# Clonal Dahlia seed production

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## Abstract

Seed yield and quality information was collected from 14 clones of a Hammett double flowering semi-dwarf (0.75-1 m) bedding dahlia (*Dahlia variabilis* hort. non (Willd.) Desf.) series, in the 1994-95 season at Palmerston North. Seed yield varied widely amongst the clones and was affected more by the fecundity of disc florets than by their number. High seed production potential within this series was, therefore, likely to be maintained in clones of high bloom quality (i.e., high degree of doubleness). Clones with yellow, orange or red flowers had greater fecundity than clones with magenta, white, or pale colours. This may well reflect a fecundity-colour link related to the original hybridization of the garden dahlia from two wild species. If such a link exists then careful manipulation of clonal ratios may be required to maintain a good overall balance of colours. Maintaining seed quality required drying seed without delay, especially when seed was harvested under cooler conditions (11-16 °C). Very low levels of primary dormancy were detected (0-4 %), but half-sib seed lines germinated at a later date varied both in time to 50 % germination (over 6 days) and spread of germination (over 4 days). This could have significant implications during plant establishment under nursery conditions, and dry storage or possibly a longer period of pre-chilling is suggested to reduce this variation. This requires further evaluation.

***Additional key words:*** *dormancy, doubleness, fecundity, flower colour, seed establishment, seed quality, yield components*

## Introduction

The common garden dahlia (*Dahlia variabilis* hort. non (Willd.) Desf.) (Gatt *et al.*, 1998), is well known for its reliable, prolific, and extended flowering in a wide range of colours, sizes and forms (Huxley, 1992). Dahlias are produced commercially either by seed or stem cuttings, the latter being the most widely used (De Hertogh and Le Nard, 1993). While cuttings, being a method of asexual propagation, yield plants identical to the parent, seed produced plants will yield an almost infinite variety. The great variability in dahlia is due to the prevailing self-incompatibility (SI) which maintains in all progeny a high degree of heterozygosity. Such reproductive SI, in combination with a high percentage of heterozygosity, provides for a full exploration of the genotypic and phenotypic potential of any given breeding population in each generation (Sorenson, 1969).

A cross in New Zealand of the relatively large show dahlias with Royal Sluis dwarf 'Pink Figaro' produced the 'Figaro' series, which maintain a high quality double bloom on a more dwarf, compact plant (up to 0.6 m in height; Keith Hammett, Auckland. pers. comm., 1994), and a number of these were selected for clonal propagation. Seed-raised plants, however, belong to a different market segment. Plants are cheaper to establish and have progeny with often widely differing genotypic characteristics including flower colour. However, seed production of the 'Figaro' series is unknown and for this reason fourteen clones of the 'Figaro' Hammett semi-dwarf dahlia series were investigated for seed production potential in the 1994-95 season. Seed production and quality measurements included: observations of insect visitation, seed head fecundity, disc/ray floret ratios, seed yields, germination, viability, sprouting damage, and speed and uniformity of emergence in the glasshouse.

## Materials and Methods

### Trial 1

The initial experiment was conducted at Massey University, Palmerston North (40° S, 170° E) on a Karapoti brown sandy loam that had a pH of 5.8, an Olsen P of

63, and had grown a crop of oats previously. It was ploughed in November 1994 and rotary cultivated on 14 December 1994. Cuttings were taken weekly (7 September to 16 November 1994) from 14 'Figaro' series dahlia clones (Table 1) from tubers forced in a glasshouse (16-22 °C). These cuttings were planted in a peat:pumice (2:1 v/v) mix and provided with bottom heat (21-22 °C) and fogging 15 h/day (6 am - 9 pm) for 2 min every 10 min within a plastic tent covering the bench in a plastic house (18-22 °C). Once rooted they were potted into 600 mL polythene planter bags using a mix of bark:pumice (4:1 v/v) with 1 kg/m$^3$ lime, 3 kg/m$^3$ dolomite and 1.5 kg/m$^3$ of 3 - 4 month Osmocote 14:16.1:11.6 (N:P:K). Plants were then placed in the original glasshouse for approximately one week and then transferred to a shadehouse. Rooted cuttings were transplanted randomly into each of four blocks in the field by hand on 20 December 1994, and plants immediately received ca. 15 mm water delivered by sprinkler irrigation. Due to differences in original tuber clump numbers, shoot production and rooting ability, the total number of plants obtained from individual clones varied. Plant spacing was 0.8 x 1.6 m. Each block size was 22.4 x 9.6 m giving a total area of 22.4 x 40.4 = 905 m$^2$.

