The effect of establishment method and plant density on dahlia (*Dahlia* spp. Cav.) seed yield

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Abstract

The effects of two establishment methods, seedling-to-seed and tuber-to-seed, and the effects of plant density on dahlia seed yield and its components were determined for the semi-dwarf Hammett 'Figaro' Series at Palmerston North in the 1995/96 season. Seed yield did not differ between the two establishment methods, and there was no interaction between establishment method and plant density for seed yield. Of five plant densities (1.6, 2.8, 6.3, 11.1 and 25.0 plants/m^2) seed yield was significantly higher from the 6.3 and 2.8 plants/m^2 densities (12.3 and 11.3 g/m^2 respectively) for a single seed harvest when 80% of the seed heads had turned brown (ca. 50% seed moisture content), and from the 11.1 and 6.3 plants/m^2 densities (15.9 and 11.2 g/m^2 respectively), when individual seed heads were picked over several weeks as they ripened. Seed yield per plant increased as plant density decreased because of greater seed head production, but this was not sufficient to compensate for the decreasing plant numbers.

Additional key words: *seedling-to-seed, tuber-to-seed, single seed harvest, multiple-seed-harvest, seed heads per plant, seeds per seed head.*

Introduction

Garden dahlia (*Dahlia* spp. Cav.), popular as cut flowers, bedding and potted plants, can be propagated by tuber division, plant cuttings or seeds (Brondum and Heins, 1993). The choice of propagation method is dependent upon the end-use of the plants produced : where prize blooms of a named cultivar are required, then division of tubers, or cuttings taken early in the growing season are the preferred methods (Rowell, 1981; Hobbs and Hatch, 1994), particularly for double' types (Hammett, 1980); for large quantities of mixed colour bedding plants which are treated as annuals, seed is usually sown (Eliovson, 1967; Phetpradap *et al.*, 1994).

As a species, dahlia produces many problems for seed production (Still, 1988), and little is known of the effect of either establishment method or plant density on seed yield (Han, 1996). 'Seed to seed' is likely to be less expensive at establishment than 'tuber-to-seed', because of reduced labour costs, but whether seed yields are comparable is not known. Plant spacing recommendations for dahlia range from 30-90 cm (Phetpradap, 1992), due to variation in plant size, but which density or densities allow maximum seed yield for any given plant size is again unknown. The objectives of this trial were therefore to compare the effects of establishment method (tubers and transplanted seedlings) and plant density on dahlia seed yield using the semi-dwarf double Hammett 'Figaro' series.

Materials and Methods

The trial was conducted at Massey University, Palmerston North, (40° S, 170° E) on a fine sandy loam in the 1995/96 season. The site had a pH of 5.5 and Olsen P of 16, and had grown dwarf beans and maize in the previous season. It was sprayed with glufosinate-ammonium (4 litres Buster/ha) on 2 October 1995, ploughed on 11 October, and then rotary cultivated on 22 and 25 October to prepare a seedbed.

Seeds and tubers of the Hammett semi-dwarf double 'Figaro' series came from tubers (clones) originally supplied by Dr Keith Hammett and multiplied in the 1994/95 season (R.C. Southward, pers. comm.). Equal proportions of seeds from eight clones were sown into trays containing a commercial potting mix on 10 October 1995 and left in a glasshouse at ambient temperature. On 1 and 2 November seedlings were transplanted from the seedling trays to individual cell trays (4.5 cm diameter x 5 cm depth) and maintained in the glasshouse until

they were transplanted into the field on 24 November (when they were at the three pair leaf stage). As 38.4 mm of rain fell from the evening of 24 November until 27 November (Han, 1996), irrigation after transplanting was not necessary. The decision to use seedling transplants rather than direct field sown seed was because of variable germination (Han, 1996), and the need to establish precise populations. Tubers from the clones were separated so that each portion had at least one healthy, undamaged bud, and planted on 30 and 31 October.

For both establishment methods five plant spacings were used *viz* 80 x 80, 60 x 60, 40 x 40, 30 x 30 and 20 x 20 cm, which gave respectively 1.6, 2.8, 6.3, 11.1 and 25.0 plants/m^2. Plot size varied from 4 x 7.2m at the lowest density to 2 x 3.0m at the highest density, in order to provide approximately the same number of plants per treatment. Each treatment was replicated four times in a complete randomized block design. For both seedlings and tubers, the total clone pool was mixed, and seedlings and tubers planted at random with respect to clones. Extra seedlings and tubers were planted adjacent to the trial area to replace missing plants if required.

