REPORT FOR HDC

Virus-tested bulb evaluation trials with narcissus

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VIRUS-TESTED BULB EVALUATION TRIALS WITH NARCISSUS

Summary

Virus-tested (VT) bulbs of narcissus cultivars Carlton and Fortune were field-acclimatised at Kirton or Rosewarne and then planted in trials at each site to compare performance with the local non-VT stock. VT and non-VT Carlton bulbs were planted at densities of 5 to 35 t/ha, following either standard hot-water treatment or high temperature HWT with 30°C pre-warming. The trials were grown for two years before bulbs were lifted and recorded; after re-equalising planting weights and grades, trials were grown for a further two year period at Kirton.

Further bulbs of varieties Carlton and Fortune, both VT and non-VT, were chipped and planted at 1.25 to 10 t chips/ha in trials at Kirton and Rosewarne. The trials were grown for two years, lifted, plots re-equalised, and grown for a further one year (at Kirton).

In the whole-bulb trials with Carlton, flower yields in the Kirton trial showed no consistent effects due to stock (VT or non-VT). In the Rosewarne trial, flower yields were higher in VT than non-VT stocks, especially in the first two years when the trial was growing at Rosewarne. Generally, flower sizes and stem lengths were slightly greater in VT stocks. In some cases, VT stocks were slightly earlier to flower and senesce. Bulb yields were greater in VT than in non-VT stocks, and especially so for the first two years of the trial at Rosewarne. Grown at Kirton, the advantage due to using VT bulbs was small. VT bulbs appeared better able to take advantage of low planting densities. Pre-warming bulbs showed a small yield advantage in all cases. For the chipped bulb trial, VT stocks produced more flowers than non-VT bulbs. Bulb yields were greater for VT stocks in the case of Fortune (at both sites) and for Carlton (at Rosewarne). VT bulbs remained essentially free of detectable viruses during these trials, whereas most non-VT bulbs produced positive virus tests. The differences in results between the two sites is discussed.

The Carlton whole-bulb trial was also carried out over two years at Auchincruive, Scotland. There were only small differences in foliage measurements between VT and local, non-VT stocks, although stem lengths were greater in VT bulbs and non-VT bulbs produced more flowers in the first year. VT stocks senesced later than non-VT stocks. Bulb yields by weight were greater for VT stocks at all planting densities.

Introduction

In the UK, the production of virus-tested (VT) narcissus bulbs began after the lack of vigour in the Isles of Scilly stocks of cv Grand Soleil d'Or was linked with widespread virus infestation (Stone, 1973; Stone et al., 1975, 1978). These authors described the benefits of apparently virus-free bulbs, and Tompsett (1983) reported comparisons of VT and 'ordinary' commercial stocks of this variety. The programme of producing VT bulbs by meristem-tip culture was extended to cover many 'mainstream' varieties (Brunt, 1980, 1985). VT narcissus stocks were released from the Virology Department, Glasshouse Crops Research Institute (GCRI) (now Horticulture Research International, Littlehampton) in 1977, allowing ADAS to undertake multiplication under quarantine conditions prior to evaluation trials at Rosewarne and Kirton Experimental Horticulture Stations (EHS) beginning in 1983. Comparisons of VT and good quality non-VT stocks were made with cultivars Carlton, Fortune, Ice Follies and White Lion from 1983 onwards (ADAS, 1986, 1987). The general advantages of VT bulbs have been established, albeit with some differences in relative performance at different sites, which could be due to a variety of causes.

In 1987, further trials were proposed to, and subsequently carried out under the sponsorship of, the Horticultural Development Council (HDC). These trials involved straightforward evaluations of VT and non-VT stocks, including their responses to some agronomic and husbandry factors. First, stocks of VT cultivar Carlton were compared with EHS (non-VT) stocks, growing at a wide range of planting densities (5-35 t/ha) and using either standard hot-water treatment (HWT) or high-temperature HWT with pre-warming (HTHWT). Secondly, the performance of VT and non-VT stocks of cultivars Carlton and Fortune were studied following chipping, again growing at a range of planting densities (1.25-10.0 t/ha). The trials were initially carried out at three sites, Kirton EHS, Rosewarne EHS and the North of Scotland College of Agriculture (NOSCA), Aberdeen, and husbandry details varied according to local practices. Interim reports of these trials have already been made available (ADAS, 1989a,b; HDC, 1988b, 1989a,b, 1992). This report contains a full summary of the trials at Kirton and Rosewarne, along with a brief appendix with information from the Scottish trial.

