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IMPROVING PRODUCTION OF ANEMONE ST PIRAN

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IMPROVING PRODUCTION OF ANEMONE ST PIRAN

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IMPROVING PRODUCTION OF ANEMONE ST PIRAN

RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

APPLICATION

The aim of this project was to improve corm and flower production of the St. Piran anemone, a superior selection of the de Caen anemone. The experimental work identified improved corm drying and storage methods, tested fungicides for controlling storage moulds, showed that vernalisation could be used for earlier flower production, and identified suitable herbicides for use in corm beds. By using and developing these techniques, growers could exploit the qualities of St Piran (eg, superior cold hardiness and disease-resistance) in the expanding European cut-flower market.

SUMMARY

St. Piran, a selection of the de Caen anemone, was produced at Rosewarne Experimental Horticulture Station. With its good flower quality, winter-hardiness and disease-resistance, St. Piran had the potential to revive interest in this traditional crop of south-west England. This project was set up in 1987 to find ways of improving corm and flower production of St. Piran.

Germination rates of St. Piran and Dutch de Caen corms varied between about 50 and 80 per cent in different tests and different years. Even at best, the percentage germination was disappointing, and instances of poor performance appeared partly due to *Penicillium* mould and *Erwinia* soft-rot. A range of fungicides was evaluated as pre-storage corm dips. Tolclofos-methyl was found to result in 80 per cent corm germination, compared with 61 per cent for untreated controls; most other fungicides tested gave rates similar to controls. Controlled drying and storage regimes were found to improve subsequent corm germination greatly, compared with using ambient temperatures. Post-lifting drying at 20°C gave superior results to drying at fluctuating ambient temperatures, regardless of subsequent storage conditions, although storage at 15°C and 60 per cent relative humidity gave the best results, almost 100 per cent germination. Under such regimes, adding a pre-storage fungicide dip gave no further advantage.

Corms are usually sown in May to maximise production of pre-Christmas flowers. June or July sowings would be preferred in some cases, so smoking, soaking and vernalisation treatments were evaluated to see if earlier production could be obtained from late-planted corms. Vernalisation consisted of storing corms in moist peat at 1°C for 6 weeks before planting. One experiment showed that vernalisation of June-planted corms increased the early crop of flowers, whereas smoking was ineffective and soaking reduced yields. July sowings produced poor flower yields, irrespective of corm treatments. A further experiment showed that, for vernalisation treatments to be successful, corms stocks must be free of fungal disease to withstand the moist conditions. Raising plants in peat blocks and transplanting gave slight earliness, whereas cell-raised plants were later to develop.

Advice is needed for controlling weeds and moss in anemone corm beds. Many of the herbicides tested in trials were ineffective or phytotoxic to the crop, but high rates of

clopyralid or terbacil appeared to be useful, especially if applied in winter rather than spring. For moss control, low rates of thiram or dichlorofen, applied in December, were effective and safe.

By putting into effect the above findings, anemone growers could certainly expect to improve plant stands and corm yields, while vernalisation treatments give scope for better pre-Christmas flower crops. St. Piran is a highly attractive flower which deserves to have a part in the expanding European cut-flower trade. Although carried out with specific reference to St. Piran, many of these recommendations could be expected to apply to de Caen anemones in general.

IMPROVING PRODUCTION OF ANEMONE ST PIRAN

EXPERIMENTAL SECTION

INTRODUCTION*

The anemone is long established in English floriculture, being one of the first flower products handled by the commission salesmen of Covent Garden in the late 1890s, and there are accounts of even earlier marketing in small mixed bunches by London hawkers. Most of the trade seems to have been French-grown *Anemone coronaria* of excellent quality, and, although there were also seedlings of this type from English growers, the most effective response to imports came from *A. fulgens*, an early speciality in the Isles of Scilly marketed between December and March.

After the Second World War the home production of *A. coronaria* was boosted in Cornwall by the efforts of Canon Boscawen of Ludgvan, who demonstrated the viability of commercial production from spring-sown seed crops for winter flowering. Some corm crops were also grown, the larger sizes (up to 5-6 cm circumference) being preferred, but Cornish growers seem to have concluded that 2-3 cm corms were most suitable to their growing conditions, or pockets, and this is the grade which has remained in most demand.

Corms were exclusively imported from The Netherlands, and grown as a colour-mix, though single colours like the cultivars Hollandia, Sylphide, Mr Fokker and The Bride were available and grown separately in commerce into the 1960s.

In 1939, 600 acres (*ca.* 240 ha) of *A. coronaria* were being grown in the south-west counties of Cornwall, Devon and Somerset, and, following an inevitable retraction during the war years, the acreage rose still higher to *ca.* 400 ha during the 1950s (ADAS, 1983). The crop enjoys the cool and moist summers and usually mild winters of the south west, and in its heyday was to be found on most dairy farms of West Cornwall, especially where the contribution to winter income and employment was valued. The anemone continues to do well in rotations where it may follow broccoli, early potatoes and cabbage.

The incidence of fungal and viral diseases, a reduction in quality and winter hardiness, and consequent and other economic pressures resulted in a decline in interest and acreage. In the early 1960s, Rosewarne Experimental Horticulture Station (EHS) responded to grower interest and embarked on a selection programme to produce stocks with superior winter hardiness and flower quality (Gill, 1980). The anemone can be kept broadly true-to-colour by selection and isolation, and nine colour families were developed by the meticulous efforts of a team led by Betty Jeff and later Margaret Gill. The culmination of this work was the establishment of the St Piran strain, which, together with a practical package of seed and corm raising know-how, and a programme of husbandry trials, made Rosewarne EHS the prime reference point for those seeking knowledge on anemone culture in the open or under protection.

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*This Introduction largely follows the text of Mr M R Pollock's progress report given in October 1988 (Pollock, 1988). The reader is referred to the 'Postscript' for the current status of St. Piran.

In 1977 marketing rights for the St Piran strain passed to Messrs Lingarden Ltd of Spalding through the agency of the National Seed Development Organisation Ltd. (NSDO). The Somerset-based co-operative group Wyvern Growers Ltd., whose association with Rosewarne in the St Piran project was of several years' standing, retained the corm production role in collaboration with Lingarden Ltd. In 1984 Rosewarne relinquished responsibility for the maintenance of basic stocks of St Piran, passing breeding lines and equipment to Wyvern Growers, and delivering seed and corm material to NSDO for storage of the genetic base.

The 1987 MAFF Census Return suggested that the acreage of outdoor anemone production then stood at only 86 acres (*ca.* 35 ha). If the average ADAS suggested output for commercial anemone flower production is taken at £14800 per ha (1988 figures), a total value of over £0.5 m results. This takes no account of revenues from retail corm sales or export opportunities. Over and above this the St Piran strain is valued for its low expression of leaf curl disease (due to *Colletotrichum* spp.) in comparison with corms raised overseas.

For the anemone St Piran to reach its full potential and compete for a profitable place in the greatly expanded European cut flower market, field production of corms and blooms must be maximised. This project between HDC, Lingarden Ltd and Rosewarne EHS was started in May 1987 with the aim of improving crop production, crop establishment, continuity of production and length of season using the St Piran strain. There were five components to the project:

1. Investigation of germination and uniformity of emergence of St Piran anemone corms compared with a Dutch-raised variety.

2. Investigation of drying and storage techniques for St Piran anemone corms.

3. Evaluation of fungal dips for the control of disease of St Piran anemone corms during storage and subsequent planting.

4. Investigation of early flower production techniques from late-planted St Piran anemone corms.

5. Evaluation of herbicides for the control of weeds and moss in St Piran anemone corm beds.

It should be noted that results quoted apply only to the batches of corms tested, and cannot necessarily be generalised to a strain as a whole. It should also be noted that some products or active ingredients used in these experiments may no longer be on the approved list of pesticides (eg, Format, Algofen, chloroxoron). The use of product names, rather than active ingredient names, under 'Results' is for convenience, and should not be taken to imply endorsement, or otherwise, of the product.

MATERIALS AND METHODS

Plant material

Corms (or tubers) of the St Piran strain of *Anemone coronaria* de Caen were supplied by Lingarden Ltd or obtained direct from Wyvern Growers, Yeabridge, South Petherton, Somerset. Dutch-grown corms of anemone de Caen (treatment history unknown) were obtained from Lingarden Ltd.

Experiments were carried out at Rosewarne EHS, Camborne, Cornwall, or (Experiment 5) at Yeabridge. Cultural procedures followed standard practices (eg, see ADAS, 1983) at Rosewarne or Yeabridge. Routine herbicides used for field germination tests were terbacil (in 1987 and 1988) and lenacil (in 1989).

Experiment 1: corm germination tests

(a) Laboratory tests Standard seed trays were filled with a mixture of 3 litres medium grade vermiculite and 1 litre aqueous captan (as 3 g Captan/litre). Fifty corms per tray were evenly spaced and pressed into the surface of the substrate, but were not covered. Each seed tray was enclosed (but not sealed) in a thin (120 gauge) polythene bag, and placed in a constant-temperature store at 15°C. Three replicate trays were set up for each of St. Piran and Dutch corms. Trays were inspected daily (up to 4 weeks), and the number of germinating corms recorded as those producing both shoots and roots.

(b) Field tests Fifty corms were planted in field plots in rows 0.5 m apart with in-row corm spacings of *ca.* 125 mm (eg, in plots 1 m x 3 m with double rows). Three replicate plots of each strain were used. Corm emergence was assessed three times a week over 3 months.

Laboratory and field tests were carried out in May 1987, 1988 and 1989.

Experiment 2: corm drying and storage

St. Piran corms were collected from Yeabridge immediately after lifting and washing in July. They were dried for 14 days in forced air, either at ambient temperatures or at a controlled 20°C. After drying, corms were either dipped in aqueous thiram (as 4 g Thiram/litre) or were left undipped. Corms from all treatment combinations were stored at the following combinations of temperature and relative humidity: 15°C/75%, 15°C/60% or 20°C/75%. In the following May corms were tested for germination using the field test described above under Experiment 1(b).

The experiment was carried out in 1988 and repeated in 1989.

