Full Report of Littlehampton first year's work, with covering Summary as used in PN-6

PC/13 Winter quality of pot chrysanthemums

FIRST YEAR REPORT - IHR, LITTLEHAMPTON

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The work described in this report was that carried out during the first year of a two-year contract placed at IHR, Littlehampton. Separate reports have been submitted to cover the work at Lee Valley EHS.

OBJECTIVE:

To study the development of variation in chrysanthemums grown five to a pot and to determine at which stage or stages of growth cultural practices might best be applied or modified to ameliorate the problem.

SUMMARY:

For both Bright Golden Anne (BGA) and Yellow Favour (YF), careful grading of cuttings by weight before sticking effectively minimised initial variation not only for this character, but also for others such as stem diameter, and leaf number. Cutting weight correlated well with growth made (as determined by stem length) up to pinching with heavy cuttings tending to give the largest plants at this stage. However, initial weight was only weakly correlated with post-pinching characters such as total numbers of breaks and flowers and had no significant influence on final flower stage. Similarly, within-pot variation for initial weight was in no way correlated with variation in final flower stage which is, perhaps, the most important determinant of final pot variability.

In contrast, variation in final flower stage for BGA correlated positively with variation in stem length at pinching (but not with initial variation in cutting length which was very small). It appeared that variation in 'plant size' before pinching (which is in part influenced by cutting weight) largely determined the pattern of subsequent variation, even though pinching was carried out in an attempt to eliminate variation at this stage. There was no such association of characters for YF. Subsequent experiments of a similar type are currently undergoing mathematical analysis.

Although variation in root growth during propagation was shown in cuttings of BGA and YF, this could not be related to any easily measured character of the cuttings at receipt. The extent of rooting correlated with increase in stem length during propagation and up to the time of pinching, but could not be directly linked with any aspect of variation shown in pots at harvest. Variation in rooting potential may, however, be one of, perhaps, several minor factors (including initial cutting weight) contributing to final pot variation by influencing plant stature at pinching.

Given that variation in plant stature prior to pinching can have a major bearing on final variation, the way that pinching is done could be a crucial factor in improving quality. However, final leaf number on a break (as one component of variation) appeared to be effectively determined well before the time of pinching as a 'fixation' effect caused by the presence of an induced terminal bud. Thus, although a lateral break may not itself be initiated to flower at the time of pinching, it may produce similar numbers of leaves whether it remains in short days or is subsequently transferred to long days.

It appeared that pinching to a lower leaf gave leafier breaks than did pinching to a higher leaf. The time of pinching to a given leaf and, by inference, the length of the pinch removed, did not affect this relationship. Pinching to a higher leaf tended to give larger numbers of breaks, time of pinching again having little or no consistent effect. The higher the leaf to which the pinch was made, the later the date of ultimate harvest; the later the time of pinching to a given leaf, the later the date of ultimate harvest. Taking these factors into account and also effects on numbers of flowers produced, the optimal treatment appeared to be to remove a pinch of c. 1.5-2.0 cm above the 8th or 10th leaf. This is essentially what is already practiced in commerce. The plants most delayed in flowering in any given treatment tended to be those which were particularly small at the time of pinching and from which very small pinches were removed in order to leave the required number of leaves.

A further pinching experiment with ungraded cuttings tested three alternative procedures as means of minimising final within-pot variation; a) pinching rigorously to a given leaf number, b) pinching rigorously to a given stem length and c) removing a constant length of pinch. None of the treatments effectively eliminated variation but, of the three methods, pinching to a constant stem length was marginally the best.

In addition to further analysis of experiments already carried out, future work will concentrate on attempting to achieve uniformity prior to pinching to see if this has the effect of eliminating or reducing subsequent variation as might be expected on the basis of the experiments already conducted.

BACKGROUND:

Variation between plants grown five to a pot, particularly in flower stage attained at marketing, can seriously reduce the quality and value of the product. Unlike the situation in cut-flower crops, there is no possibility at final harvest of re-grading plants which have been associated together within pots at 'sticking'.

PROCEDURES:

Cultivars. Bright Golden Anne (BGA) and Yellow Favor (YF) were used in these studies, bought in as required as unrooted cuttings from Messrs. Yoder Toddington Ltd., Littlehampton.

Compost. Levington M2 potting compost was used; this is essentially the same as Lee Valley's Fisons Pot and Bedding. For BGA, Phosfleur 1.5 was incorporated at the rate of 0.445 kg per cubic metre. Yellow Favor was grown without any growth regulant.

Sticking. In most experiments, cuttings graded as per treatment were direct stuck around the rim of 14cm half-pots, and 5-10 mm in from the edge, upright or slightly inclined from the vertical. Cuttings were stuck using a template to ensure uniformity of spacing and care was taken to ensure that cuttings were stuck to similar depths. Cuttings were specified as being from the Canaries, and had already been treated with rooting hormone (2% IBA plus fungicide). Cuttings were watered in with plain water and given a HV spray with Rovral.

Rooting. Pots were arranged pot-thick on benches with heating cables to maintain a compost temperature of c. 21°C. They were covered with thin clear polythene sheeting in intimate contact with the cuttings. Polythene sheets were removed after 7-9 days and plants then remained in the propagation area for a further week. Aerial temperature in the propagation house was set at a minimum 16°C.

Long Days (LD). LD were given from sticking for the two weeks of propagation. Incandescent lamps were used to give a minimum of 150 lux at plant height (outside polythene) for 3 hours (March) or 4 hours (Nov. to Feb.) each night, around midnight GMT.

Short Days (SD). SD were generally given immediately the pots were transferred from the propagation area. Black polythene sheets were pulled over each bench to give an aerial environment akin to that in commerce. Covers were put on at 16.30-17.00 GMT and taken off at 08.00 GMT (on for 15.0-15.5 hours).

Spacing. Pots were put at half-spacing at the start of SD (22cm x 22cm) for 2-3 weeks and then put at their final spacing (30cm x 30cm).

Pinching. Tips of 1-2 cm were pinched out after 7-21 SD to leave c. 8 leaves. Other pinching procedures were determined by the needs of the experiment (see later).

Growth Regulants. To avoid interactions with treatment, these were not used. For BGA, reliance was placed on the use of Phosfleur at sticking.

Feeding. Liquid feed was applied at each watering (hand watering) using 250 N and K, 50 P, 0.5 Fe.

Temperature. 16°C day/night, venting at 21°C.

CO_2. Enrichment to 800-1000 ppm was practiced when vents were closed. Pure CO_2 was used.

Disbudding. Lateral buds on the breaks were not removed from BGA as total flower bud number was one of the characters scored.

Pest and Disease Control. The following prophylactic programme was followed.