Materials and Methods

Plant material

Initial stocks of VT bulbs of narcissus cultivars Carlton and Fortune were obtained from the Virology Department, GCRI. These had been derived from field-grown bulbs indexed for freedom from detectable viruses. They were grown to virus-tested mother stock (VTMS) standards in insect-proof tunnels at Rosewarne EHS and propagated by chipping. Prior to use in trials at Rosewarne or Kirton, stocks (from a mixture of clones) were grown in the field for two years at the respective sites, in isolation from non-VT bulb stocks, to allow acclimatisation.

Non-VT stocks of bulbs were grown at Rosewarne and Kirton, using normal, two-year-down husbandry. These EHS stocks were of good quality, free of visible virus and basal rot.

Bulbs for trials were lifted in July 1987 and 1988. A high standard of commercial husbandry was routinely practised with the stocks, including treatment with thiabendazole fungicide within 48 hours of lifting, initial drying at 35°C for 5 days, and subsequent drying and storage at ambient temperatures using fans to provide good air movement through the bulbs. At Kirton, stocks routinely received standard HWT consisting of a 3 hour dip at 44.4°C in aqueous thiabendazole, formaldehyde and wetter (as 500ml Storite Clear Liquid, 500ml commercial formalin and 60ml non-ionic wetter/100 litres), followed by fan-drying at ambient temperatures. At Rosewarne, stocks routinely received HTHWT (3 hours at 46°C, additives as above) after pre-warming (7 days at 30°C) and pre-soaking (3 hours at ambient temperatures with formaldehyde and wetter only).

Planting density and pre-warming trials

After grading stocks in July 1987 at Kirton and Rosewarne, bulbs of VT and EHS stocks of cv Carlton were allocated for the trial, using bulbs of grade 12-14cm at Kirton and 13-15 and 15-17cm grades at Rosewarne. Bulbs were weighed into plots to correspond to planting densities of 5.0, 12.5, 20.0, 27.5 and 35.0 t/ha, and either received standard HWT (see above) following storage at ambient temperatures or pre-warming and HTHWT (see above). HWT dates were 26 and 14 August 1987 at Kirton and Rosewarne, respectively. The trials were planted 30 September 1987 and lifted 16 June 1989 (Kirton), and planted 22 September 1987 and lifted 28 June 1989 (Rosewarne).

Following bulb lifting, fungicide treatment, drying and grading in 1989, equalised lots were weighed from each plot for re-treating and re-planting. Different pre-warming treatments were not tested within trials this time. For the Kirton trial, equal weights of 8-10, 10-12 and 12-14cm grade bulbs were used, HWT was given without pre-warming on 16 August 1989, and the trial was planted on 6 September 1989. For the Rosewarne trial, a 2:5:5 mixture of 8-10, 10-12 and 12-14cm grade bulbs was used, all bulbs were pre-warmed and given HTHWT on 16 August 1989, and transferred to Kirton. Both trials were planted on 6 September 1989 and lifted on 29 July 1991.

Plant density and chipping trials

After grading stocks of cvs Carlton and Fortune in July 1988 (Kirton) or July 1987 (Rosewarne), bulbs of grade 10-12cm (Kirton) or 11-13cm (Rosewarne) were allocated for the chipping trial.

Bulbs were chipped to 16 segments each: at Kirton, chipping was by a prototype chipping machine, and was carried out 7-9 September 1988, and at Rosewarne chips were cut manually on 27-28 August 1987. After cutting, chips were dipped in aqueous benomyl + captafol (as 2g Benlate Fungicide and 40ml Sanspor/litre) for 15 minutes at ambient temperatures, drained, mixed with equal volumes of dampened vermiculite, and stored in trays wrapped with thin polythene film for 12 weeks at 20°C. General details of chipping methods were as given in ADAS (1985a). At the end of incubation, bulbil production was assessed on 100-chip samples (at Kirton only), and chips were weighed into plots corresponding to the planting densities required (1.25, 2.5, 3.75 and 5.0 t/ha at Kirton, and 2.5, 5.0, 7.5 and 10.0 t/ha at Rosewarne).