Weed control was achieved by inter-row spraying of glufosinate-ammonium (1.4 kg/ha) on 16 and 25 January, paraquat (0.6 kg/ha) on 28 March and some hand weeding on 5 February 1995. Plant protection included an electric rabbit fence (6-7000 volts) and methiocarb snail and slug bait (7 kg/ha). A regular spray programme that began on 13 January and continued every 2 - 3 weeks until 24 April included an insecticide (taufluvalinate at 0.36 g/L), a fungicide (benomyl at 1 g/L, chlorothalonil at 1.5 g/L or iprodione at 1 g/L), a miticide (propagite at 0.6 g/L or dicofol at 0.32 g/L) and a wetter/sticker/rainproofer (poly-1-p-menthene non-ionic at 1 ml/L).

Four clones were selected to observe pollinator behaviour (7055/3 - lemon, 7058/2 - white, 7072/2 - red, and 7074/3 - apricot). Three replicates (plants) per clone were chosen and the number of visits per receptive inflorescence was recorded for one minute at three times during the day (7 April: 9-10 am, 2-3 pm, and 6-7 pm). This was repeated on the 10 April except for the dusk time. Receptive inflorescences were those in which at least one row of the styles had elongated, and the stigmatic lobes had separated and curled back exposing their formerly hidden receptive surfaces for pollination (Patil and Zingre, 1986). Early to mid-April was the period around peak flowering. A small bumblebee (*Bombus terrestris* L.) hive supplied by Zonda Resources Ltd of Havelock North was introduced on 26 January and when the bees had apparently died out after about eight weeks, was replaced by a new hive on 29 March. The number of bees in a bumblebee hive was about 100. This supplemented the natural population, but to what degree is unknown. A honeybee (*Apis mellifera* L.) hive

**Table 1. Description of the flower colours of 14 Hammett 'Figaro' series semi-dwarf dahlia (*Dahlia variabilis*) clones.**

| Clone | Flower Colour |
|---|---|
| 7073/2 | Yellow with a heavy red secondary colouring of the rays. |
| 7055/3 | Yellow-lemon. |
| 7073/1 | Yellow with a light red secondary colouring of the rays. |
| 7056/1 | Apricot. |
| 7072/2 | Red. |
| 7074/3 | Apricot. |
| 7055/2 | Yellow with a very light red secondary colouring of the rays. |
| 7052/3 | Yellow. |
| 7058/1 | Purple. |
| 7052/6 | Pale pink. |
| 7052/11 | Lavender. |
| 7075/3 | Pale yellow with heavy dark pink secondary colouring of the rays. |
| 7058/2 | White. |
| 7052/8 | White with a small amount of red secondary colouring of the rays. |

was introduced on 27 January and removed after flowering had finished. The number of honeybees in this hive was approximately 60,000 (Southward, 1997).

Five inflorescences of each clone were randomly selected from each of the four blocks, and carefully dissected. Ray, disc and total floret numbers were counted for each inflorescence. In addition, both seed numbers and position (whether ray or disc) were also recorded.