Experiment 3: fungicide dips

In June 1988 corms were lifted and washed at Yeabridge, and then received one of seven 3-hour dip treatments immediately:

1. fenpropimorph (as 0.25 ml Mistral/litre);
2. dichlofluanid (as 1 g Elvaron/litre);
3. thiram (as 4 g Thiram/litre);
4. tolclofos-methyl (as 0.25 g Rizolex/100 g corms);
5. thiabendazole (as 0.5 ml Storite Clear Liquid/litre);
6. furalaxyl (as 1 g Fongarid/litre); and
7. control (not dipped).

Corms were dried at 15°C, stored at 15°C and 60% relative humidity and field emergence tests were carried out in May 1989 as described under Experiment 1(b). There were three replicates of 50 corms each for each dip treatment. Plants were assessed for diseases at intervals and finally 12 weeks after sowing.

Experiment 4: methods for early flower production from late-planted corms

St. Piran corms received one of five treatments before planting:

1. untreated;
2. smoked;
3. soaked then smoked;
4. vernalized; and
5. soaked, smoked and vernalized.

Smoking consisted of placing the corms in a sealed cabinet in which straw (50 g/m^3) was burnt twice in a 48-hour period. Soaking was carried out using running tap-water for 24 hours. Vernalization consisted of storing corms in moist peat at 1°C for 6 weeks, the corms being soaked in aqueous captan (as 3 g Captan/litre) for 10 minutes beforehand. Treatments were carried out for two planting dates in 1987, 17 June and 8 July. There were four replicates of 240 corms each for each treatment at each planting date. Corms were planted in rows 0.5 m apart, with in-row spacings of 125 mm (15 m^2 plot size). The numbers and quality of flowers cropped was recorded regularly.

The trial was repeated in 1988/89, with planting dates of 22 June and 6 July 1989.

These and other techniques for improving crop establishment and early flower production were examined in a supplementary experiment (Experiment 4a) in 1988-89. St. Piran corms were planted during the week beginning 23 May 1988, either (a) dry (untreated controls), (b) after vernalization (as above), (c) using plants raised in cellular trays, (d) using plants raised in peat blocks, or (e) after soaking in running tap-water for 12 hours. There were four replicate plots of 120 corms each for each treatment, planted as for Experiment 4 (7.5 m^2 plots). Numbers and grades of flowers cropped were recorded regularly.

Experiment 5: weed and moss control

Herbicide trial 1987-88 The first weed control experiment was conducted in 1988 on standard seed-raised corm production crops of St. Piran growing at Yeabridge. Herbicide treatments, applied to plots 2.5 m long x 2 m wide, were:

clopyralid (as 1, 2 or 3 litre Format/ha);
metoxuron (as 5 litre Dosoflo/ha);
metoxuron + wetter (as 2.5 litre Dosoflo + 5.5 litre Actipron/ha);
oxadiazon (as 2 or 4 litre Ronstar/ha);
bentazone (as 3 litre Basagran/ha);
alloxydim-sodium (as 3 kg Clout/ha);
pendimethalin (as 3 or 6 litre Stomp/ha);
napropamide (as 5 litre Devrinol/ha);
bromocil (as 1 kg Hyvar X/ha);
aziprotryne + wetter (as 2 kg Brasoran + 5.5 litre Actipron/ha);
sodium monochloroacetate (30 kg/ha);
glyphosate (as Roundup Weedwipe); and
control (no herbicide treatment).

Herbicides were applied in 1100 litre/ha using a knapsack sprayer, except for glyphosate which was applied as a weedwipe treatment along and across crop rows. There were four 'replicate' areas (numbered 1 to 4, respectively, in 'Results'), replicate 1 (on a site previously treated post-crop-emergence with clopyralid) being treated on 28 March 1988, and replicates 2 to 4 (on previously untreated sites) being treated on 30 March, 13 April or 27 April, respectively.

The effects of treatments on weeds and the crop were assessed at intervals. The main assessment was made on 4 May 1988, when mayweed was the main weed present, on a scale from 0 (no visible damage) to 5 (leaves severely damaged). A further assessment was made on 2 June 1988, when the weed population was more diverse: each species was scored from 0 (absent) through 1 (occasional weeds present) and 2 (half of plot covered) to 3 (most of plot covered). At the end of cropping, corms were recovered and their germination was assessed in a field test in May 1989, as described for Experiment 1(b).

Herbicide trial 1988-89 A second trial was carried out on crops at Yeabridge, with experimental details generally as before except that the trials area had been sterilized using methyl bromide on 8 August 1988. The crop was sown on 23-25 August 1988, and pre-emergence terbacil was applied on 12 September 1988. The herbicide treatments were:-

terbacil (as 0.13, 0.25 and 0.5 kg Sinbar/ha);
clopyralid (as 1, 2 or 3 litres Format/ha);
metamitron (as 2.5, 5 or 10 kg Goltix WG/ha); and
control (no herbicide treatment).

These treatments were applied to plots in one bed in late-December 1988 (after which plots were covered with polythene) and to plots in another bed in late-March 1989 (after cover removal). Treatment combinations were not replicated. Crop growth was scored form 1 (poor) to 5 (good) and weeds from 1 (most weeds) to 5 (least). The numbers and weights of anemone corms recovered from plots were recorded. Subsequent corm emergence was not studied.

Moss killer trial 1988-89 Experimental details were as for the preceding experiment except that the chemicals were applied in 500 litres water/ha and were:

thiram (as 7, 3.5 or 1.75 ml Thiram/m^2);
dichlorofen (as 8, 4 or 2 ml Algofen/m^2);
chloroxuron (as 0.45 or 0.23 g Tenoran/m^2) or
chloroxuron (as 0.45 or 0.23 g Tenoran/m^2, washed off immediately after application).

The trial was scored in a similar way to the previous trial (1, most moss to 5, least moss).

Statistical analysis

Where suitable, randomised block designs were used, with three or four replicate blocks and surrounding guard plants. Data were subjected to the analysis of variance, where appropriate.

RESULTS AND DISCUSSION

Experiment 1: corm germination tests

Table 1 shows the percentage germination of St. Piran and Dutch corms in laboratory and field tests for the three years of the experiment. Overall, the percentage germination of St. Piran was 67% and that of Dutch corms 66%. Performance in laboratory and field tests was also similar (both 66%, overall), as was overall performance in the three years (67, 68 and 64%, respectively). Relative performance changed in the various tests, however (ie, the experimental factors interacted strongly).

In 1987, Dutch corms performed better than St. Piran in both tests, with about 20 per cent greater viability. Percentage germination was 5 to 8% greater in the laboratory tests than in field tests. In 1988, Dutch corms were received late for trialling, and, although their performance was similar to that of St. Piran in the field test, under the moister conditions of the laboratory test, there were considerable losses due to soft-rot (*Erwinia amylovora*). In 1989, St. Piran corms were superior in germinability to Dutch corms in the field test, but both strains had similar germination rates in the laboratory, where corms of both types were affected by *Penicillium* mould.

Germination in field tests started within 15 to 20 days, continuing slowly over the next 20 days. In the laboratory tests, germination begun within 10 days and was mostly completed by 20 days. Figure 1 shows the typical time course of germination, taken from the 1987 results (note that the relative performance of the two strains was not always similar).

Overall, although there were no consistent differences between the two strains, the performance of both was less than satisfactory, confirming growers' experience that germination-enhancing treatments are needed.

In previous laboratory studies, Jones (1986) found corm germination rates for St. Piran of between 88 and 100 per cent, while de Munk and Buschman (1981) reported rates of 78 to 88 per cent for de Caen anemones. Jones (1986) found that mean time to germination was shorter at 18°C (5-6 days) than at lower temperatures, being 11 to 13 days at 9°C. Slow germination in the field is probably due to sub-optimal soil temperatures (typically 9-12°C in April to May in south-west England) and possibly slow re-hydration under dry soil

conditions. There were significant, but probably commercially unimportant, differences in the germination of the different colour families (Jones, 1986).

Experiment 2: corm drying and storage

Field germination tests following drying and storage treatments are summarised for both years of the experiment in Table 2. During ambient drying, temperatures fluctuated widely, as shown (for the 1988 experiment) in Figure 2.

Emergence rates were better than observed for St. Piran from ambient storage (see Experiment 1). Drying and storage treatments had very significant effects on corm germination. Post-lifting drying at 20°C gave superior results to ambient-temperature drying, regardless of subsequent storage regime. The best storage treatment was 15°C with 60% relative humidity. There was generally little effect of including or omitting a thiram dip, although fungicide treatment was beneficial in the case of ambient-temperature drying followed by storage at 20°C/75% relative humidity. Effects were consistent for both years of the experiment.

Anemone corms are usually dried and stored at ambient temperatures. The experiment showed that St. Piran corm germination can be increased to nearly 100 per cent by appropriate drying and storage treatments. Meynet (1993) recommended that *Anemone coronaria* corms should be dried to about 15 per cent water content at 25 to 30°C and then stored at 15 to 25°C; this seems to conflict with the results of using lower temperatures in the present study with St. Piran.

Experiment 3: fungicide dips

Field test germination results for corms treated with different fungicides before storage are given in Table 3.

Compared with untreated controls, using Rizolex significantly enhanced emergence (80%, compared with 61% in controls). Mistral reduced emergence, although this effect just failed to achieve statistical significance at the 5 per cent level of probability. Elvaron, Thiram, Storite Clear and Fongarid gave germination rates similar to those of controls.

These results should be treated with caution, as they are based on a single experiment. However, the beneficial effect of Rizolex should be investigated further.

Experiment 4: methods for early flower production from late-planted corms

St. Piran anemone was developed for winter hardiness and the production of flowers after Christmas. Corms are usually sown in May to maximise production. Late sowing, say in June or July, would be preferable for some crop rotations: this experiment was set up to discover whether treatments such as smoking or vernalization could allow early flower production from these late sowings. It is considered that at least 60 flowers/m^2 (three per corm) should be cropped by the end of December.

1987-1988 experiment In this first run of the experiment (1987-1988), summer was dull and plant establishment was initially slow; however, autumn was mild and plant growth recovered. Table 4 shows the yield of marketable flowers obtained by the end of October 1987, January 1988 and April 1988. For the June sowing, vernalization, but not smoking, increased the number of flowers cropped before the end of January. Soaking reduced yields. Flower yields from July sowings were poor, regardless of corm treatment. The cropping periods for marketable flowers are shown graphically in Figures 3 (June sowing) and 4 (July sowing). For the former, it can be seen that vernalization (used alone or in conjunction with soaking and smoking) shifts the usual March peak of flower production to the previous October-November period. With a July sowing, this benefit of vernalization was virtually lost, although there was a small peak of flower production in December.