The trials were planted on 12 December 1988 (Kirton) and 17 November 1987 (Rosewarne), and lifted after 2 years (31 July 1990 and 29 June 1989, respectively). After fungicide treatment, drying and grading (and transfer of the Rosewarne bulbs to Kirton in August 1989), bulbs were bulked within each treatment combination and three equal lots were weighed for each for re-planting at the same planting densities as before. For the Kirton trial, equal weights of bulbs of grades <8 and 8-10cm were used, while for the Rosewarne trials bulbs of 7-9cm grade were used. The trials were planted on 10 October 1989 (Rosewarne) and 27 September 1990 (Kirton) and grown for a further year before lifting (on 31 July 1990 and 29 July 1991, respectively).

Routine husbandry

At Kirton, plots of whole bulbs were planted in netting (eg, Netlon Oriented 1), with guard rows planted loose; the opposite routine was used at Rosewarne, but this is unlikely to affect yields. All chip plots were planted in netting. At planting, the trials areas were ridged out, the plots marked in the furrows, and bulbs were evenly distributed along their plots before the ridges were split back. Ridge centres were generally 0.76m, although 0.71m centres were used at Kirton up to and including 1989 plantings; plot weights were adjusted to give the appropriate planting densities in each case.

Routine crop husbandry at Kirton included autumn and winter weed control with paraquat + diquat, pre-emergence residual herbicide application (eg lenacil + linuron or chlorpropham + linuron, but chloridazon + chlorbufam for the first year of chipped crops), and late-season residual herbicide (bentazone). Routine fungicide sprays were vinclozolin, chlorothalonil and benomyl. Husbandry was similar at Rosewarne, except that the initial trials

area was sterilised with 1,3-dichloropropene, aldicarb was applied into the furrows at planting, and the crop was de-headed when about half the flowers had opened. Fertilisers were applied according to analysis and ADAS recommendations (ADAS, 1985b). In two-year-down growing, crops were re-ridged between growing seasons.

Recording crop growth

Each spring flowering dates were recorded, along with flower numbers, flower diameter and scape (stem) and leaf lengths recorded as near as practical to the full flowering date. Percentage foliage senescence was estimated at about twice-weekly intervals. In non-flowering crops, leaves were counted and measured at the dates shown. Measurements were generally carried out on 20 central plants of each plot.

After lifted bulbs had been dried and hand-cleaned, the weights and numbers of bulbs were recorded in size grades (any additional rotted bulbs were recorded separately).

Virus testing

Leaf samples (10 leaves at random) were taken in spring 1990 from each stock and examined individually for virus content by inoculation to Chenopodium quinoa and electronmicroscopy. This was carried out by the Virology Branch, MAFF Central Science Laboratory.

Design and statistical analysis

The planting density and pre-warming trials for 1987-89 each consisted of three replicate blocks. Stocks and densities were fully randomized to the 10 plots within each replicate and pre-warming treatments were assigned to the ends of each plot in a split-plot arrangement. Other trials were of a randomised block design with three blocks for each cultivar, cultivars being analysed separately. Each plot was surrounded by appropriate guard plants at corresponding planting densities. Data were subjected to the analysis of variance as appropriate. Plot (or split-plot) sizes were 2m long, except for the initial planting of the whole bulb trial at Kirton where 1m long split-plots were used.

In the 1987-1989 Rosewarne planting of the planting density/pre-warming trial, different planting grades were used in different blocks, but as this factor did not interact significantly with others it was subsequently discounted. In the first season of the same trial, the theft of flowers from some plots could have influenced subsequent plant measurement by leaving the relatively poorer blooms: however, this was countered by analysing plots of residuals against field position (which did not reveal any atypical behaviour) and by subsequently cropping all plots to equalise effects due to flower removal on bulb yields.

Results

Kirton trial

1988 results. Flower and foliage measurements for 1988 are shown in Table 1.1. The outstanding result was that EHS stocks out-yielded VT stocks considerably in flower yield per kg planted, irrespective of both planting density and pre-warming treatment which had no significant effects. Flower diameter was not affected significantly by any treatment factor. Stem length was greater in the EHS stock than in the VT stock, increased with increasing planting density (up to 27.5 t/ha), and was greater following pre-warming. Flowering date was virtually unaffected by these treatments.

The rate of foliage senescence is shown in Table 1.2. Senescence was earlier with denser plantings and in EHS compared with VT stocks (at least at higher planting densities), but was unaffected by pre-warming treatment.