Wk 1	Hostaquick
Wk 2	Saprol
Wk 3	Pentac
Wk 4	Saprol
Wk 5	Hostaquick
Wk 6	Saprol
Wk 7	Pentac
Wk 8	Saprol
Wk 9	Pirimor
Wk 10	Saprol

EXPERIMENTS:

Experiments 1,2 and 3. These were designed to follow the development of variability during the growth of crops. Normal commercial procedures were followed, as described above, with careful initial grading of cuttings by weight (Expts. 1 and 2). Grading was into five categories (extra-light, light, intermediate, heavy, extra-heavy), with the central three assigned equal ranges (determined on the basis of an initial sample of the cuttings supplied) to give similar starting variances (variance is a mathematical measure of variation between the plants within a pot). The two extreme categories constituted the tails of the normal distribution and groups of five cuttings taken from either of these categories would have been likely to have larger variances. Some pots were stuck using 'mixed' cuttings i.e. two extra-heavy and three extra-light or three extra-heavy and two extra-light. Pots were numbered, and plants within pots identified by counting clockwise from a mark on the outside of the pot.

The following plant records were kept:

a) at receipt - cutting length, length from base to first node, diameter of base, number of expanded leaves > 1 cm^2, fresh weight.

b) after propagation - root development (carefully removing the plant pot and giving a 1-5 score, with 1 as no rooting and 5 as uniform and extensive rooting down the full depth of compost), stem length (above compost), number of expanded leaves.

c) at pinching - height and number of expanded leaves before and after pinching.

d) 14-21 days after pinching - number of 'useful' breaks and length and number of expanded leaves of the second break (from the axil of the penultimate leaf, counting from the top). Note that, in practice, data collected at this time added little of value and are not referred to in the 'Results' section below.

e) approaching harvest - total number of breaks, numbers of flowers per plant (stage 4 or beyond), length, leaf number and flower stage of the terminal flower of the uppermost break.

EXPT. 1:

Potted	- 7 October (BGA)
	8 October (YF)
To SD	- 21 October (BGA)
	22 October (YF)
Pinched	- 6 November (after 17 SD)
Near harvest scoring	- 21 December (YF) (after 61 SD)
	11 January (BGA) (after 81 SD)

An excess of extra-heavy cuttings (BGA) and extra-light cuttings (YF) over what had been anticipated on the basis of initial samples, meant that in each case an additional 'near-uniform' category of pot was included. Categories used:

BGA - light:	(1.41 - 1.65g)	11 pots
BGA - intermediate:	(1.66 - 1.90g)	12 pots
BGA - heavy:	(1.91 - 2.15g)	10 pots
BGA - extra-heavy:	(> 2.15g)	7 pots
BGA - mixed:	(< 1.41, > 2.15g)	17 pots*
		Total 57 pots

* 8 with three extra-heavy and two extra-light, 9 with two extra-heavy and three extra-light.

YF - extra-light:	(≤ 1.95g)	13 pots
YF - light:	(1.95 - 2.30g)	15 pots
YF - intermediate:	(2.31 - 2.66g)	9 pots
YF - heavy:	(2.67 - 3.02g)	6 pots
YF - mixed:	(< 1.95 - > 3.02g)	9 pots*
		Total 52 pots

* 3 with three extra-heavy and two extra-light, 6 with two extra-heavy and three extra-light.

EXPT. 2 :

Potted	- 11 November (BGA), 12 November (F)*
To SD	- 25 November
Pinched	- 11 December (BGA) (after 16 SD)
	15 December (F) (after 20 SD)
Near harvest scoring	- 3 February (F) (after 70 SD)
	16 February (BGA) (after 83 SD)

* Favor supplied instead of Yellow Favor.

Pot categories utilised:

BGA - light	(1.50 - 1.70g)
BGA - intermediate	(1.71 - 1.91g)
BGA - heavy	(1.92 - 2.12g)
BGA - mixed	(<1.50, ≥2.12g)
F - light	(1.80 - 2.09g)
F - intermediate	(2.10 - 2.39g)
F - heavy	(2.40 - 2.69g)
F - mixed	(<1.80, >2.69g)

EXPT. 3: This differed from the first two experiments in that there was no initial selection. First scoring was after propagation.

Potted	- 13 January
To SD	- 25 January
Scored	- 26 January (BGA)
	27 January (YF)
Pinched	- 17 February (BGA) (after 23 SD)
	19 February (YF) (after 25 SD)
Near harvest scoring	- 11 April (BGA) (after 77 SD)
	7 April (YF) (after 73 SD)

<u>Experiments 4 and 5.</u> These were designed to see if differences in rooting of cuttings can be linked with characters which can be scored on receipt.

In experiment 4, cuttings were scored for total length, number of leaves and length to the first node. They were then carefully graded by weight into light (1.20 - 1.40g for BGA; 2.00 - 2.30g for YF), heavy (1.50 - 1.70g for BGA; 2.50 - 2.80g for YF) and unselected (0.70 - 2.15g for BGA; 1.21 - 3.06g for YF) categories, and planted five to a pot. There were nine or ten pots per category. Root growth after propagation was scored on a 1-4 scale (1 = uneven rooting with roots averaging 1-2 cm in length or with few longer roots; 4 = even and prolific rooting with roots averaging 4-6 cm in length). At this stage plants were also scored for total length (after lifting) and final leaf number. Cuttings were stuck on 4 November and scored on 18 November.

Experiment 5 was similar to 4 except that cuttings were rooted in troughs of aerated Hoagland's No. 1 nutrient solution at pH 5.8-6.0 and conductivity c. 2mS. 150 unselected cuttings of each cultivar were used, each being scored at insertion for weight, length, length to first node, stem diameter and leaf number. The cuttings were held in place by foam rubber collars lining holes in lids which fitted over the troughs. To facilitate this, leaves less than 10 mm from the base of cuttings were removed. Cuttings were covered with polythene during the first week as usual. At the final harvest, cuttings were scored for root weight (fresh weight after blotting with paper tissues), total stem length and leaf number. At this stage corrections were made to take account of leaves removed earlier. Cuttings were put into place on 21 January (BGA) or 22 January (YF) and scored on 9 February (BGA) or 10 February (YF).

<u>Experiments 6,7 and 8.</u> These experiments were concerned with pinching since it is generally accepted that the way in which this is done can have a profound effect on the final appearance of the pot mum and, possibly, the extent of variation within the pot.

In experiments 6 and 7, the effect of time of pinching was examined. Batches of plants (14 per batch) grown in individual 9cm half-pots were pinched to 6,8 or 10 leaves as soon as this became possible (very light pinch) or 3,6,9 and 12 days later (progressively larger pinches). Half of the plants on each occasion were transferred to LD and half remained in SD. The difference in the number of leaves (SD v LD) on a given break was calculated as an indication of whether flower initiation had occurred at the time of pinching - a possible source of final variability. At harvest, plants in SD were scored for leaf numbers on the upper breaks, lengths of the breaks, numbers of breaks and flowers (stage 4 or beyond) and final flower stage of the terminal flower on the uppermost break. Plants were assigned to treatments in a systematic manner to give a representative range of initial weights in each.