1988-1989 experiment Profiles for cropping of marketable flowers in the second experiment are shown in Figures 5 and 6. It was recorded that poor corm quality was observed during vernalization, presumably referring to disease development under the moist conditions pertaining. It was not, therefore, surprising that flower production in soaked, vernalized corms was poor: despite this, there was a suggestion that, for June-sown corms, flower production in this treatment peaked earlier (November) than in the control and in other treatments (December-January). In the July-sown corms, all treatments peaked in the December to February period. Relating to the poor performance of vernalized corms in the June sowing, the percentage of marketable flowers was lower in these treatments than in others (Figure 7); however, in the July sowing the proportion of marketable quality blooms was similar in all treatments (Figure 8).

Experiment 4a In the supplementary 1988-1989 experiment, flower production from vernalized corms was poor, as expected from the results above. The cropping periods for this experiment are shown in Figure 9 and the percentage of flowers marketable in Figure 10. Cell-raised plants were somewhat poorer, and slightly later, than controls, while block-raised plants were slightly earlier. Soaking corms did not affect performance, compared with controls.

These experiments show that there is considerable potential for producing flowers in October and November from June-sown corms, using a 6 week vernalization period. To use this treatment it is essential to have healthy corms or to control diseases during the vernalization treatment.

These findings confirm earlier experimental work with *A. coronaria*. Thus, Maia (1973) found a 4 to 6 week treatment at 1°C of rehydrated corms was most effective for hastening subsequent flowering. For forcing, Meynet (1993) gave the following recommendations: corms are soaked in water for 36 hours, then in a fungicide (eg, prothiocarb or mancozeb plus carbendazim) for 12 hours at 20°C, followed by storage for 5 to 6 weeks in moist perlite in polythene bags at 2°C.

Experiment 5: weed control

Effective weed control treatments are needed in anemone growing to increase growth and facilitate lifting. Paraquat should be used pre-emergence, pentanochlor (as Atlas Solan 40) has approval on the crop as a contact herbicide, and low rates of lenacil, terbacil and simazine

have previously been used in trials (ADAS, 1983). A selective contact herbicide is needed before and after polythene covering, and also generally in the unprotected crop.

Herbicide trial 1987-88 The effects of treatments on weed control (mainly mayweed) and on crop toxicity in early May are summarised in Table 5. In these results, mild crop toxicity was represented by occasional yellowing or scorching, bronzing of foliage being evident in more severely affected plots. Mild weed toxicity was evidenced as scorched leaves, severe effects by twisted, bronzed or blotched leaves. Most herbicides tested had only weak effects on weeds, the best effects being achieved using Format (at 2 or 3 litre/ha rates), sodium monochloroacetate and Roundup Weedwipe although the last two severely damaged the crop. Table 6 shows the diversity of weed species present. The use of Format (or other materials) did not reduce weed growth effectively.

Subsequent germination tests on corms recovered from the experiment (Table 7) showed that, on plots not previously treated with Format, emergence was reduced by a few percent (compared with controls) when Ronstar (at the higher rate), Clout or sodium monochloroacetate had been used, although statistically these reductions were not significant. However, germination was severely reduced (to 42%) when glyphosate had been used. There were only small and inconsistent differences between these plots when the dates of herbicide treatment was considered, hence only the averaged results are presented in the table. In the additional 'replicate' where Format had been previously used, a further application of the same material (at the 2 litre/ha rate) reduced emergence further, and Hyvar X also had a detrimental effect on germination.

Clearly, anemones are sensitive to several of the herbicides used, although Format is worthy of further trials, perhaps using earlier or repeated applications, or higher rates (3 litre/ha). It is also recommended that alternative techniques, such as soil sterilisation with dazomet, or using raised beds (to enhance drainage and crop establishment), should be investigated.

Herbicide Trial 1988-89 Table 8 summarises the results from this trial. Goltix reduced crop growth whether applied in December or March. Sinbar and Format reduced crop growth to a lesser extent, but both caused some crop toxicity in the form of chlorotic leaves when used at the higher rates in March. Corm yield data were highly variable, which was expected as the uniformity of crop emergence was noted as being poor. In general, yields correlated with crop scores, in particular showing the adverse effect of Goltix on the crop.

Weeds present were mainly chickweed, shepherd's purse, speedwell and willowherb. Effective weed control resulted from using Sinbar at the higher rates in December or March, Format at the highest rate in December, and Goltix at the highest rate in March; other applications were ineffective. In this experiment a high rate of Sinbar applied in December appeared to offer the best weed control and freedom from crop toxicity.

These results should be treated with caution because of the lack of replication and poor uniformity of the crop. There is certainly scope for further trials.

Moss killer trial 1988-89 The results, given in Table 9, showed that Thiram and Algofen, applied in December, effectively controlled moss even at the lowest rates of application, which had relatively slight adverse effect on the crop. Tenoran caused severe crop losses.

Applied in March, none of the materials controlled moss. The results showed there is scope for safe use of Thiram and Algofen in winter.

CONCLUSIONS

1. Corm germination of St. Piran and Dutch de Caen anemone is similar. *Penicillium* moulds and *Erwinia* soft-rot may be problems. Temperature and rehydration requirements may be sub-optimal in field plantings. These problems suggest that the use of suitable fungicides and bactericides is important, and that vernalisation, pre-germination or transplanting from modules should be considered for achieving good crop establishment.

2. Corm germination of St. Piran can be improved (to approaching 100%) by drying corms at 20°C then storing at 15°C under 60% relative humidity, rather than by using ambient conditions.

3. Further trials on suitable pre-storage fungicide dips are needed although, on the basis of a single experiment, tolclofos-methyl might be considered further, and fenpropimorph might be avoided.

4. For earlier flower production from June plantings, St. Piran corms should be vernalised in moist peat at 1°C for 6 weeks before planting, preferably following an effective fungicide dip. Soaking treatments should be avoided.

5. Further trials are needed on herbicides for use in anemone corm beds, particularly for spring application. Clopyralid should be considered (at rates equivalent to 2 or 3 litres Format/ha, or using a split-dose programme). December application of terbacil (at rates of 0.25 or 5 kg Sinbar/ha) should also be further tested. Cultural techniques which optimise crop establishment should also be studied.

6. Moss on anemone beds can safely be treated using low rates of thiram or dichlorofen applied in December.

POSTCRIPT

<u>The future of St. Piran</u>

Despite the attention which St. Piran anemone caused when it was introduced, in the time since the experimental work in this report was carried out the strain has apparently disappeared from commerce. (Interestingly, the name St. Piran appears in at least one current retail bulb catalogue.) The breeding lines were lost from the production site in Somerset and the genetic base was not maintained by the NSDO or its successors. Several factors may be cited for this. First, the U.K. recession may have had a general effect on enthusiasm for a new, more expensive variety, despite its advantages over imported corms which are sensitive

to leaf curl disease and which are less hardy. Secondly, practical difficulties were encountered in maintaining nuclear stocks of the separate colour families (St. Piran itself is an open-pollinated mixture of the basic colours) and in growing the crop in an area perhaps not expert in bulbous crops. Thirdly, F_1 hybrid anemones Mona Lisa and the John Innes Institute's Jinetta were introduced about the same time and, although designed for the protected cropping situation, may have detracted interest from St. Piran.

Ironically, interest in St. Piran has been reported in the last year. Despite the demise of commercial stocks and of the genetic base of St. Piran, all may not be lost. A project is now under way at Duchy College, Rosewarne, to salvage and re-select the strain from various sources. This, if successful, will need to be coupled with an improved understanding of the agronomy of the crop, if previous failings are not to be repeated. The techniques available from this report and elsewhere will help towards achieving quality crops of this prime anemone strain.

ACKNOWLEDGEMENTS

Overall management of this project was by Mr M R Pollock, then Director of Rosewarne EHS. Trials at Rosewarne were under the management of Dr J R Smith, and work at the Yeabridge site was managed by Mr N J Hurford (ADAS, Taunton). Plant pathology support was provided by ADAS Starcross. The contributions of ADAS staff, of Mr A K C Broughton (Wyvern Growers Ltd), and of Lingarden Ltd in the project are all acknowledged.

I would also like to acknowledge the help received from my former colleague, Mr S K Jones, who worked on St. Piran at GCRI, Littlehampton in the 1980s. I thank Miss S Hammond (HRI Littlehampton), who commented on statistical aspects of the report. Thanks are also due to the various unnamed correspondents who explained the current status of St. Piran to me.

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Table 1 Germination of St. Piran and Dutch anemone corms in laboratory and field tests (Experiment 1)

Strain	Percentage corm germination					
	1987		1988		1989	
	Lab.	Field	Lab.	Field	Lab.	Field
St. Piran	61	53	73	73	71	72
Dutch	79	74	48*	78	67	49
SED (6 df)	4.7		12.4		6.5	

*corms affected by soft-rot

Table 2 St. Piran corms emergence in the field test following drying, dipping and storage regimes (Experiment 2)

Storage regime (temperature, relative humidity)	Percentage emergence			
	Ambient-drying		20°C drying	
	+ Thiram	Control	+ Thiram	Control
			1988 experiment	
15°C, 75%	78	76	94	96
15°C, 60%	91	85	98	99
20°C, 75%	61	41	92	97
		SED (22 df) = 5.2		
			1989 experiment	
15°C, 75%	58	55	87	89
15°C, 60%	76	76	92	96
20°C, 75%	49	35	89	89
		SED (22 df) = 4.8		

Table 3 St. Piran corm emergence in the field test following fungicide dip treatments and storage (Experiment 3)

Fungicide	Percentage emergence
Mistral	45
Elvaron	69
Thiram	61
Rizolex	80
Storite Clear	61
Fongarid	61
Control	61
SED (12 df)	7.7

Table 4 The effect of soaking, smoking and vernalization treatments, and of sowing date, on time of flower cropping in St. Piran (Experiment 4, 1987-88)*

	Marketable flowers cropped/m^2 (by 3 dates)								
	Planted 29 May**			Planted 17 June			Planted 8 July		
Corm treatment	31 Oct	31 Jan	30 Apr	31 Oct	31 Jan	30 Apr	31 Oct	31 Jan	30 Apr
Untreated	24	66	97	11	41	89	1	12	48
Smoked	-	-	-	12	41	83	1	11	44
Soaked + smoked	-	-	-	8	31	61	1	8	32
Vernalized	-	-	-	33	74	92	5	28	52
Soaked + smoked + vernalized	-	-	-	37	82	101	4	24	42