Plants were individually harvested by hand using hedge clippers in mid to late May 1995. The cut was made sufficiently low to include all seed heads, but high enough to reduce the amount of vegetative matter. Once harvested, seed heads were air-dried in a glasshouse (20 – 25 °C) for one week, then threshed through a Westrup (LA-H) Dehuller with a screen size of 10 x 10 mm. The seed samples were then cleaned through an air-screen cleaner (Burrows Office Clipper Tester and Cleaner) using oblong-shaped screen sizes 1.98 x 19.05 mm and 5.99 x 1.07 mm and an airflow setting of 1.32 $m^3$/min. Seeds were then processed through a Westrup (LA-T) Indented Cylinder Separator with a 7.25 mm indent, followed by hand picking. Seed weights, seed yields per plant, and yields per hectare were then determined. Seed moisture content (SMC) and thousand seed weight (TSW) were determined (ISTA, 1996), and seed yield expressed at 10 % SMC.

Seed quality was measured by a germination test and topographical tetrazolium test. The germination test was conducted during October-November 1995 using the method prescribed in the International Seed Testing Association rules (ISTA, 1996). This included a pre-chilling treatment at 5 °C for 4 d followed by 21 d at 20 °C. Blotters were examined after 7 d, 15 d (interim counts), and 21 d (final count) and any normal seedlings were removed at the interim counts. All seeds/seedlings were classified as normal or abnormal seedlings, fresh ungerminated, dead, or empty seeds (ISTA, 1996). The topographical tetrazolium test was conducted using the following procedure based on the ISTA rules (ISTA, 1996). The seeds were soaked for 17 h at 25 °C in a 1 % (w/v) tetrazolium chloride solution and embryos were examined and classified as either viable or non-viable according to the staining pattern. Sprouting damage was recorded by examining the seed used for the tetrazolium test (before soaking) for any visible evidence of germination including radicle and/or cotyledon emergence from the seed.

Data were analysed using the analysis of variance (ANOVA) procedure in SAS for Windows (Release 6.12, SAS Institute, Cary, NC, USA). In addition correlations between fecundity measurements and seed yields were completed with log transformed data using the PROC REG procedure (SAS). Any non-linear regressions were "linearised" before analysis.

**Trial 2**

A glasshouse emergence trial using seed collected from six clones in Trial 1 was conducted during September-October 1995. Five replicates of 120 seeds were sown in 45 mL cell plug trays using Yates Black Magic Seed Raising mix. After watering, the sown trays were pre-chilled for 5 d at 5 °C and transferred to a glasshouse (18-23 °C). Emergence was recorded every 2 - 3 d for 30 d. Median time taken to germinate, spread of germination and total germination were calculated using the methodology described by Coolbear *et al.* (1984). Data were analysed using the analysis of variance (ANOVA) procedure in SAS as previously described.

## Results and Discussion

**Trial 1**

No variation in the number of insect visitors occurred for the four clones chosen despite colour differences. A mean of 24 % of receptive inflorescences were visited over a one minute period in the morning (9-10 am) and the afternoon (2-3 pm) on two days, one week apart, during the peak flowering period. Visits did not differ with time of day, although on the first day a dusk observation (6-7 pm) revealed no pollinator visits. However, a very small number of moths were observed in the crop as a whole. Of the recorded visits, 89 % were by honeybees, 9 % by bumblebees (only *Bombus terrestris* L. was specifically identified), with the remaining visitors (3 %) being flies, butterflies or moths. Of these, a number were caught and identified including: Dronefly (*Eristalis tenax* L.), Yellow Admiral (*Bassaris itea* F.), Red Admiral (*Bassaris gonerilla* F.), Common Blue (*Zizina otis labradus* Godt.), Common Copper (*Chrysophanus salustius* F.), Monarch (*Danaus plexippus* L.), White Cabbage (*Artogeia rapae* L.), Magpie moth (*Nyctemera annulata* Boisd.), and Tomato Fruitworm moth (*Heliothis armigera confertus* Walk.).

