readily available information in what to look for in good trees and on good handling and establishment techniques. M.A.F. "Ag Links", N.Z.F.S. Extension Officers, Catchment Authorities, Farm Forestry Associations, and the N.Z. Nurserymen's Association should all have pamphlets giving this information.

6. The present nursery registration system should be scrapped in favour of a well informed group of advisors sponsored by M.A.F., N.Z.F.S., or N.Z.N.A. who can advise growers, retailers, and customers on the suggested techniques outlined above.

INFLUENCE OF SEVERAL PRE-SOWING TREATMENTS ON GERMINATION OF *CYCLAMEN PERSICUM* SEED

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Abstract. Several pre-germination treatments were given to *Cyclamen persicum* Mill. seed with the objective of improving germination percentage, speed, and uniformity. Soaking seed in water and in gibberellic acid improved germination speed, but the latter reduced survival. Etridiozole, benomyl, thiram, and sodium hypochlorite treatments did not reduce or delay germination as has been reported elsewhere, but gave no consistent advantage.

INTRODUCTION

Improvements in germination of *C. persicum* seed have been achieved through sodium and calcium hypochlorite surface disinfection treatments (1,8) but optimum germination has not been attained on a routine basis (12). *C. persicum* seeds show variability in uniformity, speed, and germination percentage, and are highly sensitive to environmental and pathogenic factors.

In 1977, 1.13 to 2.75 cents (NZ) were paid per cyclamen seed. Low and irregular germination of this expensive seed contributes to already high production costs particularly with increasing use of the more highly priced F_1, hybrid seed.

Germination of freshly harvested cyclamen seed tends to be slow and irregular (6,9), therefore, the following series of experiments used aged seeds. Heydeker (4) states that the ideal assessment of germination is taken when a viable, self-supporting photosynthesising plant has been produced. To avoid discrepancies between results, seedlings must be grown

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sufficiently large that defects can be seen and borderline cases included (or excluded) consistently. The experiments reported here were designed to examine the influence of a range of pre-sowing treatments and chemicals on germination speed and percentage.

MATERIALS AND METHODS

Four experiments were carried out to study the influence of pre-sowing treatments on the germination of *Cyclamen persicum* seed.

Experiment A — Water soak treatments.

Cyclamen seed of the cultivars, 'Rose of Aalsmeer', 'Early Deep Scarlet', 'Fringed Mont Blanc', 'Mont Blanc' (plan white), and 'Perle of Zehlendorf' were given surface disinfection in 5% sodium hypochlorite solution for one minute. The seeds were rinsed and soaked in sterile distilled water for 0, 1, 12, or 48 hours. Forty seeds of each cultivar were blocked according to cultivar, each with five randomised blocks.

On 31 March, 1977, seed was sown into trays of Springhill sphagnum peat containing 37 g a.i.m.$^{-3}$ etradiazole fungicide (Terrazole 50% wettable powder). The trays were placed in a germination cabinet in the dark at 15°C, and watered as required. After one month, the trays were removed to a glass-house and the emerging seedlings watered fortnightly with a balanced liquid fertiliser. A drench of benomyl was applied at this stage.

Experiment B — Water soak and fungicide treatments.

Seeds in this and subsequent experiments had been stored for 18 months to eliminate the post-harvest delay. Massante (1963) has shown that cyclamen seed can be stored for long periods without loss of germination potential. Seed of 'Aalsmeer Giants' and 'Foremost Mixture' (Colegraves' Seeds, England), was pretreated or sown with a treatment solution or suspension as specified in Table 2. Seeds were sown on 3 November, 1978 in sterile petri dishes on germination paper which had been soaked in 10ml of sterile distilled water or a treatment solution/suspension. The dishes were placed in the dark at a mean temperature of 19.4°C with a maximum of 23°C and a minimum of 12°C. Distilled water was added in 5 ml aliquots as required.

Experiments C and D — Gibberellin, fungicide, and water treatments.

The effect of gibberellic acid (GA_3), thiram, benomyl, etradiazole, and hot water treatments on germination of *C. persicum* seed were studied.