*only meaned data available, hence no statistical analysis
**data for May sowing extrapolated from a comparable trial

Table 5 Effect of herbicide treatments on anemone crop and weeds (mainly mayweed) assessed on 4 May 1988 (Experiment 5, 1987-88)*

Herbicide (rate)	Crop toxicity				Weed toxicity			
	plot 1	plot 2	plot 3	plot 4	plot 1	plot 2	plot 3	plot 4
Format (1 l)	0	1	1	0	1-2	1-2	2	2
Format (2 l)	0	0	1	1	1-2	1-2	1-2	2-3
Format (3 l)	nd	nd	0	0	nd	nd	2	2
Dosoflo (5 l)	0	1	1	0	1-2	2	1-2	1
Dosoflo (2.5 l)	1	1	1	0	1-2	1-2	1-2	0
Ronstar (2 l)	1	1-2	1-2	1	1-2	1	1-2	2
Ronstar (4 l)	1	1	1-2	0	1-2	1	1-2	2
Basagran	1-2	1	1-2	0	1-2	1	1-2	1
Clout	1	1	1	0	1-2	1-2	1	1
Stomp (3 l)	1	1	1	0	1-2	0	1	1
Stomp (6 l)	1	1	1	0	1-2	0	1	1
Devrinol	1	1	1	0	2	0	1-2	1
Hyvar X	0	1	0	0	1-2	1	2	1
Brasoran	1	1	0	0	2	1-2	1-2	1
Sodium monochloracetate	nd	nd	1-2	2	nd	nd	2	2
Roundup	nd	nd	2	2	nd	nd	5	3

* Toxicity scored from 0 to 5 (see text for details). Assessed separately on four 'replicate' plots, of which number 1 had previously been treated with Format.
nd, not determined.

Table 6 Effect of herbicide treatments on weed species in anemone crop, assessed on 2 June 1988 (Experiment 5, 1987-88)*

Herbicide (rate)	Mayweed	Couch	Volunteer cereal	Flea sedge	Speedwell	Thyme-leaved speedwell	Polygonum	Buttercup	Chickweed	Willowherb	Annual meadow grass	Shepherd's purse	Grass (other)	Groundsel	Sowthistle	Marestail	Redshank	Poppy	Lamium	Annual nettle
Format (1 l)	13	15	10	8	5	8	5	8	8	5	3	0	5	3	0	0	0	0	0	0
Format (2 l)	15	13	10	8	3	10	10	8	8	10	0	3	5	3	0	0	0	0	0	0
Format (3 l)	10	5	10	20	5	10	15	0	10	0	5	0	0	0	0	0	0	0	0	0
Dosoflo (5 l)	20	10	8	0	5	5	3	5	8	0	3	0	0	3	3	0	0	0	0	0
Dosoflo (2.5 l)	20	13	3	5	0	3	0	3	0	0	5	3	3	5	0	0	3	0	3	0
Ronstar (2 l)	18	15	10	5	5	5	5	5	5	5	0	5	0	0	0	0	0	0	0	0
Ronstar (4 l)	18	13	8	8	10	3	8	0	5	0	3	3	0	3	0	0	0	0	0	0
Basagran	18	8	13	5	8	8	15	0	3	0	0	5	0	3	0	0	0	0	0	0
Clout	18	8	10	8	10	5	10	0	3	3	3	3	0	0	5	3	0	0	0	0
Stomp (3 l)	15	15	10	8	0	0	5	0	0	3	3	5	0	0	0	3	0	0	0	0
Stomp (6 l)	20	8	10	8	0	0	8	0	8	8	3	0	0	0	0	3	0	0	0	0
Devrinol	20	5	5	5	3	10	8	0	3	10	3	5	0	0	3	0	0	0	0	0
Hyvar X	20	10	5	3	0	5	3	3	0	5	3	0	0	0	0	3	3	0	0	3
Brasoran	20	10	5	8	0	5	13	0	0	5	0	0	0	0	3	0	0	3	0	0
Sodium monochloracetate	25	5	5	5	0	5	5	0	0	5	0	10	0	0	0	0	0	0	0	0
Roundup	5	0	0	5	5	0	15	0	0	0	5	5	0	3	0	0	5	0	0	0
Control	23	8	10	10	5	5	10	0	3	5	3	5	0	3	0	0	0	3	0	0

* weed populations assessed on a scale of 0 to 3 (see text for details); scores are means (x 10) of all 'replicate' plots

Table 7 Effect of previous herbicide treatments on subsequent emergence in the field test (Experiment 5, 1987-88)

Herbicide (rate)	Percentage germination	
	Means of plots 2-4	Plot 1
Format (1 l)	93	96
Format (2 l)	91	73
Format (3 l)	93	nd
Dosoflo (5 l)	88	90
Dosoflo (2.5 l)	92	94
Ronstar (2 l)	88	84
Ronstar (4 l)	85	82
Basagran	87	86
Clout	86	94
Stomp (3 l)	88	98
Stomp (6 l)	90	98
Devrinol	92	94
Hyvar X	89	78
Brasoran	92	92
Sodium monochloroacetate	86	nd
Roundup	42	nd
Control	91	-
SED (32 df)	8.0	

nd, not determined.

Table 8 Effect of herbicides on crop and weed growth* (Experiment 5, 1988-89)

Chemical (rate)	December application				March application			
	Crop score	Weed score	Corm yield		Crop score	Weed score	Corm yield	
			No/plot	Kg/plot			No/plot	Kg/plot
Sinbar (0.13 kg)	3	2	170	0.71	5	2	390	0.71
Sinbar (0.25 kg)	3	3	240	0.57	3	5	140	0.28
Sinbar (0.5 kg)	4	5	270	1.28	4+	5	160	0.28
Format (1 l)	3	4	320	0.85	5	4	410	0.57
Format (2 l)	3	4	140	0.28	5+	4	300	0.43
Format (3 l)	3	5	130	0.28	3+	2	160	0.28
Goltix (2.5 kg)	1	4	70	0.28	3+	3	140	0.14
Goltix (5 kg)	0	4	40	0.14	1	3	80	0.09
Goltix (10 kg)	2	3	150	0.28	4	5	270	0.43
Control	4	3	210	0.43	5	4	470	0.71

* crop growth and weed control assessed from 1 (poor) to 5 (good)
\+ crop leaves with chlorosis

Table 9 Effect of moss killers on crop and moss growth* (Experiment 5, 1988-89)

Chemical (rate)	December application				March application			
	Crop score	Moss score	Corm yield		Crop score	Moss score	Corm yield	
			No/plot	Kg/plot			No/plot	Kg/plot
Thiram (7)	3	5	310	0.43	5	2	660	2.27
Thiram (3.5)	3	5	470	0.57	5	1	nd	nd
Thiram (1.8)	4	4	450	0.71	4	1	nd	nd
Algofen (8)	3	5	390	0.57	5	1	740	2.27
Algofen (4)	3	5	250	0.43	5	1	nd	nd
Algofen (2)	4	5	420	0.57	5	1	nd	nd
Tenoran (0.45)	0	4	nd	nd	5	1	530	1.70
Tenoran (0.23)	0	4	nd	nd	nd	nd	nd	nd
Tenoran (0.45)**	0	4	nd	nd	nd	nd	nd	nd
Tenoran (0.23)**	0	4	410	0.57	nd	nd	nd	nd
Control	5	0	nd	nd	-	-	-	-

* crop growth and moss control assessed from 1 (poor) to 5 (good)
** these treatments had Tenoran washed off crop after application
nd, not done

Fig.1 Germination tests (1987)

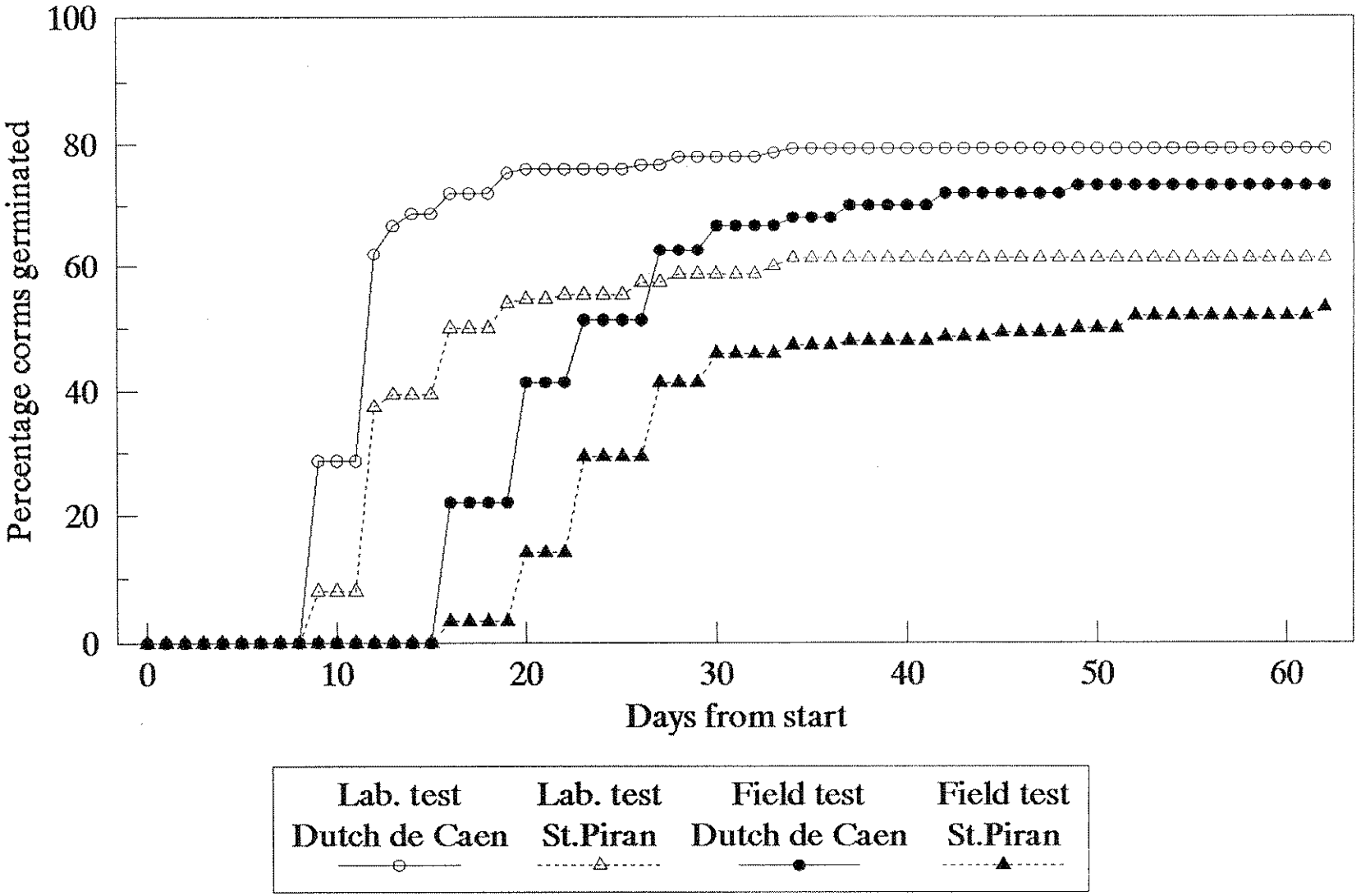


Fig. 2 Typical temperature fluctuations during ambient drying over 5 days (Experiment 2). Temperatures (°C) indicated on left-hand axis.