Seed head fecundity data varied widely amongst all 14 clones (Table 2). Mean ray floret numbers per inflorescence ranged from 65 (7052/3) to 142 (7073/2). Disc floret numbers per inflorescence varied from 21 (7055/8) to 58 (7072/2). Three (7052/8, 7058/2, 7075/3) of the four lowest yielding clones also had the lowest number of disc florets, but no further pattern was evident and disc floret number amongst most clones was remarkably similar (nine of the 14 clones had mean disc

**Table 2. A comparison of seedhead fecundity[1] of 14 Hammett 'Figaro' series semi-dwarf dahlia (*Dahlia variabilis*) clones.**

| Clone | Ray floret no. | Disc floret no. | Total floret no. | Disc floret (%) | Ray/disc ratio | Seed no. | Disc fecun. (%) | Viable disc fecun. (%) |
|---|---|---|---|---|---|---|---|---|
| 7073/2 | 142 a[2] | 41 cd | 183 a | 22.5 ef | 3.53 b | 23 bc | 55 ab | 41 a |
| 7055/3 | 123 bc | 49 bc | 171 abc | 28.4 de | 2.55 cd | 27 ab | 56 ab | 40 a |
| 7073/1 | 112 cd | 44 cd | 156 cd | 28.2 de | 2.57 cd | 23 bc | 38 cd | 31 b |
| 7056/1 | 135 ab | 41 cd | 176 ab | 23.3 ef | 3.37 bc | 14 de | 34 d | 26 bc |
| 7072/2 | 105 def | 58 a | 163 bc | 35.5 bc | 1.91 de | 27 ab | 46 bc | 31 b |
| 7074/3 | 91 fgh | 40 d | 131 efg | 31.0 bcd | 2.32 d | 26 bc | 35 d | 26 bc |
| 7055/2 | 92 fgh | 43 cd | 135 efg | 31.7 bcd | 2.17 d | 14 de | 34 d | 18 cd |
| 7052/3 | 65 i | 55 ab | 120 g | 45.9 a | 1.20 e | 29 a | 53 ab | 20 cd |
| 7058/1 | 82 gh | 47 bcd | 129 efg | 36.8 b | 1.84 de | 9 ef | 19 e | 11 de |
| 7052/6 | 96 defgj | 41 cd | 137 ef | 30.0 cd | 2.39 d | 15 d | 36 ab | 13 de |
| 7052/11 | 95 efgh | 25 ef | 120 g | 21.1 f | 3.81 b | 3 fg | 11 ef | 7 e |
| 7075/3 | 109 cde | 31 e | 140 de | 21.9 ef | 3.82 b | 6 fg | 18 e | - |
| 7058/2 | 85 gh | 46 cd | 131 efg | 35.0 bc | 1.89 de | 4 fg | 9 ef | - |
| 7052/8 | 100 defg | 21 f | 121 fg | 17.5 f | 4.81 a | 1 g | 7 f | - |

[1] Number of seeds formed per potential site, i.e., disc floret.
[2] Means within the same column followed by the same letter were not significantly different at $P < 0.05$.

numbers in the 40s). The number of disc florets (46) of the semi-double white clone with a clearly visible central disc (7058/2), did not vary from eight other clones which were more double in appearance. In this case 7058/2 had a lower number of ray florets which allowed the central disc to be visible from early unfurling of the ray florets.

Total floret number per inflorescence varied from 120 (7052/11) to 183 (7073/2). There was a reasonably good relationship between total floret number and seed yield ($r^2 = 0.72$).

The percentage of disc floret to total floret numbers ranged from 18 % (7052/8) to 46 % (7052/3), but that of the highest seed yielding clone (7073/2) did not differ from three of the lowest seed yielding clones (7075/3, 7052/11, 7052/8).

The ratio of ray:disc florets ranged from 1.2 (7052/3) to 4.8 (7052/8). Although the ranking of clones was not identical to that for the percentage of disc florets to total floret numbers, a number of significant differences still occurred. However, there was no significant relationship between this ratio and seed yield ($r^2 = 0.09$).