1989 results. Flower and foliage data for 1989 are set out in Table 1.3. Between-stock differences in flower yields were now non-significant, the only significant effect being due to planting density, with yield per kg bulbs

planted decreasing with increasing densities. Flower diameter was greater in EHS stocks than in VT, and decreased with increasing planting density. Stem and leaf length increased with increasing planting density, but there were no significant between-stock differences. These variables were unaffected by pre-warming treatment.

Foliage senescence (Table 1.4) was earlier in the highest planting density than in the lowest, but there were no clear effects due to stock (VT or EHS) or pre-warming treatment. VT bulbs were earlier to first flowering than EHS stocks, but no clear treatment differences were evident at the full flowering date (Table 1.4).

Bulb yields after the first two-year-down growing cycle are given in Table 1.5. As expected, planting density had the greatest effect on yields (weight and numbers). VT stocks gave greater yields than EHS bulbs, and the yield from VT bulbs was particularly improved at the lowest (5t/ha) and middle (20t/ha) planting densities, producing a significant 'stock x density' interaction. Pre-warmed bulbs gave a small but significant yield benefit compared with non-pre-warmed bulbs in yields by weight, while in terms of numerical yields, VT bulbs produced fewer bulbs following pre-warming than when not pre-warmed, EHS bulbs showing no such response. Table 1.5 and Fig. 1.1 also show percentage weight increases: at the middle planting density (20t/ha) VT bulbs averaged 166 per cent and EHS bulbs 134 per cent.

Table 1.6 shows the effects of the main treatment factors on bulb yield in grades. The overwhelming effect is the expected one of planting density, with increasing yields with increasing density except for the largest grade, where yields decline with increasing density. The yield advantage of VT stocks was most evident in the smaller grades of bulbs, particularly 8-10cm grade. There was a marked interaction of density and stock, with the yield of 10-12cm grade bulbs especially peaking at a planting density of 20t/ha for VT bulbs but only at higher densities with EHS bulbs.

1990 results. Flower and foliage measurements are given in Table 1.7. Bulbs from EHS stocks produced slightly but significantly more flowers per kg bulbs than VT stocks, although the effect of density was greater, with more flowers produced at higher planting densities. VT stocks produced longer stems and foliage, but flower diameter was not affected by stock. In denser plantings, plants were taller with a tendency for smaller flowers.

There was a tendency for a few days' earlier flowering and senescence in VT stocks than in EHS stocks, although these effects were not entirely consistent (Table 1.8).

1991 results. Table 1.9 gives flower and foliage data. There were no significant effects of stock on flower numbers per kg bulbs, flower size or stem or leaf lengths. At higher planting densities, fewer, smaller flowers were produced, with longer stems and leaves.

Flowering began on the same date in all treatments, but the full flowering date was up to a week earlier planted at 35t/ha than at 5t/ha. Foliage senescence occurred at the same rates in all treatments. There were no effects of stock on these measurements.

Bulb yields are shown in Table 1.10. Weight and numerical yields were unaffected by stock, both increasing with planting density as the percentage weight increase declined. Percentage weight increases averaged 386 at 5t/ha, falling to 53 at 35t/ha. Less than 0.5 per cent of bulbs harvested were discarded due to rotting, with no significant effects of treatment detectable. There were no effects of stock on bulb yields in individual grades. The advantage of VT bulbs over EHS stocks in percentage weight increase at a 20t/ha planting density was not significant, the figures being 139 per cent for VT and 123 per cent for non-VT bulbs.

Table 1.1 Kirton trial. Effect of planting density, stock and pre-warming on flower and plant characteristics in the first season (1988).

Planting density (t/ha)	Stock	Pre-warming treatment	Flowers per kg bulbs	Flower diameter (mm)	Stem length (mm)	Leaf length (mm)
5.0	VT	-	22.2	106	249	328
	VT	yes	19.4	103	380	397
	EHS	-	26.9	103	356	413
	EHS	yes	25.0	104	394	422
12.5	VT	-	16.5	105	310	407
	VT	yes	20.6	106	426	429
	EHS	-	30.3	102	407	418
	EHS	yes	30.3	103	441	450
20.0	VT	-	17.8	103	362	411
	VT	yes	20.0	106	429	438
	EHS	-	25.1	107	379	420
	EHS	yes	25.4	105	447	470
27.5	VT	-	17.4	106	409	428
	VT	yes	20.2	104	441	423
	EHS	-	26.2	104	420	459
	EHS	yes	27.5	105	466	472
35.0	VT	-	17.7	105	364	445
	VT	yes	19.0	103	452	453
	EHS	-	27.3	102	457	465
	EHS	yes	26.1	103	452	477
SED (df = 20)			1.93	1.8	23.2	13.9
SED between pairs of pre-warming treatments			2.01	1.6	24.6	12.9
Summary of significant factors and interactions[+]						
Stock (S)			***	NS	***	***
Density (D)			NS	NS	***	***
SXD			*	NS	NS	NS
Pre-warming (P)			NS	NS	***	***
SXP			NS	NS	**	NS
DXP			NS	NS	NS	*
SXDXP			NS	NS	NS	*