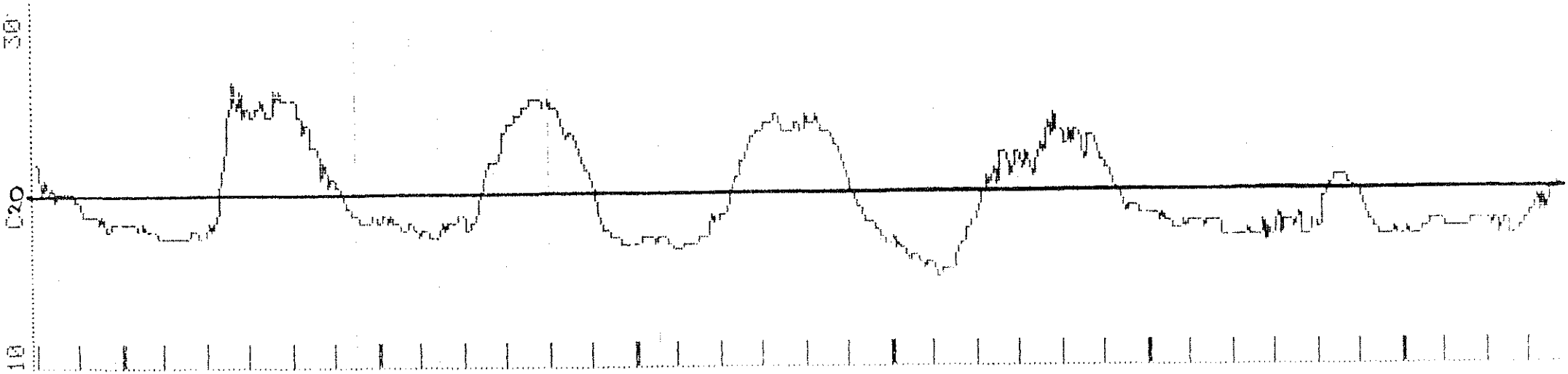


Fig.3 Cropping period of St.Piran sown 17 June
(Experiment 4, 1987-88)

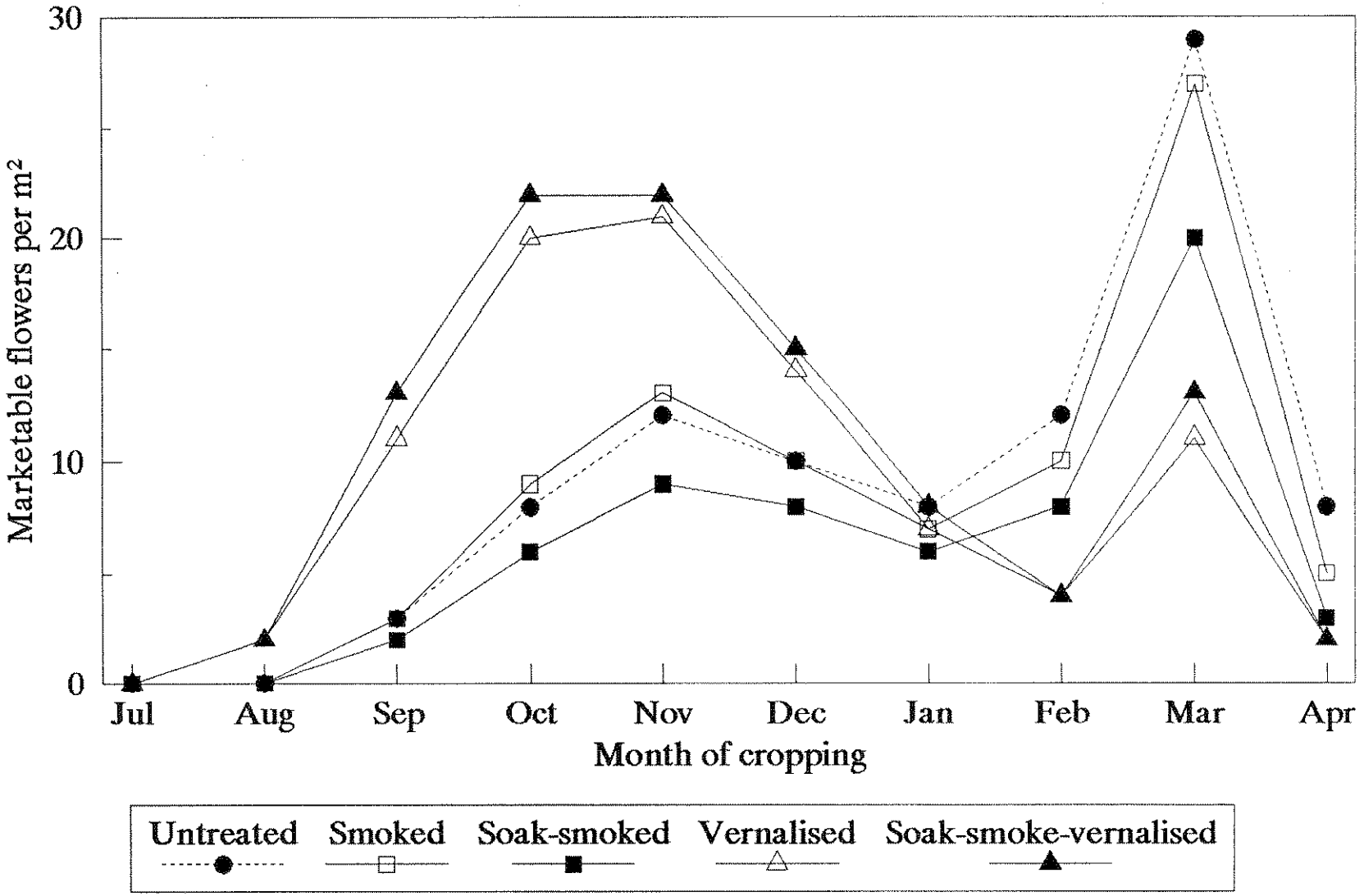


Fig.4 Cropping period of St.Piran sown 8 July
(Experiment 4, 1987-88)

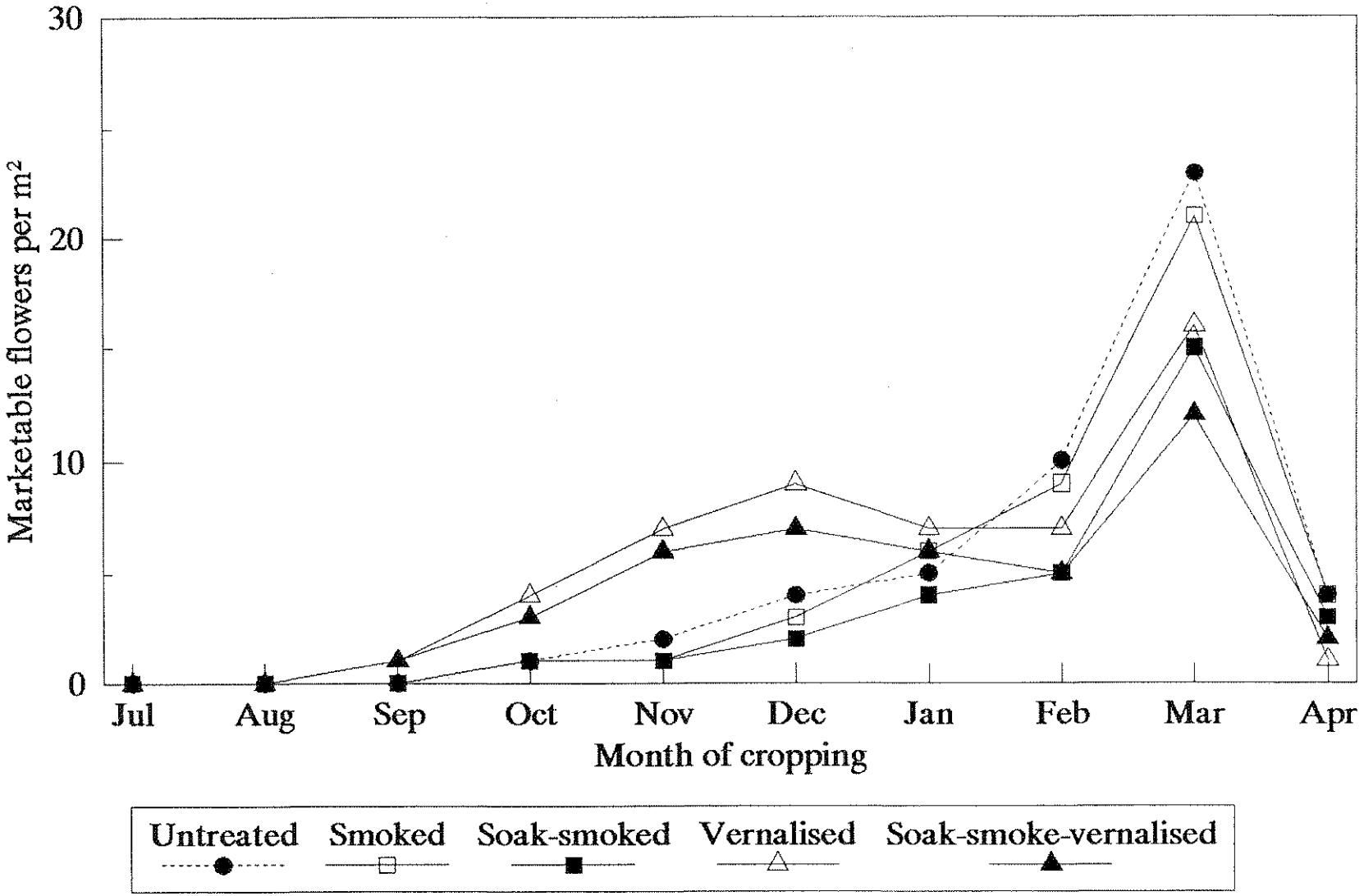


Fig.5 Cropping period of St.Piran sown 22 June
(Experiment 4, 1988-89)