Seed number per inflorescence varied from 29 (7052/3) to 1 (7052/8). There were three groups: those with means between 23 and 29, which comprised six of the top seven yielding clones; the middle group of three clones (7052/6, 7056/1, and 7055/2) with means of 14 - 15 seeds per inflorescence; and apart from one clone 7058/1 (mean of 9) which was not significantly different from the middle and lowest group, the remaining four clones (7075/3, 7052/11, 7058/2, 7052/8) with means between 1 and 6 were also those which gave lowest seed yields.

The fecundity of disc florets was significantly related to seed yield ($r^2 = 0.77$), although the relationship between viable seed fecundity and viable seed yield was much stronger ($r^2 = 0.97$).

The four clones with the highest viable seed yield (2.08 to 5.02 g/plant) also had the heaviest seed (TSW) which ranged from 8.57 g to 10.90 g. The remaining clones that yielded lighter seed (TSWs ranged from 6.67 to 7.62 g) had much lower yields (0.10 to 1.09 g/plant). There was one exception, 7072/2, which with a TSW of only 6.98 g, did not yield (1.09 g/plant) as poorly as others of a similar TSW. The seed shape (more curved and narrower) and size appeared quite different from the rest of the series.

Clones 7073/2 (6.66 g) and 7055/3 (6.63 g) had the highest yields per plant followed by clone 7073/1 (4.32 g/plant). After that, the mean yields declined quickly with 8 of the 14 clones yielding a mean of less than 1 g/plant. The yield of the highest clone (7073/2) was 222-fold greater than that of the lowest yielding clone (7052/8).

When expressed as viable seed yield per plant, there were some minor differences in the order of clones and also changes in the significant differences. The most significant effect was that the top four yielding clones contributed over 80 % of the total yield for the series. Three of the four lowest yielding clones (7075/3, 7058/2 and 7052/8) had insufficient seed to carry out a germination test and so no viable yield is listed.

Both the seed number and viable seed number per plant gave a similar result to that described previously. Although there was no significant difference between clones 7056/1 and 7072/2 in both seed number and viable seed number, the viable seed yield of clone 7056/1 was nearly twice as large, due mainly to the influence of higher TSW. The seeds of clone 7056/1 were nearly 60 % heavier than those of clone 7072/2.

Due to constant plant spacing the clonal yields per hectare did not differ in ranking from yield per plant (Table 3).

Within the population provided, white/lavender, light pink or purple-magenta flower coloured clones produced lower seed yields, whereas red, orange or yellow flowered clones produced seed yields typically much higher (Tables 1 and 2). Whether or not this is a coincidence could be important in maintaining a reasonable colour range in a subsequent seed mix. The modern garden dahlia is considered a hybrid, originally the product of a cross between a white/purple-magenta flowering species (probably *D. pinnata*) (Lawrence and Scott-Moncrieff, 1935; Sorenson, 1969) and a red to yellow flowering species (*D. coccinea*) (Lawrence and Scott-Moncrieff, 1935; Sorenson, 1969). This suggests there may be a genetic link between flower colour and disc fecundity related to this original hybridization, leading to white/purple-magenta coloured flowering plants contributing a lower seed yield. It is interesting to note that Sorenson (1969) also mentions that the only wild *Dahlia* species that might be described as a 'weed' is *D. coccinea*. Presumably, therefore, it must be a good seeder, as was the case with most of the yellow, orange or red flowering clones in this study. Only testing of further clones will determine if this is correct.

Germination ranged from 35% (7052/6) to 79% (7073/1) which is the corrected value after all empty seeds were removed (Table 4). The highest germination occurred typically with clones that gave the highest seed yields (compare with Table 3). Fresh ungerminated or dormant seed did still exist at the end of the germination test period (21 days) but at very low levels (0 % - 4 %). However, there were varying degrees of dormancy recorded amongst clones within the germination test period. This phenomenon was investigated more thoroughly in Trial 2.