Methiocarb (8 kg product/ha) was broadcast around all plots on 3 November and again on 4 December to provide protection from slugs and snails. On 23 January 1996, fertiliser (NPK 12:10:10) was broadcast at 50 kg/ha. Weeds were controlled by hand-hoeing when required. Iprodione (1 g a.i./litre water at 4 litres/ha) was applied on 27 February to control *Botrytis* infection, and this treatment was repeated on 21 March and 20 April.

Seeds were considered ready to harvest when 80% of the seed heads had turned brown (Phetpradap *et al.*, 1994), at which time seed moisture content was around 50% (Han, 1996). Two harvest methods were employed:

1. single seed harvest - ten randomly chosen and previously identified plants per plot were cut at ground level when 80% of the seeds heads were ajudged by eye to have turned brown. Dates for this harvest were 16 April (25.0 and 11.1 plants/m^2 densities), 23 April (6.3 plants/m^2 density) and 7 May (2.8 and 1.6 plants/m^2 densities).
2. multiple seed harvest - seed heads from five randomly chosen and labelled plants in each plot were selectively hand picked when they had turned brown. Depending upon density, this harvesting began in mid-April and continued until early May.

Seed heads per plant, the number of seed heads containing one or more seeds, and seeds per seed head were determined from the ten plants per plot removed for the single seed harvest. The latter two yield components were also re-assessed for a further five plants per plot following each of the multiple seed harvests. Once removed from the plant, seed heads were ambient air dried for 21 days, then hand-threshed and weighed. The seed samples were then air-blast cleaned (Burrows Model No. 1836-4 at an air flow setting of 8.5 m^3/minute), and finally screen cleaned using a 2 mm oblong screen. Seed moisture content and thousand seed weight (TSW) were determined (ISTA, 1996), and seed yield expressed at 0% seed moisture content.

Results

Seed yield did not differ between the two establishment methods, and there was also no interaction between establishment method and plant density. Plants established from tubers had more ($P<0.05$) seed heads per plant (71.6 cf. 55.9) but a lower ($P<0.05$) TSW (5.30 g cf. 6.47 g) then those established from seedling transplants, but there were no differences in the number of seeds per seed head. The only significant interaction between establishment method and plant density was for seeds per seed head, when at the 11.1 plants/m^2 density, plants established from seedlings had more ($P<0.05$) seeds per seed head than those established from tubers.

For the single seed harvest seed yield per plant decreased as plant population increased, because seed head number, the percentage of seed heads containing seeds, seeds per seed head and TSW all decreased (Table 1). Yield/m^2 was greatest at the 6.3 plants/m^2 density, but this did not differ significantly from that at the 2.8 plants/m^2 density (Table 1). There was also no significant difference in yield/m^2 for the 1.6, 2.8 and 11.1 plants/m^2 densities, while yield did not differ between the two highest densities.

Seed yield per plant following the multiple seed harvest still declined as plant density increased (Table 2), but the yield from the two highest plant densities was approximately three times as much as it was for the single harvest. This was because the percentage of seedheads containing a seed had increased (e.g., from 45% to 60% at the 11.1 plants/m^2 density), and seeds per seed head had also increased by about one-third. The greatest seed yield/m^2 following the multiple harvest was produced at the 11.1 plants/m^2 density. Yield per m^2 at the other densities did not differ

Table 1. The effect of plant density on dahlia seed yield and its components for a single seed harvest[1].

Plant density (no./m^2)	Seed heads /plant	% effective[2] seed heads/plant	seeds/ seed head	TSW4[3] (g)	seed yield g/plant	seed yield g/m^2
1.6	110.3 a[4]	69.9	6.5 a	6.27 a	4.49 a	7.0 b
2.8	84.0 b	72.9	7.5 a	6.47 a	4.06 a	11.3 ab
6.3	40.6 c	88.2	7.9 a	6.15 a	1.97 b	12.3 a
11.1	28.1 c	45.3	4.2 b	5.00 b	0.59 c	6.6 bc
25.0	11.5 d	39.6	2.8 c	4.69 b	0.15 d	3.9 c

[1] hand harvested when 80% of heads had turned brown (ca. 50% seed moisture content)
[2] seed heads containing at least one seed
[3] thousand seed weight
[4] values with the same letter in a column do not differ significantly at P<0.05

Table 2. A comparison of dahlia seed yields from the single and multiple seed harvests (values with the same letter in a column do not differ significantly at P<0.05).