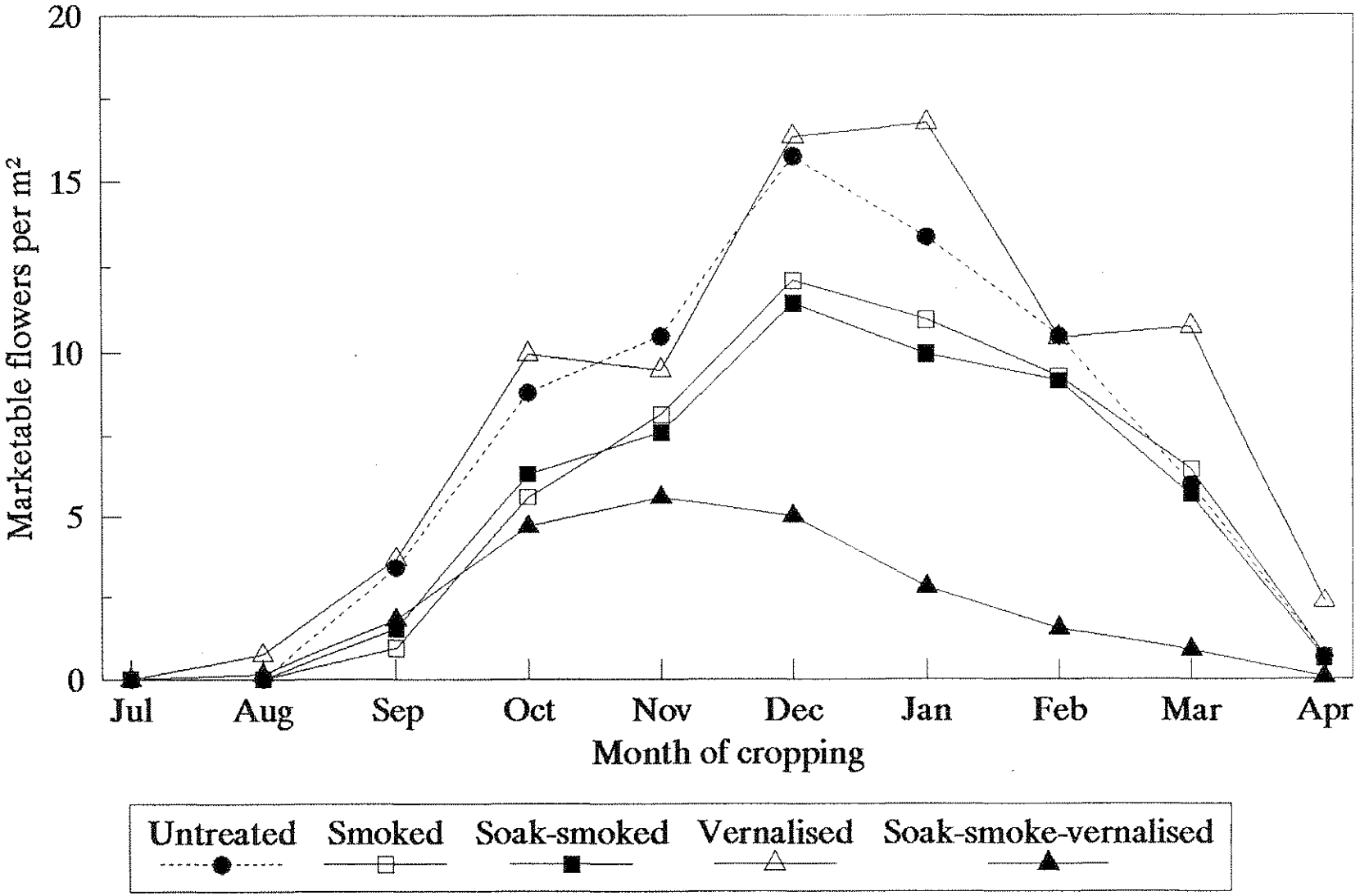


Fig.6 Cropping period of St.Piran sown 6 July
(Experiment 4, 1988-89)

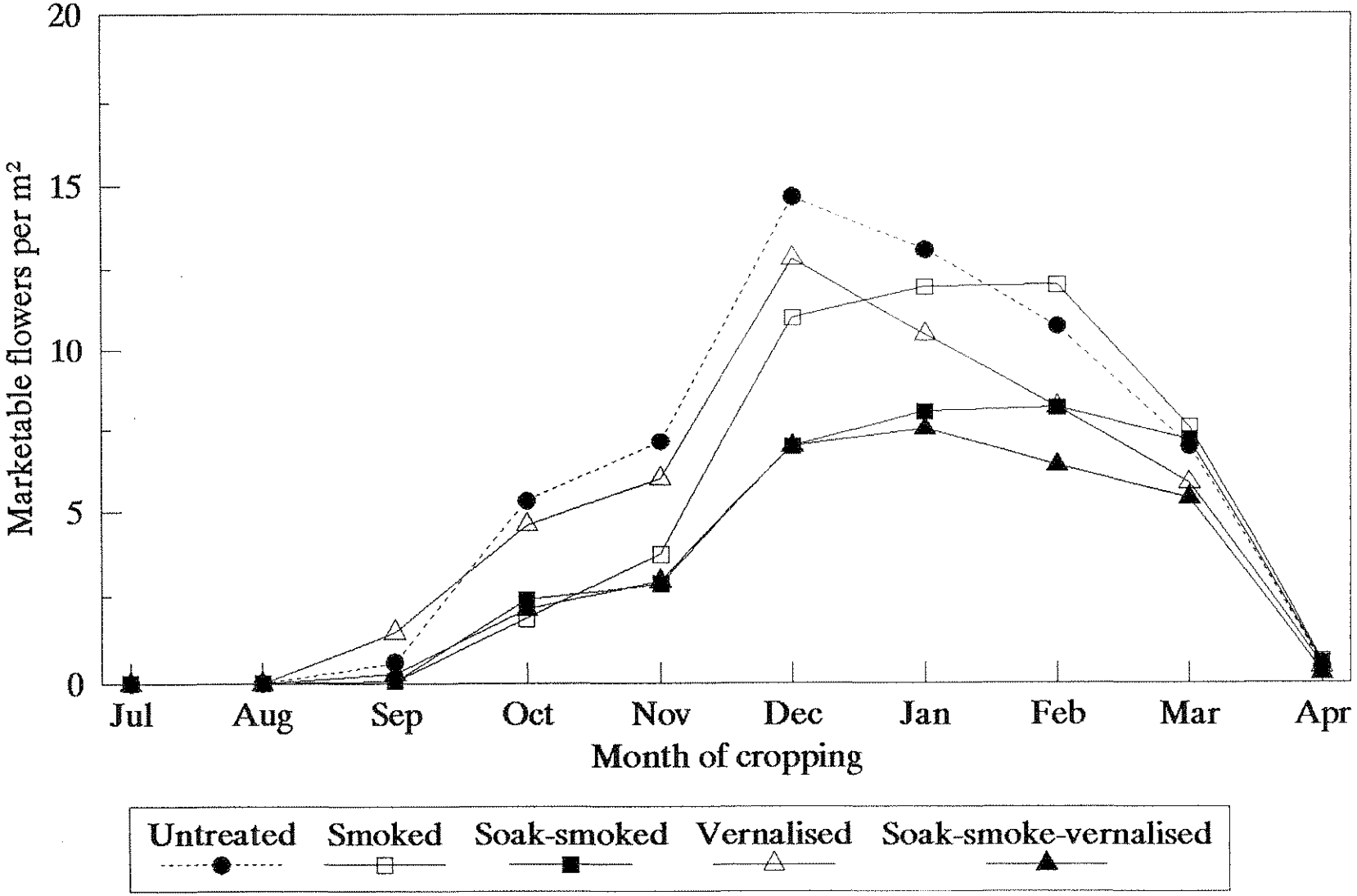


Fig.7 Flower quality of St.Piran sown 22 June
(Experiment 4, 1988-89)