Dead seed varied from 19 % to 57 %. Abnormal seedling data are not given as they made only a minor contribution to the total and can be calculated from the tabulated data. The tetrazolium (viability) test followed

**Table 3. A comparison of seed yield components of 14 Hammett 'Figaro' series semi-dwarf dahlia (*Dahlia variabilis*) clones.**

| Clone | TSW (g) | Total yield (g/plot) | Viable yield (g/plot) | Total seed no./plt | Viable seed no./plt | Total yield (kg/ha)[1] | Viable yield (kg/ha)[1] |
|---|---|---|---|---|---|---|---|
| 7073/2 | 9.17 bc[2] | 6.66 a | 5.02 a | 727 a | 541 a | 103.7 a | 78.2 a |
| 7055/3 | 8.57 c | 6.63 a | 4.65 ab | 758 a | 529 a | 103.5 a | 72.5 ab |
| 7073/1 | 9.36 b | 4.32 b | 3.46 b | 462 b | 370 b | 67.4 b | 53.9 b |
| 7056/1 | 10.90 a | 2.66 c | 2.08 c | 240 c | 188 c | 41.4 c | 32.5 c |
| 7072/2 | 6.98 de | 1.63 cd | 1.09 d | 234 c | 156 c | 25.4 cd | 17.0 d |
| 7074/3 | 7.62 d | 1.20 de | 0.92 d | 149 dc | 121 cd | 18.6 de | 14.4 d |
| 7055/2 | 7.47 d | 0.94 defg | 0.57 de | 125 de | 76 de | 14.7 defg | 8.8 de |
| 7052/3 | 7.56 d | 0.97 def | 0.36 ef | 128 de | 48 ef | 15.1 def | 5.7 ef |
| 7058/1 | 7.07 de | 0.47 fgh | 0.30 ef | 66 ef | 42 ef | 7.4 fgh | 4.7 ef |
| 7052/6 | 6.60 ef | 0.65 efg | 0.24 ef | 98 def | 36 ef | 10.1 efg | 3.7 ef |
| 7052/11 | 7.60 d | 0.15 hi | 0.10 f | 20 gh | 13 f | 2.3 hi | 1.6 f |
| 7075/3 | 6.67 ef | 0.46 gh | - | 63 gf | - | 7.2 gh | - |
| 7058/2 | 7.07 de | 0.08 i | - | 11 h | - | 1.3 i | - |
| 7052/8 | 6.12 f | 0.03 i | - | 5 h | - | 0.5 i | - |

[1] Based on a plant density of 15,625 plants/ha at a spacing of 0.8 x 0.8m.
[2] Means within the same column followed by the same letter are not significantly different at $P < 0.05$.

a very similar pattern to the germination plus fresh ungerminated result ($r^2 = 0.84$). Either misinterpretation of incomplete tetrazolium staining or misclassification of abnormal seedlings mainly caused differences between the two tests.

Seed germination in the present study was disappointing, particularly since Atwater (1980) reported an average germination of 77 % (from 200 seed lots), and Phetpradap et al. (1994) consistently obtained germination results between 79 % to 89 %. Two main factors may be responsible. Firstly, flowering did not peak until mid-April. Lower temperatures at this time of the year are likely to have slowed and may have curtailed seed development before maximum food reserve accumulation had occurred. Dahlia seed reaches full maturity about 42 days after peak flowering (Phetpradap, 1992) but this may be extended under cooler temperatures. The presence of empty seed and high levels of dead seed (19 % - 56 %) supports this possibility.

Secondly, the system for air drying seed after harvest, in this present study, involved spreading seed out on a concrete floor in a heated glasshouse. This may well have reduced quality. Vis (1980) reported that dahlia seed, dried under glass for three days with subsequent drying with heated air, gave a germination of 65 %, compared with seed dried with heated air immediately after harvest, which gave a germination of 85 %. Phetpradap (1992) followed this second method and obtained high seed germination. Rapid removal of moisture from moist seed appears critical. Late harvest (May), in combination with very wet seed (some of which may have been immature, and/or diseased) is likely to have exacerbated the situation. If harvesting had been completed earlier, these factors may have been less critical. The large number of samples (composed of branches, leaves and seed heads) involved in this present study prevented the use of the Kiwi minidriers used by Phetpradap (1992).