Two experiments were intended to further investigate the preliminary results from Experiment B. Seed of cyclamen cultivars, 'Early Pink', 'Perle von Zehlendorf', 'Mont Blanc', (plain white), 'Rose von Aalsmeer', 'Early Pure White', 'Early Flowering Deep Scarlet' (Arthur Yates, NZ), were surface disinfected in sodium hypochlorite (see Expt. A) and, after treatment as detailed in Table 3 and 4, were germinated in conditions described for Experiment B. The experiment was, therefore, a randomised block experiment of six replicates.

ASSESSMENT AND ANALYSIS OF DATA

In Experiment A germination was recorded when the seedlings emerged from the medium. In Experiments B, C, and D, seedling emergence was recorded, but germination was not regarded as complete and successful until a clearly defined corm and root system had formed and the first leaf was extending. The variation in morphological development creates a major source of error in the timing of this stage. Uniformity of germination was measured as the days between germination of the first and last seeds. Duncan's new multiple range test was used to compare all treatments.

Fungal colonies from the seed plates were grown on potato destrose agar and exmined for pathogens.

RESULTS

Experiment A. Overall germination was poor and treatments showed no significant influence on percentage germination (Table 1). Speed of germination was improved according to the length of imbibition treatment. A 48 hour water soak reduced mean germination by 12 days.

Table 1. Experiment A: The effect of pre-sowing water imbibition treatments on germination of *C. persicum* seed.

Treatment	Mean percent germination	Mean days to emergency
Control	25 a	51 a
1 hour imbibition	23 a	49 b
12 hours imbibition	26 a	44 c
48 hours imbitition	29 a	39 d
CV percent	15.6	4.33

Any means not followed by the same letter are significantly different at the 5% level according to Duncan's new multiple range test.

Experiment B. Although a high degree of significance was not achieved in this preliminary trial the results (Table 2) suggested the following:

(i). Although a faster rate of germination occurred as a

result of higher levels of GA_3 treatments, such treatments tended to reduce germination percentage while occasionally influencing uniformity.

(ii). The fungicidal treatments improved germination percentage, but here etradiazole and thiram showed a slight tendency to slow germination.

(iii). Hot water reduced germination percentage.

Table 2. Experiment B: Influence of different treatments on germination of cyclamen seed.

Treatment	Mean percent germination		Means days to germinate		Mean uniformity (days)	
Untreated	52	abcd	40.3	b	38.5	abc
Water soak, 1 min	55	abcde	41.0	bc	46.0	bc
SD (Control)	41	abcd	47.0	de	44.6	abc
SD 2hr water soak	48	abcde	40.4	bc	27.5	abc
SD GA_3, 1 ppm[2]	30	a	40.4	b	12.0	a
SD 2hr soak, 1 ppm GA_3	40	abcd	46.9	de	33.0	abc
SD 2hr soak, 10 ppm GA_3	43	abcde	40.8	b	22.0	abc
SD 2hr soak, 50 ppm GA_3	31	ab	39.9	b	47.5	bc
SD 2hr soak, 100 ppm GA_3	32	abc	34.6	a	35.0	abc
Hot (60°C) water, 5 min soak	32	abc	41.6	bc	47.5	bc
0.01% a.i. benomyl pretreatment	52	abcde	43.8	bcde	33.5	abc
SD 0.01% a.i. benomyl pretreatment	58	de	43.4	bcde	38.0	abc
1.0% a.i. benomyl pretreatment	60	de	43.1	bcd	36.0	abc
SD 0.005% a.i. etradiazole[1]	61	de	41.4	bc	30.8	abc
0.005% a.i. etradizole[1]	44	abcde	40.4	b	17.0	ab
0.05% a.i. etradiazole[1]	57	bcde	45.4	bcde	46.9	bc
0.5% a.i. etradiazole[1]	56	bcde	48.0	e	41.0	abc
Benomyl and etradiazole[2]	60	de	40.6	b	40.5	abc
0.1% a.i. thiram pretreatment	59	de	41.6	bc	51.0	c
SD 0.1% a.i. thiram pretreatment	67	e	43.8	bcde	47.5	bc
0.5% a.i. thiram pretreatment	59	de	46.3	cde	35.5	abc
1.0% a.i. thiram pretreatment	58	de	44.3	bcde	35.0	abc
CV%	24.5				38.6	

[1] Supplied as suspension or solution in the water in which the germination pad was soaked.
[2] 0.1% Benlate pretreatment and 10 ppm 0.005% etradiazole[1].
SD = surface disinfected for one minute in 5% sodium hypochlorite solution.