Experiment 8 compared alternative pinching procedures for pot mums grown without initial selection. Pots were assigned at random to three treatments:
1. Plants pinched to a specific height - based on the length of the shortest cutting in the pot (height and leaf numbers noted).

2. Plants pinched to a specific leaf number - also based on that appropriate for the shortest cutting in the pot (leaf number and heights noted).
3. A uniform length pinch removed (1.5 cm), (leaf numbers and heights noted).

There were 20 pots per treatment.

EXPT. 6:

Potted	- 14 October (BGA)
	15 October (YF)
Uncovered	- 23 October
To benches	- 28 October (but still given LD lighting)
To SD	- 2 November (total LD = 18 or 19 days)
Pinching to 6 leaves	- 2, 5, 8, 11 and 14 November
Pinching to 8 leaves	- 9, 12, 15, 18 and 21 November
Pinching to 10 leaves	- 16, 19, 22, 25 and 28 November

EXPT. 7:

Potted	- 16 December
To SD	- 30 December
Pinching to 6 leaves	- 7, 10, 13, 16 and 19 January
Pinching to 8 leaves	- 14, 17, 20, 23 and 26 January
Pinching to 10 leaves	- 21, 24, 27, 30 January and 2 February

Near-harvest flower stage scored as the range exhibited in each treatment; 2 March (YF) and 3 March (BGA).

EXPT. 8:

Potted	- 25 November
To SD	- 9 December
Pinched	- 6 January (after 28 SD)
Scored	- 15 February (YF)
	- 8 March (BGA)

RESULTS:

Experiment 1 (BGA)

The correlation matrix in Table 1 (simplified from the 17 x 17 character matrix actually calculated) shows how values for one character related to those for other characters scored on the same plant. No account is taken of initial selection category to which cuttings were assigned or to effects imposed on individual cuttings by the pots themselves.

Table 1. Correlation matrix of primary data for 7 characters (Expt. 1, BGA)

Characters: Initial weight of cutting (1), stem length after propagation (2), stem length before pinching (3), stem length after pinching (4), number of breaks (5), number of flowers (6) and flower stage of the terminal flower on the uppermost break at final scoring (7).

	1	2	3	4	5	6	7
1	-	0.44 ***	0.43 ***	0.29 **	0.18 *	0.18 *	0.11
2	0.44 ***	-	0.75 ***	0.54 ***	0.11	0.25 **	0.28 **
3	0.32 ***	0.75 ***	-	0.75 ***	0.06	0.30 **	0.35 ***
4	0.29 **	0.54 ***	0.75 ***	-	0.05	0.28 **	0.30 ***
5	0.18 *	0.11	0.06	0.05	-	0.36 ***	0.14
6	0.18 *	0.25 **	0.30 **	0.28 **	0.36 ***	-	0.58 ***
7	0.11	0.28 **	0.35 ***	0.30 ***	0.14	0.58 ***	-

Approximate P levels: *** 0.30, ** 0.23, * 0.17 (df = 265)

Initial cutting weight was significantly correlated with 'growth' (as measured by stem length) up to pinching. However, it had only a weak correlation with post-pinching characters such as numbers of breaks and flowers and no correlation with final flower stage. Pinching appears to dissipate the influence of initial weight. Other primary cutting characteristics showed weaker associations with subsequent growth characters.

Stem length, both before and after pinching, which reflects the vigour or otherwise of plant growth from sticking (when there was less variation in this character, was significantly correlated with earlier cutting characters (such as weight) and final pot characters including flower stage.

It seems likely that variability in flower stage at final harvest, which is probably the most important character determining one's visual impression of variability, is going to be little influenced by rigorous initial grading, but will be influenced by variation in stature at pinching.

An alternative way of looking at the data is via variances which measure variation within individual pots. Such variances, tabulated against initial selection category, are shown in Table 2.

Table 2. Average pot variances ($\log_{10}$ transformed) (Expt. 1, BGA)

	Pot category					
Character	Light	Inter-mediate	Heavy	Extra heavy	Mixed	F*
Cutting weight	-2.304	-2.244	-2.399	-1.514	-0.333	201.72
Cutting length	1.516	1.276	1.324	0.758	1.424	4.14
Cutting stem diameter	-0.787	-1.090	-0.750	-1.039	-0.495	7.80
Leaves on cutting **	0.133	0.113	0.128	0.133	0.278	7.66
Length to first node	1.758	1.745	1.765	1.758	1.879	0.34
Root development **	0.118	0.103	0.146	0.153	0.155	0.71
Stem length after prop.	1.900	1.899	1.590	1.754	2.131	3.62
Leaves after prop. **	0.136	0.079	0.123	0.128	0.336	14.28
Height at pinching	1.931	1.893	1.791	1.977	2.118	1.65
Leaves at pinching **	0.262	0.226	0.186	0.290	0.491	8.59
Height after pinching	1.188	1.185	1.333	1.256	1.338	0.62
Leaves after pinching **	0.184	0.211	0.163	0.154	0.212	0.87
Number of breaks **	0.089	0.145	0.155	0.142	0.126	0.56
Number of flowers **	0.133	0.136	0.173	0.187	0.211	1.16
Length of top break	1.921	1.883	2.085	2.063	2.062	0.59
Leaves on top break **	0.168	0.207	0.209	0.163	0.192	0.33
Flower stage - top break **	0.301	0.273	0.288	0.250	0.279	0.03

* 4 and 52 df for characters to final harvest; 4 and 49 df for characters at final harvest, F = c. 2.57 for P = 0.05.

** $\log_{10}$ (variance + 1)

As expected, there were no significant differences between average pot variances for initial cutting weight in the three 'defined range' categories (light, intermediate and heavy), but significantly more (***) in the extra heavy category where there was no defined upper limit, and significantly more (***) in the mixed category.

One would not expect great differences in variance for initial cutting length since propagators take cuttings on the basis of this character. However, extra heavy category pots showed significantly less variance (* or **) for cutting length than other types of pot. It is not clear why this was.

In addition to increased variance for weight, the mixed category pots showed significantly more variance than pots in other categories for initial stem diameter and number of leaves. They also showed the greatest variance for stem length after propagation (* significance against heavy and extra heavy pots) and leaf number after propagation (*** all other categories). This probably reflects differential growth rates of heavy and light cuttings planted together. This trend for increased variance in mixed pots was maintained to pinching when variance for leaf numbers in mixed pots was greater than in other categories of pot (** against extra heavy pots, *** against others).

However, pinching effectively eliminated the enhanced variances associated with mixed pots and no significant differences were found for any character thereafter. This is not to say that pot to pot variability disappeared, merely that variance could no longer be related to the criterion of initial selection - cutting weight. In practical terms, careful selection on the basis of cutting characters is unlikely to have much effect on final pot variability.