Plant density no/m^2	seed yield g/plant single	g/plant multiple	g/m^2 single	g/m^2 multiple
1.6	4.49 a	4.32 a	7.0 b	6.7 b
2.8	4.06 a	3.92 ab	11.3 ab	10.2 b
6.3	1.97 b	1.78 bc	12.3 a	11.2 ab
11.1	0.59 c	1.44 c	6.6 bc	15.9 a
25.0	0.15 d	0.39 c	3.9 c	10.0 b

significantly. The greater seed yield per plant at the two highest densities after multiple harvesting also resulted in a large increase in yield/m^2 (Table 2).

Discussion

Establishment method did not affect the seed yield of the semi-dwarf double Hammett 'Figaro' series dahlia used in this experiment, although yield components differed slightly. Even though tubers were planted 24 days earlier than seedlings, the flowering patterns for the two establishment methods were similar (Han, 1996). This result was expected, as in dahlia daylength, not plant age or size, is the factor controlling floral initiation (Mastalerz, 1976).

The choice over whether 'tuber-to-seed' or 'seed-to-seed' systems should be used therefore comes back to cost, and what difference there is in the distribution and composition of flower colours in the F2 (seed-to-seed) compared to the F1 (tuber-to-seed). Flower colour in this series ranges from white and mauve to deep red, orange and yellow, and seed yield potential is much lower in the former than the latter colours (Robert Southward, pers. comm.). Plants grown from F1 seed of the series produce flower colours which still include white and mauve, but tend to be dominated by reds and yellows. What happens to flower colour in plants grown from F2 seeds is yet to be established. For increased consistency of production with respect to flower colour, producing seed from a predetermined ratio of tubers from the clones would be the preferred option, but against this must be weighed the increased costs involved (Voigt, 1994).

Information on dahlia densities for seed production is very limited. Reilly (1978) stated that spacings from 30-90cm could be used. Phetpradap *et al.* (1994) used 30 x 30 cm spacings, but commented that growing the plants at higher density may have reduced the effects of indeterminancy (i.e., by allowing a shorter flowering period and hence a more even seed maturity). In many flower crops, similar seed yields can be obtained over a range of plant densities (Phetpradap *et al.*, 1993) but for the semi-dwarf double Hammett clones trialed, optimal densities were 40 x 40 cm/ 60 x 60 cm spacings for the single harvest, and 40 x 40 cm/ 30 x 30 cm spacings for the multiple harvest.

At the 40 x 40cm spacing nearly 90% of the seed heads contained seed, and the greatest number of seeds per seed head was recorded. As plant population increased, the number of seed heads containing seeds, and the number of seeds per seed head fell, but the reason for this was not determined. It is likely however that pollination was not as successful, as more flower heads at higher densities tend to be

hidden under the canopy, and are not as readily accessible to bees. The higher within-canopy humidities at high plant populations may also have encouraged *Botrytis* infection (Still, 1988), as even though a fungicide was applied, blackened seed heads, typical of *Botrytis* infection (Robert Southward, pers. comm.) were observed.

The two harvest methods were employed to determine whether seed yield would be lowered by a single harvest when only 80% of the seed heads had reached the ripeness stage as recommended by Phetpradap *et al.* (1994). At the three lowest densities, there was no seed yield advantage from continuous harvesting, but continuous harvesting nearly tripled seed yield at the two highest densities. However continuous hand harvesting would be the only method by which this extra yield could be realised, as delaying the timing of a single harvest would result in an increasing proportion of seed being shed from earlier maturing flowers (Phetpradap, 1992), the net result being no yield advantage. These harvest results have demonstrated that a single harvest when 80% of the seed heads have turned brown (or more accurately at ca. 50% seed moisture contact) will produce a reasonable seed yield. However, this was by hand picking. Whether combine harvesting of the dahlia seed crop is feasible is yet to be determined.

Conclusions

1. Seed yield did not differ with establishment method, so that the choice between 'seed-to-seed' or 'tuber-to-seed' is one of cost and the 'end product' requirements.
2. For the semi-dwarf double Hammett 'Figaro' series trialed, a plant spacing of 40 x 40 or 60 x 60 cm produced the greatest seed yield from a single hand harvest when 80% of the seed heads had turned brown.
3. Greater seed yields were produced from multiple hand harvesting at 30 x 30 cm and 20 x 20 cm spacings than from a single harvest, but this harvest method is unlikely to be economically practicable.

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