[+] throughout these Tables, NS = not significant, *, ** and ***, significant at 5,1 and 0.1% levels, respectively.

Table 1.2 Kirton trial. Effect of planting density and stock on flowering and senescence dates in the first season (1988)

Planting density (t/ha)	Stock	Flowering dates		Percentage foliage senescence			
		First	100%	27 June	1 July	8 July	20 July
5.0	VT	28 Mar	5 Apr	5	10	20	20
	EHS	21 Mar	5 Apr	5	10	20	25
12.5	VT	26 Mar	15 Apr	5	15	25	30
	EHS	25 Mar	5 Apr	5	10	20	35
20.0	VT	25 Mar	15 Apr	10	15	35	45
	EHS	26 Mar	5 Apr	20	30	35	45
27.5	VT	21 Mar	5 Apr	15	20	35	50
	EHS	25 Mar	5 Apr	25	45	45	55
35.0	VT	26 Mar	15 Apr	30	45	45	55
	EHS	26 Mar	5 Apr	30	50	50	55

Table 1.3 Kirton trial. Effect of planting density, stock and pre-warming on flower and plant characteristics in the second season (1989).

Planting density (t/ha)	Stock	Pre-warming treatment	Flowers per kg bulbs	Flower diameter (mm)	Stem length (mm)	Leaf length (mm)
5.0	VT	-	48.2	112	357	347
	VT	yes	57.4	111	364	376
	EHS	-	53.7	116	344	363
	EHS	yes	50.0	115	358	371
12.5	VT	-	38.6	110	418	424
	VT	yes	46.8	110	408	430
	EHS	-	40.5	116	414	415
	EHS	yes	43.1	111	417	406
20.0	VT	-	41.6	110	454	459
	VT	yes	44.4	108	439	451
	EHS	-	35.7	113	433	425
	EHS	yes	38.5	110	434	430
27.5	VT	-	38.1	109	435	440
	VT	yes	37.4	108	437	444
	EHS	-	37.3	110	453	469
	EHS	yes	34.5	111	446	461
35.0	VT	-	37.4	107	484	482
	VT	yes	34.4	110	484	472
	EHS	-	35.7	110	475	473
	EHS	yes	36.3	110	456	465
SED (df = 20)			3.38	2.0	11.0	20.6
SED between pairs of pre-warming treatments			2.89	2.0	7.9	10.6
Summary of significant factors and interactions						
Stock (S)			NS	***	NS	NS
Density (D)			***	**	***	***
SXD			NS	NS	NS	NS
Pre-warming (P)			NS	NS	NS	NS
SXP			NS	NS	NS	NS
DXP			NS	NS	NS	NS
SXDXP			NS	NS	NS	NS

Table 1.4 Kirton trial. Effect of planting density and stock on flowering and senescence dates in the second season (1989)

Planting density (t/ha)	Stock	Flowering dates		Senescence dates	
		First	100%	5%	50%
5.0	VT	13 Mar	6 Apr	31 May	12 June
	EHS	20 Mar	6 Apr	31 May	12 June
12.5	VT	13 Mar	30 Mar	31 May	12 June
	EHS	20 Mar	30 Mar	23 May	5 June
20.0	VT	10 Mar	30 Mar	23 May	5 June
	EHS	13 Mar	30 Mar	31 May	12 June
27.5	VT	10 Mar	30 Mar	23 May	12 June
	EHS	13 Mar	30 Mar	23 May	5 June
35.0	VT	6 Mar	30 Mar	23 May	12 June
	EHS	13 Mar	30 Mar	23 May	5 June

Table 1.5 Kirton trial. Effect of planting density, stock and pre-warming on bulb yields after the first two-year cycle (1989).