The correlation matrix linking average pot variances for the 17 characters scored (over all pots in the trial) gave the clearest indication of how variation within a pot for one character related to variation in another. For simplicity a reduced 7 x 7 matrix (as per Table 1) is shown below in Table 3. Correlations are for non-transformed variances (the results are essentially the same for transformed variances).

Table 3. Correlation matrix of variances for 7 characters (Expt. 1, BGA)

Characters: Initial weight of cutting (1), stem length after propagation (2), stem length before pinching (3), stem length after pinching (4), number of breaks (5), number of flowers (6) and flower stage of the terminal flower on the uppermost break at final scoring (7).

	1	2	3	4	5	6	7
1	-	0.37 **	0.31 *	0.11	-0.08	0.29 *	0.03
2	0.37 **	-	0.56 ***	0.19	-0.02	0.06	0.08
3	0.31 *	0.56 ***	-	0.60 ***	0.04	0.35 **	0.43 **
4	0.11	0.19	0.60 ***	-	0.00	0.47 ***	0.65 ***
5	-0.08	-0.02	0.04	0.00	-	0.08	-0.16
6	0.29 *	0.06	0.35 **	0.47 ***	0.08	-	0.66 ***
7	0.03	0.08	0.43 **	0.65 ***	-0.16	0.66 ***	-

*** 0.44, ** 0.35, * 0.27 (df = 52)

Variance for flower stage was significantly correlated with variance for stem length both before and after pinching. This appears to confirm that variation in plant 'size' at pinching had a real influence on final variation. Variation in plant height after pinching was even more closely related to final variation showing the importance of pinching procedure in achieving uniformity. To put these effects into perspective, 17.2% of the variation in final flower stage variance could be attributed to the simple linear dependence on height before pinching; 40.8% could be attributed in the same manner to height after pinching.

Within pot variance for initial cutting weight correlated with variance in other early characters such as stem length after propagation and stem length before pinching (and also with variance for stem diameter, and number of leaves after propagation and before pinching). However, it had little influence on variances of post-pinching characters. Substitution of particularly small or particularly large cuttings within a pot after propagation appears unlikely to have much effect on final pot variability. However, substitution or assembly of cuttings at pinching, if practicable, would appear likely to have a major effect on improving final pot uniformity, especially when combined with careful pinching to give uniform pots at this stage.

Experiment 1 (YF)

Table 4 gives the simplified correlation matrix for YF on an individual cutting basis equivalent to that in Table 1 for BGA.

Table 4. Correlation matrix of primary data for 7 characters (Expt. 1, YF)

Characters: Initial weight of cutting (1), stem length after propagation (2), stem length before pinching (3), stem length after pinching (4), number of breaks (5), number of flowers (6) and flower stage of the terminal flower on the uppermost break at final scoring (7).

	1	2	3	4	5	6	7
1	-	0.23 **	0.31 ***	0.26 **	0.04	0.17 *	-0.02
2	0.23 **	-	0.79 ***	0.59 ***	0.23 **	0.35 ***	0.21 *
3	0.31 ***	0.79 ***	-	0.63 ***	0.17 *	0.38 ***	0.28 **
4	0.26 **	0.59 ***	0.63 ***	-	0.36 ***	0.31 ***	0.28 **
5	0.04	0.23 **	0.17 *	0.36 ***	-	0.51 ***	0.31 ***
6	0.17 *	0.35 ***	0.38 ***	0.31 ***	0.51 ***	-	0.24 **
7	-0.02	0.21 *	0.28 **	0.28 **	0.31 ***	0.24 **	-

Approximate P levels: *** 0.30, ** 0.23, * 0.17 (df = 258)

As with BGA, initial weight in YF was highly correlated with other characters to pinching, but not thereafter except for a slight link with number of flowers. Pinching appears to dissipate its influence. In contrast, stem length both before and after pinching correlated with earlier characters and with final plant characters, including flower stage (as with BGA). Plant stature at this point of production again appears to be a key element determining final variability.

Table 5 shows how these correlative effects show up in pot variances (akin to Table 2 for BGA)

Table 5. Average pot variances (log_{10} transformed) (Expt. 1, YF)

Character	Pot category: Extra light	Light	Intermediate	Heavy	Mixed	F*
Cutting weight	-1.534	-2.164	-2.059	-1.998	-0.085	67.67
Cutting length	1.113	1.283	1.094	1.243	1.287	0.68
Cutting stem diameter	-0.901	-0.992	-0.926	-0.833	-0.754	0.66
Leaves on cutting **	0.118	0.121	0.098	0.084	0.271	6.92
Length to first node	1.746	1.714	1.657	1.560	1.894	1.14
Root development **	0.193	0.224	0.153	0.136	0.243	1.16
Stem length after prop.	1.700	1.786	1.356	1.673	1.768	2.59
Leaves after prop.**	0.158	0.128	0.152	0.171	0.262	2.19
Height at pinching	1.855	1.951	1.663	1.861	2.031	1.45
Leaves at pinching **	0.286	0.381	0.201	0.218	0.608	7.43
Height after pinching **	1.043	1.389	0.757	0.973	1.262	2.79
Leaves after pinching **	0.336	0.299	0.286	0.378	0.328	0.21
Number of breaks **	0.225	0.257	0.253	0.360	0.302	1.04
Number of flowers **	0.973	0.826	0.692	0.713	0.907	2.42
Length of top break	2.083	2.080	1.876	1.808	1.901	1.00
Leaves on top break **	0.259	0.208	0.269	0.226	0.356	2.05
Flower stage - top break **	0.066	0.112	0.071	0.098	0.084	0.84

* 4 and 47 df for all characters, F = c. 2.58 for P = 0.05.

** Log_{10} (variance + 1)

Large differences in pot variance for initial cutting weight reflect the effects of the mixed pot category (*** all others) and, to a lesser extent, the extra light category with no defined lower limit (** or *** the others). The only other major differences in variance for the five categories were for initial numbers of leaves and the numbers of leaves at pinching. In each case this reflects significantly greater variances in the mixed category pots (***); there were no significant differences between the others. These early differences do not carry over into the final pots, but it can be argued that this reflects, at least in part, the relatively small number of mixed pots employed and relatively little final variation overall.

The correlation matrix in Table 6 (akin to Table 3 for BGA) shows how pot variance for one character was linked with variance in another.

Table 6. Correlation matrix of variances for 7 characters (Expt. 1, YF)

Characters: Initial weight of cutting (1), stem length after propagation (2), stem length before pinching (3), stem length after pinching (4), number of breaks (5), number of flowers (6) and flower stage of the terminal flower on the uppermost break at final scoring (7).