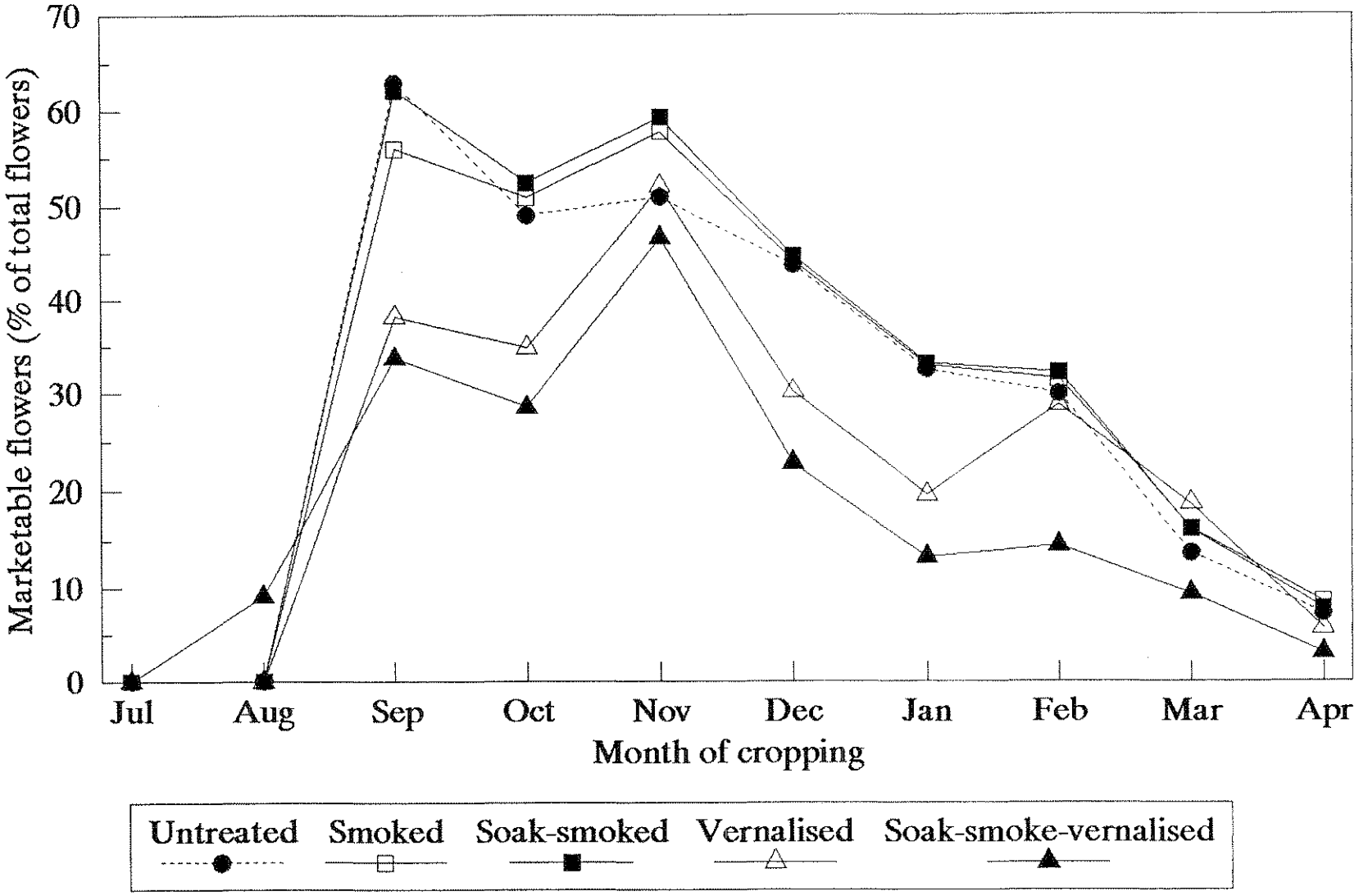


Fig.8 Flower quality of St.Piran sown 6 July
(Experiment 4, 1988-89)

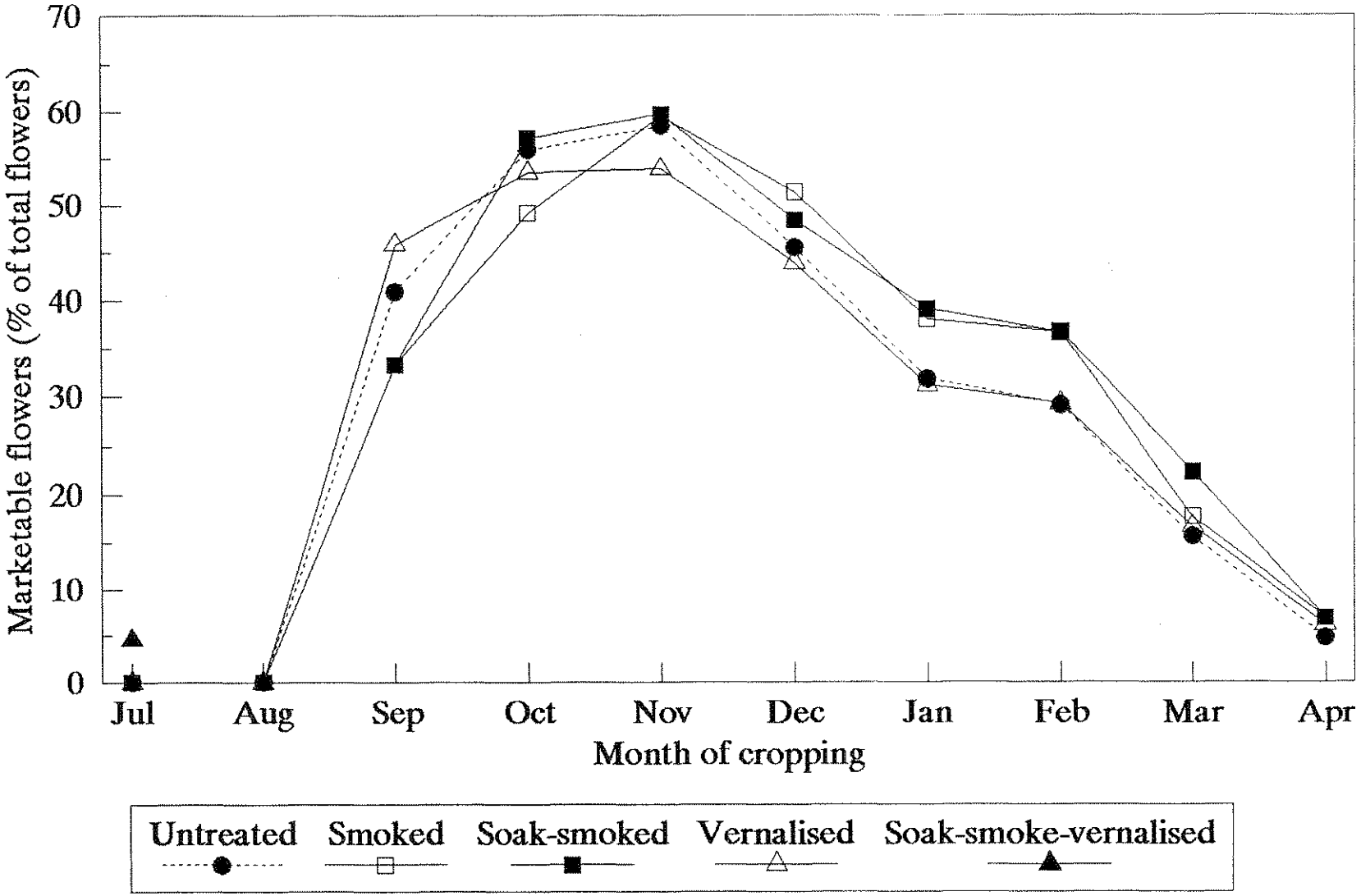


Fig.9 Cropping period of St.Piran planted 23 May
(Experiment 4a, 1988-89)