Experiment C. Gibberellic acid treatments gave up to eight days' improvement in germination time (Table 3), but the levels which gave these improvements resulted in 15% reduction in germination. Pre-soak GA_3 treatments showed greater improvements in germination speed than where the solution was included in the germination solution. No significant changes in uniformity of germination occurred.

Table 3. Experiment C: The effect of gibberellic acid on germination of cyclamen seed.

Treatment	Mean percent germination	Means days to germinate	Mean uniformity (days)
Control	64.8 b	39.9 a	32.3 a
0.1 ppm GA_3[1]	76.7 a	39.1 a	27.2 a
1.0 ppm GA_3[1]	56.7 bc	39.0 a	25.7 a
10 ppm GA_3[1]	41.8 d	35.9 ab	28.2 a
1 ppm GA_3 pretreatment[2]	56.5 bc	33.7 b	13.2 a
10 ppm GA_3 pretreatment[2]	48.8 cd	27.9 c	36.3 a
100 ppm GA_3 pretreatment[2]	49.0 cd	32.2 b	21.5 a
CV%	15.4	10.2	61.7

[1] Supplied with the solution in which the germination pad was soaked (10ml).
[2] Pretreatment here means a two-hour soak.

Treatments not followed by a common letter are significantly different at the 5% level according to Duncan's new multiple range test.

Experiment D. Overall no significant differences occurred among treatments in germination percentage. Because the controls of two cultivars showed an average of 92.5% germination, they were excluded from a repeat analysis of variance which showed a significant germination improvement as a result of 0.05% a.i. etradiazole treatment and 0.1% a.i. benomyl pretreatment (Table 4).

A 1.0% a.i. benomyl pretreatment significantly improved speed of germination. No differences in uniformity were significant.

It was not possible to determine causes of failure. Identified fungi growing on the seeds and those isolated were all common saprophytes.

Table 4. Experiment D: Effects of various fungal protection treatments on germination of cyclamen seed.

Treatment	Mean percent Germination	Mean Germination[1]	Mean days to Germinate	Mean Uniformity (days)
Hot (60°C) water, 5 min soak	56.2 a	24 a	43.7 a	26.5 a
Control	57.3 a	40.7 b	40.5 ab	32.3 a
0.1% a.i. thiram pretreatment	68.0 a	44.3 bd	43.1 a	39.5 a
1.0% a.i. thiram pretreatment	66.7 a	48.7 bde	41.9 a	20.4 a
0.05% a.i. etradiazole[2]	79.0 a	63.3 e	40.2 ab	20.2 a
0.5% a.i. etradiazole[2]	70.8 a	41.7 b	37.0 b	27.3 a
0.1% a.i. benomyl pretreatment	75.3 a	57.3 de	37.9 b	15.8 a
1.0% a.i. benomyl pretreatment	71.3 a	45.7 bd	31.0 x	18.2 a
C.V.%	15.4	24.7	7.57	54.6

[1] Cultivars: Plain White, Early Flowering Deep Scarlet, and Plain Rose Vaalsmeer only. Those means not followed by a common letter are significantly different according to Duncan's new multiple range test at the 5% level.
[2] Supplied in the solution in which the germination pod was soaked. Pretreatment here means a 1 minute dip.