	1	2	3	4	5	6	7
1	-	0.10	0.21	0.01	0.04	0.14	-0.06
2	0.10	-	0.64 ***	0.30	0.03	0.00	0.01
3	0.21	0.64 ***	-	0.42 **	0.02	-0.07	0.21
4	0.01	0.30 *	0.42 **	-	-0.02	0.00	0.14
5	0.04	0.03	0.02	-0.02	-	0.29 *	0.16
6	0.14	0.00	-0.07	0.00	0.29 *	-	0.12
7	-0.06	0.01	0.21	0.14	0.16	0.12	-

*** 0.44, ** 0.35, * 0.27 (df = 50)

Unlike BGA there were no correlative associations of variance for final flower stage in YF with variance in any other character. There were also no associations with variance for initial cutting weight. The only associations of note were between stem length after propagation, at pinching and after pinching, and between numbers of breaks and flowers. These would all be expected. It remains to be seen in later trials under conditions of poorer light whether within-pot variation for final flower stage in YF really is independent of variation in any other character scored, or whether there was too little variation overall for effects to show up.

Experiments 2 and 3

Data analysis is continuing.

Experiment 4

The numbers of cuttings in the various rooting categories after propagation, and average pot variances for this character are shown in Table 7.

Table 7. Root development in BGA and YF (Expt. 4)

Cutting type	Rooting category 1	2	3	4	Mean*	Mean variance per pot
BGA unselected	2	9	34	3	2.79	0.381
BGA light	0	8	36	5	2.94	0.267
BGA heavy	1	6	31	11	3.06	0.434
YF unselected	0	7	27	15	3.16	0.431
YF light	0	9	23	16	3.15	0.510
YF heavy	0	5	18	22	3.38	0.468

* $SD_{\bar{x}}$ for BGA = c. 0.087; for YF = c. 0.102

YF tended to root rather better than BGA but in each case there were no obvious relationships with cutting weight (differences between means were non-significant). Similarly, variance for rooting on a pot basis appeared unrelated to initial cutting weight with no more variability in pots of unselected cuttings than in pots of selected cuttings of the same cultivar.

Whilst there would appear to be no obvious way of determining rooting potential at time of receipt (see also later), it is necessary to determine whether this character has an influence on final pot variability. Tables 8 and 9 show that root growth during propagation is correlated with shoot length after propagation (*** for BGA, * for YF) and, by inference, shoot growth during propagation. In addition, pot variances for rooting and shoot length after propagation are correlated in BGA (*), but not in YF. Reference to experiment 1 shows that, for BGA, rooting scored over all cuttings was correlated with initial weight (**), length after propagation (**), leaf number after propagation (*), height at pinching (**), leaf number at pinching (**) but to no subsequent character. Within pot variation in rooting was not correlated with variation in any other character. For YF in experiment 1, rooting was correlated with height (**) and leaf number (*) at pinching, height after pinching (*) and, unlike BGA, with final flower stage (*). However, this latter relationship did not carry over into a significant correlation between pot variances. Overall, it seems that variation in rooting potential may be a factor contributing to final pot variation by influencing plant stature at pinching (along with initial cutting weight).

The experiment provided further data on correlations between initial cutting characteristics and those after propagation as shown in Tables 8 and 9. In general, selection on the basis of weight gave a very effective discrimination between cuttings since, on a total cuttings basis, weight was strongly correlated (***) with initial leaf number, length after propagation and leaf number after propagation. Interestingly, initial weight was only weakly correlated with initial length (* in YF, and N.S. in BGA), suggesting that heavy cuttings tend to be 'fat' rather than long. The correlations with post-propagation characters indicate that heavy cuttings do grow away the fastest. In both cultivars, length after propagation was correlated with root growth (*** for BGA and * for YF), indicating a link between shoot and root growth during propagation. As a consequence, there was a weak positive correlation between initial weight and rooting which just reached significance in BGA (*) but not in YF. Initial weight was negatively correlated with the length from the base of the cutting to the first node (** in BGA and *** in YF). This probably indicates that heavy cuttings tend to come from longer shoots where the tendency for long internodes between successive pairs of leaves has disappeared (ie cuttings taken from above the 4th, 5th or higher leaf rather than from above the second).

Table 8. Correlation matrix of primary cuttings data (Expt. 4, BGA)

Characters: Initial weight of cutting (1), initial length (2), length to first node (3), initial number of leaves (4), length after propagation (5), leaf number after propagation (6), rooting category (7).

	1	2	3	4	5	6	7
1	-	0.12	-0.26 **	0.44 ***	0.33 ***	0.45 ***	0.19 *
2	0.12	-	0.14	0.00	0.31 ***	0.14	0.02
3	-0.26 **	0.14	-	-0.31 ***	0.05	-0.29 **	0.15
4	0.44 ***	0.00	-0.31 ***	-	0.15	0.40 ***	0.16
5	0.33 ***	0.31 ***	0.05	0.15	-	0.39 ***	0.38 ***
6	0.45 ***	0.14	-0.29 **	0.40 ***	0.39 ***	-	0.09
7	0.19 *	0.02	0.15	0.16	0.38 ***	0.09	-

*** 0.30, ** 0.23, * 0.17 (df = 143)

Table 9. Correlation matrix of primary cuttings data (Expt. 4, YF)

Characters: As Table 8

	1	2	3	4	5	6	7
1	-	0.18 *	-0.31 ***	0.64 ***	0.32 ***	0.48 ***	0.11
2	0.18 *	-	-0.10	0.28 **	0.35 ***	0.15	0.05
3	-0.31 ***	-0.10	-	-0.38 ***	-0.10	-0.37 ***	0.17 *
4	0.64 ***	0.28 **	-0.38 ***	-	0.20 *	0.39 ***	-0.02
5	0.32 ***	0.35 ***	-0.10	0.20 *	-	0.37 ***	0.20 *
6	0.48 ***	0.15	-0.37 ***	0.39 ***	0.37 ***	-	0.15
7	0.11	0.05	0.17 *	-0.02	0.20 *	0.15	-

*** 0.30, ** 0.23, * 0.17 (df = 140)

Experiment 5

Data analysis is continuing.

Experiments 6 and 7

Bud initiation:

Breaks on plants in LD which had no more than one leaf more than the maximum number of leaves shown on plants of the equivalent batch in SD, were assumed to have been budded at the time of transfer. Table 10 shows numbers so found for uppermost laterals against the total number of short days experienced to the time of transfer (and bearing in mind that plants in the seventh experiment had 8 SD before pinching treatments started).

