplasm.

## Origin

Arugula seed ('Rucola Cultivata') from Detassis Sementi (Trento, Italy) was planted in the greenhouses of the Department of Horticulture and Landscape Architecture, Purdue University, on 10 Jan. 2001 (surviving population, 1664 plants). Plants were subjected daily to 16 h of incandescent light (110–140 $mmol \cdot m^{-2} \cdot s^{-1}$) immediately after germination for 3 months. Plants were eliminated daily when flowers appeared. Nine nonflowering plants of various phenotypes were selected at the end of the experiment on 11 Apr. 2001, 91 d after planting, and were labeled 1 to 9. Plants 1 and 2 were dark green, robust, and attractive. All plants were self-pollinated (using bud pollination) and intercrossed.

Selfs and crosses were planted in the greenhouses on 6 Feb. 2002, and about 500 plants were planted in the field (Meigs Farm, near Romney, Ind.; latitude, 40.25°N) on 30 May 2002, but most of these plants died as a result of soil herbicide contamination. However, plants of the cross 1 × 2 that survived in one plot grew vigorously, were attractive, and remained vegetative until the beginning of Oct. On 2 Oct. 2002, the best five plants of this cross were transplanted into 7.6-L pots and placed in the greenhouses under a 16-h photoperiod. The plants started flowering 3 weeks after being moved to the greenhouse and were each hand pollinated with mixed pollen from the five plants. Seed was collected from each plant separately from Dec. 2002 to Feb. 2003 and was labeled Purdue 1 to Purdue 5. After trials of the five lines in Washington and Indiana in 2003, Purdue 3 was considered the most outstanding of these five lines and was named 'Adagio'. The name *Adagio*, which refers to a slow tempo in Italian, emphasizes the slow-bolting characteristic of this cultivar.

## Description

'Adagio' is a new arugula cultivar with a uniqueness that derives from slow bolting, which provides a longer vegetative growth stage and consequently higher yields for growers. 'Adagio' has large, thick, dark-green leaves with a peppery flavor, which makes it ideal for the preparation of flavorful fresh salads, alone or in a mix. Plants and flowers are shown in Fig. 1.

## Evaluation

The leaves of 'Adagio' and the original source material, 'Rucola Cultivata' from Detassis Sementi, were compared in 2003 in field trials with three replications at the Meigs


Fig. 1. Plants **(A)** and flower **(B)** of 'Adagio' arugula. Photos by Luis Felipe Purquerio, Campinas, Brazil. **(C)** Comparison of 'Adagio' (right) with 'Astro' (left) at Mount Vernon, Wash., planted 19 June 2003 and photographed 5 Aug. 2003.

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Table 1. Comparison of 'Rucola Cultivata' and 'Adagio' arugula for flowering and leaf characteristics, Romney, Ind., 2003.

| Variable | Rucola Cultivata | Adagio |
|---|---|---|
| | *29 April planting* | |
| Days to 50% flowering | 71 | 87* |
| Tip leaf lobe length (cm) | 6.3 | 9.1* |
| | 24 *June planting* | |
| Days to 50% flowering | 103 | Did not flower[z] |
| Leaf size, width (cm) | 14.9 | 13.9 |
| Length (cm) | 25.9* | 22.3 |
| Petiole length (cm) | 10.4* | 7.4 |

[z]Experiment ended 22 Oct., 120 d after planting.
*Significantly different at the 5% level.

Table 2. Number of days 4.4 °C or less, Wanatah, Ind., 2003.

| Planting date | No. of days 4.4 °C or less |
|---|---|
| 23 Mar.–20 Apr. | 41 |
| 6 Apr.–4 May | 22 |
| 20 Apr.–18 May | 15 |
| 4 May–1 June | 5 |
| 20 May–17 June | 1 |
| 3 June–1 July | 0 |
| 16 June–14 July | 0 |
| 30 June–28 July | 0 |

Farm with two planting dates 29 Apr. and 24 June (Table 1). At the first planting date, the leaf tip lobe was significantly larger in 'Adagio' compared with 'Rucola Cultivata' (9.1 cm vs. 6.3 cm), and at the later planting date the length of the entire leaf was significantly shorter in 'Adagio' than in 'Rucola Cultivata' (22.3 cm vs. 25.9 cm), as was petiole length (7.4 cm vs. 10.4 cm). On the first planting (29 Apr.), 'Rucola Cultivata' reached 50% flowering 71 d after planting whereas 'Adagio' reached 50% flowering in 87 d, more than a 2-week delay. On the second planting (24 June), 'Rucola Cultivata' reached 50% flowering 104 d after planting whereas 'Adagio' still remained vegetative at the termination of the experiment on 22 Oct., 120 d after planting.