DISCUSSION

Imbibition treatments improved speed of germination without improving germination strike (Table 1). Anderson and Widmer (1) found that imbibition was complete within 12 hours but that, here also, germination improved further on soaking for longer than 12 hours. Anderson and Widmer (1) and Hakozaki (3) found improvements in germination percentage as well as speed as a result of water soak treatments, but their method of data collection at fixed dates could have resulted in misinterpretation of late germination as a failure. Because seed populations vary continuously, it is not possible to draw conclusions about a successful population from the size of the unsuccessful one (5). The high proportion of failures tends to indicate that the number of failures could have been higher.

Poor germination levels in Experiment A can be attributed to erratic temperature control by the germination cabinet. Germination of *C. persicum* seed is inhibited at temperatures over 20°C (5,7).

Although gibberellin treatments improved speed of germination in both Experiments B and C (Table 2 and 3), strike was reduced. Our results are similar to those reported by Anderson and Widmer (1). This treatment does not influence a known dormancy condition; the delay in germination of recently harvested seed reported by Sumitomo and Kosugi (9), and Katsuki and Okazaki (6) should not have influenced germination of these aged seed. It can be concluded therefore that the effect was a result of typical gibberellin cell division and elongation effects. See Wareing and Philips (11). Anderson and Widmer (1) found thiram, truban, captan and benomyl all tend to inhibit seed germination. Valaskova (10) found that cyclamen seed germination was sensitive to a wide range of soil disinfection treatments. Grundler (2) also found poor emergence following thiram treatment, but improvements with phenyl mercury acetate treatment.

It is notable that the strongest advantage in percent germination occurred at the lower concentrations of fungicides used in both Experiments B and D (Tables 2 and 4). This suggests that high levels of benomyl, thiram, and etradiazole may be phytotoxic and that the poor results of others may be due to

excessive concentration of fungicide. An apparent delay in germination as a result of etradiazole treatment observed in Experiment B (Table 2) was not confirmed by Experiment D (Table 4). The advantage conferred by fungicidal treatments will probably vary according to the microflora present.

Further work may be necessary to determine the most suitable levels of these fungicides, but it seems reasonable to recommend their continued use at low levels as a precautionary measure.

Hypochlorite surface disinfection was used as a general precautionary measure in Experiments A, C, and D. This practice has been recommended by Neuray (8) and Anderson and Widmer (1), but Experiment B (Table 2) suggests that a more detailed investigation might show significant reductions and delay in germination. Neuray (8) reported a delay in germination as a result of this treatment.

PRACTICAL CONSIDERATIONS

The germination experiments did not succeed in demonstrating a consistent means of gaining optimum cyclamen seed germination. Gibberellin treatments did increase speed of germination, but associated decreases in germination percentages make this treatment unacceptable. Soaking seed in still or flowing water for 48 hours prior to sowing improved germination speed without decreasing germination percentage.

Drenches of 10 ppm Terrazole (etradiazole, 50% a.i.) to the seed medium and/or seed dip in 1 g l^{-1} Benlate (benomyl 50% a.i.) is recommended as a precaution against pathogenesis.

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AIDS TO PRODUCTION AND MARKETING IN A SMALL NURSERY

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As plant propagators we are all practising conservation. It is in our interests to see that the conservation effort extends to a better use of our capital and labour inputs. Many small nurseries, and indeed larger enterprises, struggle with a shortage or at least an imbalance of capital and labour and the results show up in a variety of ways such as poor production or marketing volumes, or poor plant quality. Conservation means using what resources we have wisely. We need to make our operations cost-effective. We need to practice economy. If our businesses are running well we will have better opportunity to develop our propagation skills.

Although I am intensely interested and involved in ornamental plant production generally, I came into nursery work from a background in business management, economics, and accountancy. I use my previous experience to make my small nursery successful and my work enjoyable. The total labour force is equivalent to two full time labour units. We produce container grown ornamentals with an Australian plant emphasis. These plants are retailed from the property.

Firstly, I wish to emphasise that one of the basic keys to a successful nursery operation is good layout. With only two people in my nursery, good visual control is important, and this is achieved by grouping the retail area, the potting shed, and house, etc. around a central carpark. This reduces unproductive time to a minimum.