Table 10. Numbers of upper laterals (of 7) budded at pinching

No. SD	BGA6	BGA7	YF6	YF7
0	0	-	0	-
3	0	-	0	-
6	5	-	0	-
7	1	-	0	-
8	-	0	-	0/6
9	5	-	0	-
10	0	-	0	-
11	-	0	-	1
12	6	-	0	-
13	4	-	4	-
14	1	6	1	6
15	-	3	-	5
16	6	-	5	-
17	5	7	7	5
18	-	6	-	4
19	5	-	7	-
20	2	6/6	7	6/6
21	-	6/6	-	7
22	-	7	-	7
23	7	-	7	-
24	-	7	-	7
25	-	7	-	7
26	7	-	6	-
27	-	7	-	6/6
28	-	7	-	7
31	-	7	-	6
34	-	6	-	7

These results take no account of leaf number to which plants were pinched. Notwithstanding this they indicate for YF that the progression of budding down to the axillary bud from which the uppermost lateral break ultimately grows was complete by c. 21 days and nearly so by c. 14 days. The situation with BGA is far more complex and may well indicate that the explanation offered for YF is not the whole picture. It is inconceivable that 5/7 laterals of BGA in experiment 6 could be budded after only 6 days but only 2/7 be budded after 20 days. The variable nature of the response taken together with the fact that plants scored as not budded at transfer to long days also tend to have low leaf numbers (see Table 11), indicates that many of the plants scored as budded may be 'false positives'. It is probable that in BGA and, possibly, YF the presence of an induced terminal bud reduces the potential of vegetative lower axillaries to continue producing leaves when transferred to LD, the effect being maintained even after pinching. The consequence of this is that leaf numbers on potential breaks of BGA effectively become 'fixed' soon after the start of short days and are little if at all affected by whether they remain in short days or are transferred to long days. Such a tendency is less evident in YF. Leaf number 'fixation' is shown in Table 11 derived from BGA - experiment 7.

Table 11. Leaf numbers on the uppermost break (Expt. 6, BGA)

Treatment (leaves/days)	Leaf No. Short days	Leaf No. Long days	Difference LD -SD
6/0	8.7	13.9 (7)*	5.2
6/3	8.4	13.6 (7)	5.2
6/6	8.3	11.1 (2)	2.8
6/9	8.3	9.7 (1)	1.4
6/12	8.0	9.9 (1)	1.9
8/0	7.6	11.1 (2)	3.5
8/3	7.4	11.6 (3)	4.2
8/6	7.0	9.1 (2)	2.1
8/9	7.4	8.6 (1)	1.2
8/12	8.0	8.7 (2)	0.7
10/0	7.0	10.7 (5)	3.7
10/3	7.3	8.9 (2)	1.6
10/6	7.6	9.3 (3)	1.7
10/9	7.6	8.3 (0)	0.7
10/12	7.4	7.9 (0)	0.5

* Number of plants with an incomplete leaf count at scoring.

Only in treatments pinched 0 or 3 days after this first became possible was there still appreciable potential for further extra leaf production after pinching and transfer to LD. It seems unlikely that these were the only treatments where breaks were not already budded at pinching since the implication of this would be that breaks below the 10th leaf tended not to be budded ater 14 SD whilst those below the 6th leaf were generally budded after 6 SD. 'Fixation' leads to a situation where leaf numbers on breaks associated with a particular position on the plant are likely to vary little regardless of the time of pinching (and length of pinch) - see next section.

Leaf Numbers Per Break (Plants in Short Days):

Table 12 shows leaf numbers on the uppermost break, related to the leaf number to which plants were pinched and averaged over times of pinching.

Table 12. Leaf numbers on the uppermost break as affected by leaf number below the pinch.

Expt.	Leaf number to which plants pinched 6	8	10	SD*	Error df
6 BGA	8.3	7.5	7.4	0.12	89
7 BGA	7.5	6.7	5.6	0.14	90
6 YF	10.0	7.3	6.4	0.15	89
7 YF	8.0	6.7	5.2	0.15	89

* SD in this and following Tables represents the standard deviation

In each case there were highly significant differences in numbers of leaves on the break depending on the leaf to which plants were pinched. Small interactions were shown with time of pinching in the latter three trials but no consistent trends were obvious, except that the treatment 6/0 tended to give the highest leaf numbers of all. It appeared that pinching to a higher leaf number led to less leafy uppermost laterals. It should be noted, however, that the differences in a given trial are little greater than differences for comparable treatments across the two trials for each cultivar.

Similar results were obtained for second lateral breaks (Table 13).

Table 13. Mean leaf numbers on the penultimate break as affected by leaf number below the pinch.

Expt.	Leaf number to which plants pinched 6	8	10	SD	Error df
6 BGA	8.8	7.8	7.4	0.12	87
7 BGA	8.1	7.2	5.9	0.14	89
6 YF	10.9	7.8	6.9	0.13	89
7 YF	8.9	7.5	5.5	0.15	87

As before, obscure interactions with time of pinching were shown in the latter three trials. Inflated leaf numbers in treatment 6/0 were clearly evident in experiment 6, YF. A factor which may contribute to the pinch leaf number effect is that lower axillary buds, being furthest from the site of apical dominance, may have less inhibitory restraint placed on their leaf production. Following release from apical dominance, after initiation of the terminal bud, they may also have a marginally longer period for leaf production before 'fixation' occurs.

In contrast to the clear effect of pinch leaf number, time of pinching had little or no systematic effect on leaf numbers on the breaks. This is as would be predicted as a consequence of leaf number 'fixation'. Data in Table 14 are for the uppermost break.

Table 14. Mean leaf numbers on the uppermost break as affected by time of pinching.

	Time of pinching (days)						
Expt.	0	3	6	9	12	SD	Error df
6 BGA	7.8	7.7	7.6	7.8	7.8	0.16	89
7 BGA	6.8	6.5	6.8	6.6	6.3	0.18	90
6 YF	8.4	8.0	7.9	7.6	7.6	0.15	89
7 YF	7.4	7.2	7.4	7.3	7.3	0.20	87

Significance was reached only for YF in experiment 6 where a trend of decreasing leaf number with time of pinching was shown in treatments pinched to 6 leaves. This may have been an effect of the time lag before 'fixation' occurs.

Data for penultimate breaks confirmed that time of pinching had little effect on this character (Table 15).

Table 15. Mean leaf numbers on the penultimate break as affected by time of pinching.

Expt.	Time of pinching (days) 0	3	6	9	12	SD	Error df
6 BGA	8.0	7.9	7.9	8.1	8.0	0.16	87
7 BGA	7.0	6.9	7.0	7.4	7.0	0.18	89
6 YF	9.0	8.6	8.5	8.3	8.0	0.17	89
7 YF	7.4	7.2	7.4	7.3	7.3	0.20	87

Number of breaks:

In general, it appeared that pinching to a higher leaf number increased the number of breaks (Table 16), but significant (generally obscure) interactions with time of pinching were shown in all cases. Plants pinched to 10 leaves may have given more breaks because there were more axillary buds for breaks to grow out from. A more likely explanation, however, is that the larger plants remaining after pinching to the higher leaf numbers had the higher dry weights and leaf areas necessary to support an increased number of breaks.