'Adagio' (Purdue 3) was also evaluated by the Alf Christianson Seed Co. at Mount Vernon, Wash. (latitude, 48.42°N), in 2003, where the five Purdue lines and the commercial cultivar 'Astro' from Johnny's Selected Seeds were planted on 19 June 2003. By 5 Aug. 2003, 'Astro' reached full bloom whereas 'Adagio' and the other four Purdue lines remained vegetative, with no signs of bolting (Fig. 1C). Seed increases of 'Adagio' were carried out in Washington in 2003 and 2004.

To evaluate further the five Purdue lines, a date-of-planting trial was established in 2004 at the Pinney Purdue Farm in Wanatah, Ind. (latitude, 41.43°N). The unreplicated trial consisted of eight entries: five Purdue lines (1–5), 'Astro' (Johnny's Selected Seeds), 'SloBolt' (syn. 'Belarugula' from Bunton's Seeds, Louisville, Ky.), and a wild arugula, 'Rucola Selvatica' [*Diplotaxis tenuifolia* (L.) DC, obtained from Florsilva, Bologna, Italy]. There were eight dates of planting (23 Mar., 10 Apr., 20 Apr., 4 May, 20 May, 2 June, 16 June, and 30 June). Early plantings received vernalization based on the number of days of 4.4 °C or less at Wanatah (Table 2). At each planting date, seed of each entry was planted in 2-m plots and thinned to 20 plants each. Plants were evaluated for flowering at weekly intervals. The date of 50% flowering was determined by interpolation. The experiment ended 28 Sept.

The results of the experiment are presented in Table 3. The five lines (Purdue 1–5) acted similarly and thus only data from Purdue 3 ('Adagio') are presented here. 'Astro' and 'SloBolt' also behaved similarly. 'Adagio' consistently flowered later than the three other cultivars, but the difference increased with the date of planting. 'Adagio' was about 1 to 2 weeks later than 'Astro' or 'SloBolt' in early plantings. In late plantings (3 June or later), 'Adagio' did not flower by 28 Sept., when the experiment ended, whereas 'Astro' and 'SloBolt' reached 50% flowering 42 to 52 d after planting. The wild arugula responded differently. The seeds were much smaller than *E. sativa*, and the plants grew very slowly in early plantings and reached 50% flowering in 72 d at the first planting date, but flowering was faster because the planting date was delayed. The response to flowering in the wild arugula was shown to be dependent on the accumulation of growing degree days (data not presented).

The results obtained in 2004 were consistent with results obtained in 2003 and corroborate the distinctiveness of 'Adagio' as a slow-bolting cultivar. Although early plantings of 'Adagio' that receive vernalization in the field will flower in about 65 d, flowering is delayed over 'Astro' and 'SloBolt'. However, plantings of 'Adagio' beginning in June did not achieve 50% flowering in the field 90 d after planting.

Table 3. Planting date and time of bolting in arugula in Indiana, 2004.

| Planting date | Days to 50% flowering | | | | Difference between Adagio and Astro |
|---|---|---|---|---|---|
| | Adagio | Astro | SloBolt | Wild | |
| 23 Mar. | 65 | 59 | 58 | 72 | +6 |
| 10 Apr. | 59 | 51 | 53 | 63 | +8 |
| 20 Apr. | 67 | 52 | 52 | 52 | +15 |
| 4 May | 63 | 54 | 53 | 54 | +9 |
| 20 May | 58 | 46 | 48 | 44 | +12 |
| 3 June | >117[z] | 50 | 52 | 43 | >67 |
| 16 June | >104[z] | 43 | 46 | 41 | >61 |
| 30 June | >90[z] | 68 | 75 | 47 | >22 |

[z]Nonflowering. Experiment ended on 28 Sept.

## Availability

'Adagio' is protected by PVP and has been licensed to Alf Christianson Seed Company. Small seed quantities for experimental purposes can be obtained from Jules Janick.

## Literature Cited


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