Seed that has not germinated at the end of the normal 21 day germination test period (ISTA, 1996), but remains plump (having imbibed water) and firm is classified as fresh ungerminated seed. Such seed is alive but dormant. Most clonal seed lots produced some fresh ungerminated seeds but the levels (0 % – 4 %) were considered to be too low to have any significant implication. The tetrazolium test result, in most cases was similar to the normal germination plus fresh ungerminated seed result. These data and results by Phetpradap (1992) and Han (1996) all indicate that primary dormancy occurs at only very low levels. Indeed ISTA prescribes only a short period of pre-chilling (4 - 7 days) to break primary dormancy, a common practice for many recently harvested species (ISTA, 1996). However, the low percentages of seed remaining dormant at the end of 21 days (the length of the germination test for dahlia prescribed by

**Table 4. A comparison of seed quality of 11 Hammett 'Figaro' series semi-dwarf dahlia (*Dahlia variabilis*) clones.**

| Clone | Germination[1] (%) | Fresh Ungerm.[2] (%) | Dead Seeds (%) | Germ + Fr. ungerm.[3] (%) | TZ[4] (%) |
|---|---|---|---|---|---|
| 7073/2 | 73 abc[5] | 2 bcd | 24 c | 75 a | 75 ab |
| 7055/3 | 67 abcd | 2 bcd | 29 bc | 69 ab | 62 cd |
| 7073/1 | 79 a | 0 d | 22 c | 79 a | 71 bc |
| 7056/1 | 76 ab | 2 cd | 19 c | 77 a | 83 a |
| 7072/2 | 63 bcde | 4 abc | 30 bc | 67 abc | 71 bc |
| 7074/3 | 75 abc | 1 d | 21 c | 75 a | 69 bc |
| 7055/2 | 52 e | 4 ab | 39 b | 56 c | 58 d |
| 7052/3 | 37 f | 1 d | 57 a | 39 d | 36 f |
| 7058/1 | 59 de | 2 cd | 38 b | 61 bc | 48 e |
| 7052/6 | 35 f | 1 d | 56 a | 36 d | 38 f |
| 7052/11 | 63 cde | 4 a | 31 bc | 67 abc | 59 d |

[1] Percentage normal seedlings.
[2] Fresh ungerminated is seed that is plump and firm but ungerminated at the end of the germination test period.
[3] May differ from columns 3 + 4 due to rounding.
[4] Topographical tetrazolium test (viability test).
[5] Means within the same column followed by the same letter are not significantly different at $P < 0.05$.

ISTA) is not the only dormancy consideration. The speed of dormancy release within and/or between seed lots appeared to be important in Trial 2.

**Trial 2**

The emergence of seedlings under glasshouse conditions was lower than expected, being typically one half to two thirds of the germination result (compare Tables 4 and 5). One possible reason for this is the seedling mix used (Yates Black Magic seed raising mix). This mix was later reported to reduce germination by one third in a range of flower seeds, compared to alternative seed raising mixes in an independent test (Anon., 1996). It should be noted that the company involved made counter claims. Although the ingredients of the mixes were discussed, no specific reasons for the variation amongst mixes were given. It seems reasonably likely that this contributed to the poor emergence observed.

Despite this, however, the time to 50 % emergence (over six days) and the spread of emergence (four days) varied significantly both between and within clonal seed lots, revealing varying speeds of dormancy release over the period of 30 days of recording emergence. This variation has at least two related implications in nursery situations (especially plug production) where both even germination and emergence are important. Firstly, if all of the seed from each of the clones had been combined, then these described maternal effects would have been masked. If a large amount of the late germinating seed was not used, due to its small size at the time of transplanting or selling, then one or more clones could, in effect, have not contributed to the next generation. This would have implications for colour balance and numerous other traits in the next generation. This inter-clonal variability appears to have a physiological and genetic basis and may quantify what Ball (1991) describes as some colours in dahlia being 'weaker' than others, but later capable of developing into strong plants.