Table 16. Numbers of breaks as affected by pinch leaf number

Expt.	Leaf number to which plants pinched 6	8	10	SD	Error df
6 BGA	2.9	3.1	3.3	0.14	89
7 BGA	3.3	3.6	4.3	0.15	90
6 YF	3.1	3.9	6.0	0.15	89
7 YF	4.5	5.2	6.1	0.20	89

Less clear cut relationships were shown for time of pinching (Table 17).

Table 17. Numbers of breaks as affected by time of pinching

Expt.	Time of pinching (days) 0	3	6	9	12	SD	Error df
6 BGA	3.0	3.1	3.2	3.0	3.1	0.17	89
7 BGA	3.7	3.9	3.9	3.4	4.0	0.29	90
6 YF	3.9	4.0	4.1	4.5	5.2	0.20	89
7 YF	6.5	5.4	5.4	4.4	4.6	0.25	89

Whilst delaying the time of pinching appears to have increased break number for YF in experiment 6, the reverse trend is shown in experiment 7!

Flower Number:

The total numbers of flowers at or beyond the bud colour stage were recorded for each plant at harvest. In the case of BGA, where disbudding is practiced to retain only terminal flowers, axillary buds on the breaks are a disadvantage. The best strategy for BGA would be to optimise the pinching procedures to maximise the number of breaks, consistent with a reasonable cropping time. In the case of YF where disbudding is not practiced, axillary buds on the breaks are advantageous. Large numbers of breaks are still required to give a 'balanced' plant habit. Table 18 shows how flower numbers were affected by pinch leaf number.

Table 18. Numbers of flowers as affected by pinch leaf number.

	Leaf number to which plants pinched				
Expt.	6	8	10	SD	Error df
6 BGA	5.2	4.6	5.4	0.24	89
7 BGA	8.0	6.7	6.6	0.39	90
6 YF	6.2	6.0	7.3	0.23	89
7 YF	12.2	11.5	9.8	0.45	89

A distorting feature of these data was the extremely high flower numbers associated with treatment 6/0 in the latter three experiments (11.43, 8.00 and 18.86 respectively). These treatments gave relatively few but leafy breaks, with the majority of flowers for BGA and YF in experiment 7 being axillaries. Excluding 6/0 data gives average flower numbers for pinches to 6 leaves of 5.4 (6 BGA), 7.2 (7 BGA), 5.7 (6 YF) and 10.6 (7 YF). This effectively eliminates any possible benefits in flower number that pinching to 6 leaves may seem to have had.

The effects of time of pinching on flower number are shown in Table 19.

Table 19. Numbers of flowers as affected by time of pinching

Expt.	Time of pinching (days) 0	3	6	9	12	SD	Error df
6 BGA	5.0	5.0	5.9	5.0	4.6	0.31	89
7 BGA	8.2	8.5	7.5	5.3	6.0	0.50	90
6 YF	7.2	6.8	6.0	5.8	6.6	0.30	89
7 YF	16.1	13.4	11.5	8.1	6.9	0.57	89

Whilst accepting that some of the apparent advantages of the 0 day treatments were due to elevated flower numbers in the 6/0 treatments (see above), there seems little advantage to flower count in delaying the time of pinch.

Flower stage (Cropping Time):

Over and above the effects on leafiness of the breaks, numbers of breaks and numbers of flowers, pinching procedures affect ultimate harvest date. Data for BGA from experiment 6 are given in Table 20.

Table 20. Flower stage in BGA (Expt. 6) after 78 short days

Leaf number to which plants pinched	Time of pinching (days) 0	3	6	9	12	Mean
6	7.2	6.8	5.8	6.0	5.3	6.2
8	6.9	6.8	5.9	5.1	4.5	5.8
10	5.9	5.6	5.3	5.1	5.4	5.5
Mean	6.7	6.4	5.6	5.4	5.1	5.8

SD for a specific treatment = 0.35; df = 89
Note that the higher the score, the more open the flower.

The results appear clear on inspection, there being no significant interactions between the two factors. The higher the leaf to which the pinch was made, the later the date of ultimate harvest; the later the time of pinching to a particular leaf number, the later the date of ultimate harvest.

Best Pinching Procedures:

Given that the time of pinching to a given leaf number has little or no effect on leafiness of the breaks, numbers of breaks or numbers of flowers, but that delayed pinching does increase cropping time, there can be little reason other than to pinch to a given leaf number as soon as this becomes possible. This should, perhaps, be qualified by saying that avoiding the 0 day treatments seem advisable (characterised by pinch lengths of 1.0 cm or less). To avoid undue leafiness of the breaks and to maximise the numbers of breaks, pinching to 8 or 10 leaves would seem to be best. This recommendation is in line with normal commercial practice. Of these alternatives, pinching to 8 leaves gives more rapid flowering. Characteristics associated with the 8/3 treatment (pinch length of c. 1.5 cm) are shown in Table 21.

Table 21. Mean values associated with the 8/3 treatment

Expt.	Number of leaves		Number breaks	Number flowers	Number axillary flowers
	Upper lateral	Second lateral			
6 BGA	7.4	7.4	3.1	4.0	0.9
7 BGA	6.9	7.3	3.7	8.1	4.4
6 YF	7.1	7.4	3.7	6.3	2.6
7 YF	6.7	7.3	5.4	13.6	8.1

For comparison, values for the 10/3, later flowering treament are given in Table 22.

Table 22. Mean values associated with the 10/3 treatment.

Expt.	Number of leaves		Number breaks	Number flowers	Number axillary flowers
	Upper lateral	Second lateral			
6 BGA	7.3	7.6	3.3	5.4	2.1
7 BGA	5.3	5.6	4.7	9.1	4.4
6 YF	6.7	7.0	5.4	7.4	2.0
7 YF	5.6	5.6	6.3	13.6	7.3

It would appear that increasing quality (fewer leaves per break, more breaks and more flowers) results from leaving 10 leaves below the pinch. This increase in quality is at the expense of cropping time.

Variation:

Considerable differences are shown for the two times of experiment, with quality, as shown in Tables 21 and 22, being markedly better on the second occasion (March as opposed to January flowering). This is, presumably, a reflection of improved light conditions. More to the point, considerable variation was shown for each of the characters scored within a treatment in each of the trials. This shows up particularly for final flower stage, the dominant character in judging pot uniformity. Table 23 shows variances for this character in BGA for experiment 6.

Table 23. Variances for final flower stage (Expt. 6, BGA).

Leaf number to which plants pinched	Time of pinching (days)					Mean
	0	3	6	9	12	
6	0.99	1.07	0.57	0.92	1.27	0.96
8	1.12	0.74	0.31	1.39	1.58	1.03
10	0.39	1.48	0.15	0.56	0.62	0.64
Mean	0.83	1.10	0.34	0.96	1.16	0.88

Note - a variance of 1.00 indicates a range of at least two flower stages.