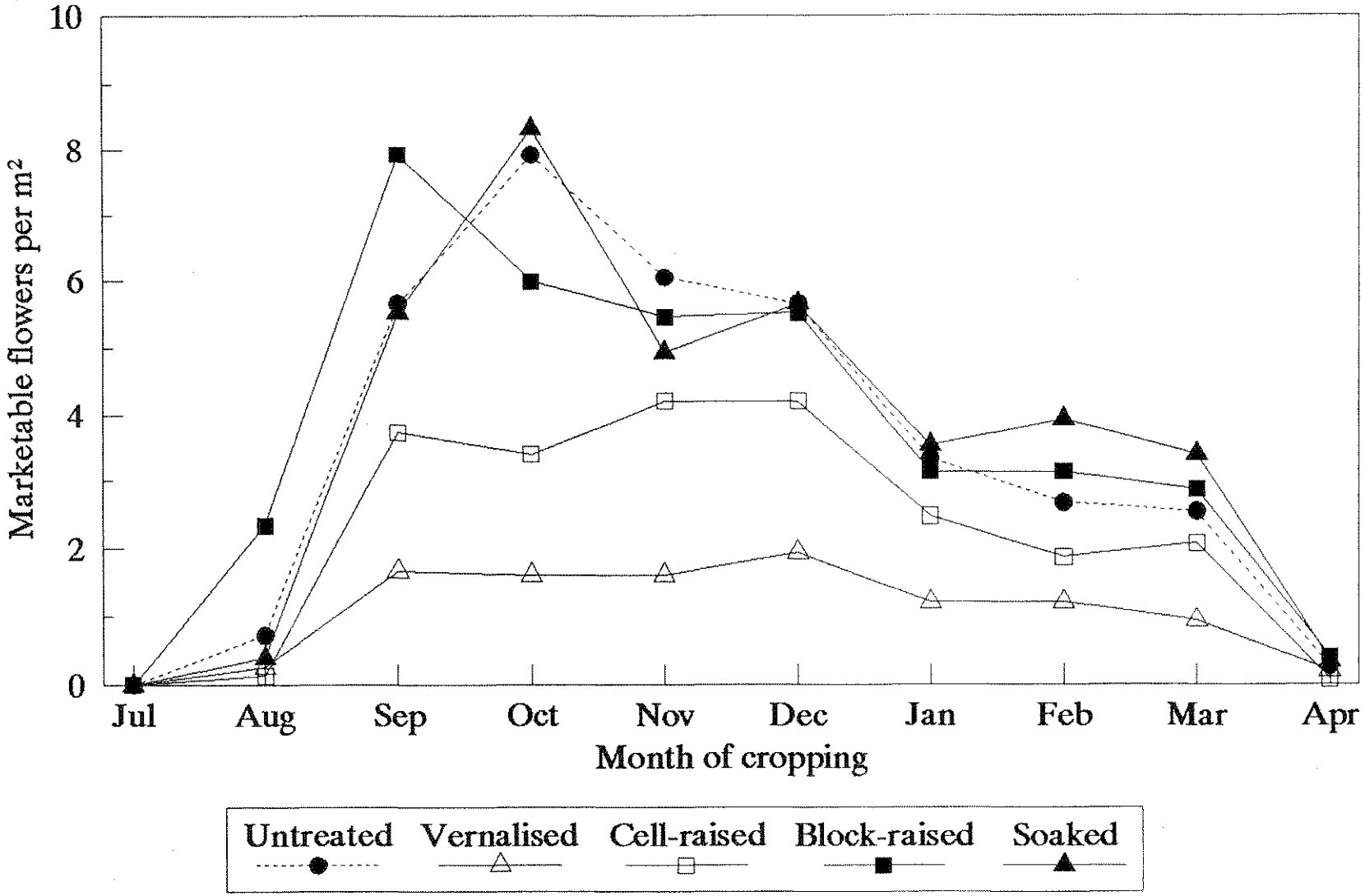
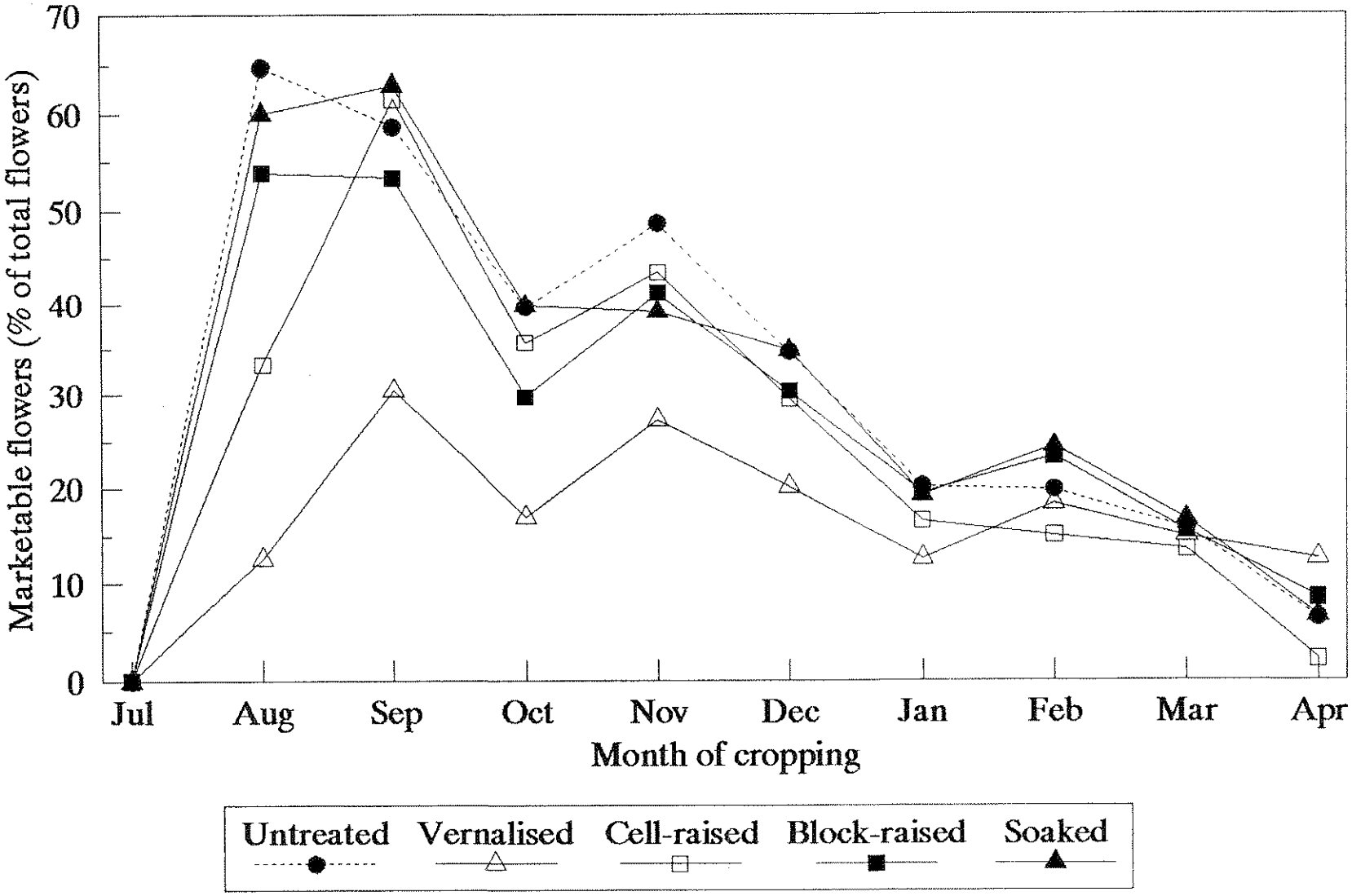


Fig.10 Flower quality of St.Piran planted 23 May
(Experiment 4a, 1988-89)



COPY OF CONTRACT

Contract between ADAS (hereinafter called the 'Contractor') and the Horticultural Development Council (hereinafter called the 'Council') for a research/development project.

PROPOSAL

1. Title of project B/10/87

Anemone (St Piran strain). Improvements in production.

2. Background

The St Piran strain of Anemone, bred at Rosewarne EHS, is hardy in the south west with good quality flowers and long stems. Dutch stocks of de Caen Anemone are no longer available for commercial planting, due to infection with *Colletotrichum* sp. (leaf curl disease).

3. Objective of this project

To improve corm production, crop establishment, continuity of production and length of season using the St Piran strain.

4. Potential benefit to the Industry

Anemone production in the south west could increase substantially and a world market exists for healthy, hardy, vigorous strains of Anemone such as St Piran.

5. Closely related work already completed or in progress

Rosewarne EHS has development work expertise, Wyvern Growers are producing the commercial corm crop and Lingarden provide the sales organisation as well as field inspection services; NSDO are also participating. A collaborative arrangement, as proposed, would enhance commercialisation of St Piran corm production and stimulate investigations into current practices to aid flower producers.

6. Description of the work

Description of proposed experiments:-

A. Investigation of germination and uniformity of emergence of St Piran anemone corms compared with a Dutch variety.

B. Investigation of drying and storage techniques for St Piran anemone corms.

C. Investigation of early flower production techniques from late planted St Piran anemone corms.

D. Evaluation of fungal dips for the control of disease infection of St Piran anemone corms during storage and subsequent planting.

E. Evaluation of herbicides for the control of weeds in St Piran anemone corm production beds.

To include:-

(i) The supply of a report by ADAS on the results of each experiment in the format of ADAS Contract Report 1, within two months of the end of recording data.

(ii) A final summary report, as may be required.

Work proposed for Experiment A:-

(1) Laboratory test for germination and emergence of corms.

Mix 3 litres of medium grade vermiculite with 1 litre of Captan fungicide solution. Place in a seed tray, level and slightly push in 50 corms per tray without covering. Enclose seed tray in 120 gauge polythene bag and incubate at 15°C. Replicate 3 times.

Viable corms will be removed daily when green shoots are seen and roots are forming. Corms producing only shoots or only roots will not be recorded as viable.

The Captan fungicide is to prevent Penicillium infection which may or may not have come from the corms.

Assessment of corm viability will terminate after 30 days and a report will be written showing the percentage number of viable corms together with the dates of emergence of roots/shoots.

One hundred and fifty corms of each variety are to be supplied free of charge by the customer.

(2) Field test for germination and emergence of corms.

Soil to be cultivated and fertiliser added according to normal husbandry practice and soil analysis. Plots to be marked out 1 m x 1.25 m to hold two rows 0.5 m apart, each with 25 corms spaced 5 cm apart. Half rate Sinbar will be applied to control weeds and irrigation will be used if necessary. Replicate 3 times.

Assessment of corm emergence will be completed three times per week for a period of 60 days from the date of sowing.

A report will be written showing dates and percentage emergence on each plot, summarised for each treatment/variety.

One hundred and fifty corms for each treatment/variety to be supplied free of charge by the customer.

Work proposed for Experiment B:-

(1) Compare drying and storage regimes.

Drying regimes	A.	Forced ambient air as done by Wyvern Growers.
	B.	Forced air at 20°C.
Storage regimes	1.	15°C at 75% RH.
	2.	15°C at 60% RH.
	3.	20°C at 75% RH.
Fungicide dip i.		Thiram dip pre-storage
	ii.	No dip.

Each treatment to be replicated 3 times.

Customer supplied corms to be treated and collected at Wyvern Growers by Rosewarne staff.

(2) Carry out field germination/emergence tests after storage, as in Experiment A(2).

Work proposed for Experiment C:-

To compare five corm treatments for two planting dates aimed at producing flowers in the shortest possible time from planting to harvest:

Treatments

1. Plant corms dry
2. Smoke corms dry before planting
3. Soak corms for 24 hrs then smoke before planting
4. Vernalize at 1°C for 6 weeks before planting
5. Soak, smoke and vernalize corms before planting

Planting dates	i.	16 June
	ll.	6 July

Each treatment to be replicated 4 times

Smoking refers to placing the corms in a sealed cabinet, filling the cabinet with smoke twice within a 48 hour period. 50 g of straw per m^3 will be used to produce the smoke at each time.

All corms will be supplied by the customer.

Work proposed for Experiment D:-

1. Dip corms in fungicide after washing but before storage and compare with untreated corms. Treatments as follows:

(a) Untreated to be used for disease testing every 2 weeks.
(b) Untreated control.
(c) Thiram.
(d) Storite Clear.
(e) Octave.
(f) Elvaron.
(g) Rizolex.
(h) Fongarid.
(i) Hypochlorite.
(j) Copper.
(k) Coded bactericide.

The use of these chemicals are subject to availability and the assumption that Trials Clearance can be obtained from PSPS.

Dips will be for 3 hours. There will be 4 replicates of each treatments for use in field test. Treatments will be done at Wyvern Growers by Rosewarne EHS staff.

2. Store corms until planting time.

3. Complete a field emergence test as in Experiment A(2).

4. Take samples of untreated corms at 2 weekly intervals and test for pathogens.

5. At the end of 12 weeks lift unemerged corms and test for pathogens.

Work proposed for Experiment E:-

1. Compare a range of herbicides to be determined in further consultations with the customer.

2. Assessments of visual damage to crops.

3. Comparison of the weight and grade of corms lifted.

As agreed this item of work will be under the overall responsibility of Rosewarne EHS within the general terms of the Contract. The field work in Somerset will be undertaken by ADAS staff of FCS based at Taunton Divisional Office.

7. Commencement date and duration

Start 1.4.87, duration three years, subject to annual review. Experiment D cannot be started before 1.7.88 owing to PSPS clearance procedures, and will in the first instance run for two years only.

8. Staff responsibilities

Project leader: M Pollock

9. Location

Rosewarne EHS and (Experiment E) field work in Somerset, undertaken by ADAS staff of FCS based at Taunton Divisional Office.

GRH6.REP