Secondly, a long spread in the emergence time period could mean that cell plugs could not be directly used. Instead, seed would need to be germinated in a seedling tray and then transplanted into cells. This technique, which involves another step (and therefore increased costs), was used by Han (1996). Dry storage of seeds until the following season may well overcome or reduce the variation between what is in effect blended seed lots. Whether this is economically feasible is unknown.

Also, it is possible a longer period of pre-chilling and/or cooler pre-chilling temperatures may reduce this variability. Another possibility for reducing variability may include various types of priming treatments. Some of these treatments have been at least partially successful with other Compositae species, such as *Coreopsis* and *Echinacea* (Samfield *et al.*, 1991; Finnerty and Zajicek, 1992; Pill *et al.*, 1994; Wartidiningsih *et al.*, 1994).

**Table 5. A comparison of emergence of seedlings under glasshouse conditions of 7 clonal half-sib lines[1] collected from Hammett 'Figaro' series semi-dwarf dahlia (*Dahlia variabilis*) clones.**

| Clone | Emergence after 30 days (%) | T50[2] (Days) | T90-T10[3] (Days) |
|---|---|---|---|
| 7073/2 | 27 bc[4] | 15.2 cd | 11.2 abc |
| 7073/1 | 30 b | 12.1 a | 9.0 d |
| 7056/1 | 40 a | 15.1 b | 10.4 bcd |
| 7072/2 | 29 bc | 18.2 d | 13.2 a |
| 7074/3 | 23 cd | 13.3 a | 9.8 cd |
| 7055/2 | 19 d | 15.7 cd | 12.3 abc |
| 7052/11 | 20 d | 16.7 cd | 12.6 ab |

[1] Seed from clones 7055/3, 7058/1, 7052/3 and 7052/6 was not included in this trial.
[2] Time to 50 % emergence
[3] Spread of emergence
[4] Means within the same column followed by the same letter are not significantly different at $P < 0.05$.

## Conclusions

Although seed yields of most clones was on average low (30 kg/ha), earlier planting in another trial gave yields averaging 110 kg/ha (Han, 1996). This would allow flowering, pollination and food reserve accumulation to be completed under more ideal climatic conditions. However, seed yield still varied widely amongst clones (0.5 - 104 kg/ha), with nine (out of 14) of the clones yielding below 20 kg/ha. Seed yield appeared to be more affected by floret fecundity than by floret number or the other factors investigated in this study. In the more dwarf Hammett 'Baby Dahl' series, fecundity and average seed yield (4 kg/ha (Southward, unpublished data) are much lower, while in a larger less double dahlia series, fecundity levels may increase, producing much higher yields of up to 600 kg/ha (F. Onland, Excel Seed New Zealand Ltd, PO Box 1213, Palmerston North, NZ, personal communication, 1995).

This study indicates that there is potential to select higher seed yielding clones while maintaining a high degree of perceived doubleness in the inflorescences. While the degree of doubleness is an important quality parameter, an unexpected complication was the outcome that yellow, orange or red inflorescences, typically, had a much higher fecundity level and seed yield when

compared with the white, purple-magenta, or pale flowering clones. Therefore, the colour range and the percentages of any given colour in any subsequent generation may change.

Varying speeds of dormancy release were observed, both within and between clonal seed lots. Implications of this variation in dormancy release include the possibility of excluding the contribution of certain clones, thus narrowing the genetic base of subsequent generations, and increasing the costs of seedling production because of uneven and delayed germination. Pre-chilling moist seed for longer or with cooler temperatures may reduce this dormancy effect. Alternatively, the dry storage of seed until the following season (15-16 months, e.g., April harvest, sowing in July-August in the glasshouse of the following year) may also be effective. In addition, priming treatments may be useful.

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