Pinching to 10 leaves generally gave smaller variances but this is probably only a consequence of smaller flower stage means (which tend to have smaller variances). A more obvious cause of variation lay in the relationship between plant size at pinching and final flower stage. Particularly small plants can be identified from the data sheets as those having had particularly short pinches removed from them compared to others given the same pinching treatment. These tend to have been delayed in final flowering. Examples, marked with asterisks, are given in Table 24.

Table 24. Relationships between pinch length and final flower score (Expt. 6, BGA)

Plant	BGA (8/3) Pinch length (mm)	BGA (8/3) Flower stage	BGA (10/3) Pinch length (mm)	BGA (10/3) Flower stage
1	25	7.5	25	6.0
2	5*	5.0	25	6.0
3	15	6.5	20	7.0
4	15	7.0	15*	4.5
5	20	7.5	25	6.0
6	20	7.0	10*	3.5
7	20	7.0	20	6.5

A more detailed investigation is required to test this association further. The problem is how to cope with it, other than to replace obviously small plants as soon as possible after propagation. Some options are: a) pinch rigorously to a given leaf number and accept the variation as above; b) pinch to a uniform height and accept that this will give variation in leaf number, c) remove a standard length of pinch which gives variation in stem length and leaf number. Experiment 8 represents a preliminary experiment to test these alternatives.

Experiment 8

A correlation matrix on an 'all cuttings' basis for BGA showed clear relationships between ultimate plant performance and stature after pinching (Table 25).

Table 25. Correlations (all cuttings) for BGA (Expt. 8)

Character	Height after pinching	Leaf number after pinching
Number of breaks	0.52 ***	0.55 ***
Number of flowers	0.58 ***	0.55 ***
Length - upper break	-0.18 ns	-0.16 ns
Leaves - upper break	-0.43 ***	-0.46 ***
Flower stage	0.54 ***	0.37 *** df = 276

This would appear to support the contention that if one could get uniformity for leaves and height at pinching, so as to give uniformity after pinching, the problem of variability would be somewhat ameliorated, since other characters (except length of the upper break) appear to be influenced by these.

An almost identical picture emerged for YF (Table 26).

Table 26. Correlations (all cuttings) for YF (Expt. 8)

Character	Height after pinching	Leaf number after pinching	
Number of breaks	0.54 ***	0.58 ***	
Number of flowers	0.61 ***	0.54 ***	
Length - upper break	-0.08 ns	-0.20 *	
Leaves - upper break	-0.25 **	-0.48 ***	
Flower stage	0.51 ***	0.45 ***	df = 293

It is not clear which of leaf number and height is the primary determinant since these are also significantly correlated (0.65 *** for BGA; 0.70 *** for YF). It is possible that a third unifying character, such as dry weight, underlies some of the associated responses.

Variation within pots (expressed as log 10 variance, or log 10 [variance plus 1]) associated with the three treatments are given for BGA in Table 27.

Table 27. Mean variances for BGA associated with pinching treatments (Expt. 8)

Character	Constant height	Constant leaf	Constant pinch	SD	df
Number of breaks	0.123	0.131	0.242	0.028	56
Number of flowers	0.154	0.181	0.361	0.036	56
Length - upper break	2.161	2.127	1.839	0.091	56
Leaves - upper break	0.357	0.323	0.300	0.046	56
Flower stage	-0.305	-0.311	-0.157	0.123	56

The constant pinch treatment gave significantly more within-pot variation than the other two treatments for numbers of breaks (**) and flowers (***), but less for length of the upper break (*). The increased variance for final flower stage was non- significant. There were no significant differences between pinching to a constant height and pinching to a constant leaf number. Adopting the correlation matrix approach for all pots in the experiment indicated that variation both in leaves to the pinch and height to the pinch correlated with variation in number of breaks and numbers of flowers. Variation in height also correlated with variation in final flower stage (Table 28).

Table 28. Correlations for variances (all pots) in BGA (Expt. 8)

Character	Height after pinching	Leaf number after pinching
Number of breaks	0.43 ***	0.50 ***
Number of flowers	0.54 ***	0.44 ***
Length - upper break	-0.05 ns	-0.03 ns
Leaves - upper break	-0.14 ns	0.09 ns
Flower stage	0.39 ***	0.10 ns df = 57

Corresponding data for YF are shown in Tables 29 and 30.

Table 29. Mean variances for YF associated with pinching treatments (Expt. 8)

Character	Constant height	Constant leaf	Constant pinch	SD	df
Number of breaks	0.344	0.300	0.541	0.051	57
Number of flowers	0.776	1.032	1.213	0.077	57
Length - upper break	2.092	2.035	1.915	0.096	57
Leaves - upper break	0.352	0.255	0.192	0.034	57
Flower stage	0.060	0.114	0.124	0.063	57

Table 30. Correlations for variances (all pots) in YF (Expt. 8)

Character	Height after pinching	Leaf number after pinching
Number of breaks	0.46 ***	0.50 ***
Number of flowers	0.75 ***	0.35 **
Length - upper break	-0.13 ns	0.21 ns
Leaves - upper break	-0.15 ns	0.20 ns
Flower stage	0.33 **	0.13 ns df = 58

The correspondences for BGA and YF are remarkable. The conclusion is inescapable that variation after pinching (and probably prior to pinching) plays a significant part in determining variation thereafter. Of the three treatments tried, the constant pinch method is, perhaps, marginally the worst in giving greater variation in number of breaks and numbers of flowers. That these effects are, at least in part, mediated through greater variation in height and leaf number after pinching is demonstrated in Table 31.

Table 31. Mean variances in BGA and YF after pinching associated with pinching treatment (Expt. 8)

Character	Constant height	Constant leaf	Constant pinch	SD	df
Height to pinch (BGA)	0.000	1.931	2.433	0.075	56
Height to pinch (YF)	0.000	0.724	2.063	0.105	57
Leaves to pinch (BGA)	0.291	0.000	0.437	0.041	56
Leaves to pinch (YF)	0.370	0.022	0.407	0.031	57

Final flower stage was correlated with height after pinching in both BGA and YF (Tables 25 and 26) and variation in flower stage was also correlated with variation in height (Tables 28 and 29). Furthermore, pinching to a constant height gave the smallest variance for flower stage in YF (although not significantly so) and as small a variance as pinching to a constant leaf number in BGA (again there were no significant differences). None of the treatments fully eliminated variation but pinching to a constant height may be marginally the best.

NEXT STEPS

A repeat experiment is required to test the effects of different pinching procedures.

Although it may not be practicable in commerce to regrade plants at the time of pinching, it is essential that this be tried on an experimental basis to test whether achieving uniformity at this stage will largely eliminate subsequent variation.