Planting density (t/ha)*	Stock	Pre-warming treatment	Total yield per plot		
			Weight (kg)	Percentage wt. increase	Number
5.0	VT	-	1.84	411	41.3
	VT	yes	1.88	413	28.7
	EHS	-	1.64	356	19.3
	EHS	yes	1.63	353	24.0
12.5	VT	-	2.66	199	55.0
	VT	yes	2.80	215	46.7
	EHS	-	2.58	189	45.3
	EHS	yes	2.78	212	42.7
20.0	VT	-	3.66	158	82.3
	VT	yes	3.89	174	80.3
	EHS	-	3.33	135	54.0
	EHS	yes	3.29	132	54.3
27.5	VT	-	4.05	108	96.3
	VT	yes	4.11	111	99.3
	EHS	-	3.69	104	76.3
	EHS	yes	3.93	102	77.7
35.0	VT	-	4.75	91	128.0
	VT	yes	4.80	92	116.7
	EHS	-	4.36	75	98.3
	EHS	yes	4.49	80	101.0
SED (df = 20)			0.116	-	5.50
SED between pairs of pre-warming treatments			0.109	-	4.50
Summary of significant factors and interactions					
Stock (S)			***		***
Density (D)			***		***
SXD			*		**
Pre-warming (P)			**		NS
SXP			NS		*
DXP			NS		NS
SXDXP			NS		NS

* Corresponding to planting weights (kg bulbs/1m plot) of 0.36, 0.89, 1.42, 1.95 and 2.49

Table 1.6 Kirton trial. Summary of main-effect means for bulb yields by grade (1989)

Factor	Treatment		Yield in Grades (kg per plot) <8	8-10	10-12	12-14	14-16	16-18
Stock	VT		0.35	0.58	0.66	0.74	0.75	0.37
	EHS		0.15	0.30	0.58	0.99	0.79	0.35
		SED	0.031	0.033	0.039	0.069	0.062	0.070
Planting density	5.0		0.18	0.13	0.18	0.32	0.28	0.66
	12.5		0.13	0.25	0.45	0.56	0.79	0.52
	20.0		0.21	0.47	0.60	0.96	1.01	0.30
	27.5		0.37	0.54	0.80	1.12	0.92	0.19
	35.0		0.37	0.82	1.05	1.37	0.86	0.13
		SED	0.049	0.053	0.062	0.110	0.098	0.110
Pre-warming	-		0.27	0.45	0.61	0.88	0.73	0.32
	Yes		0.23	0.44	0.62	0.85	0.82	0.40
		SED	0.027	0.028	0.041	0.043	0.055	0.055
Summary of significant factors and interactions								
Stock (S)			***	***	*	*	NS	NS
Density (D)			***	***	***	***	***	***
SXD			NS	*	***	NS	NS	NS
Pre-warming (P)			NS	NS	NS	NS	NS	NS
SXP			NS	NS	NS	NS	NS	NS
DXP			NS	NS	NS	NS	NS	NS
SXDXP			NS	NS	NS	NS	NS	NS

Table 1.7 Kirton trial. Effect of planting density and stock on flower and plant characteristics in the third season (1990).

Planting density (t/ha)	Stock	Flowers per kg bulbs	Flower diameter (mm)	Stem length (mm)	Leaf length (mm)
5.0	VT	21.3	110	224	249
	EHS	19.9	110	202	228
12.5	VT	25.1	100	319	315
	EHS	32.4	107	292	287
20.0	VT	27.9	100	334	338
	EHS	29.1	100	322	320
27.5	VT	28.3	100	362	342
	EHS	33.1	100	355	336
35.0	VT	30.9	100	380	372
	EHS	31.5	97	365	368
SED (df = 24)		2.20	2.0	13.8	10.9
Summary of significant factors and interactions					
Stock		*	NS	*	**
Density		***	***	***	***
SXD		NS	*	NS	NS

Table 1.8 Kirton trial. Effect of planting density and stock on flowering and senescence dates in the third season (1990)

Planting density (t/ha)	Stock	Flowering dates		Senescence dates	
		First	100%	5%	50%
5.0	VT	11 Mar	)	18 May	8 June
	EHS	11 Mar	)	18 May	8 June
			)		
12.5	VT	11 Mar	)	14 May	30 May
	EHS	8 Mar	)	18 May	8 June
			)		
20.0	VT	8 Mar	) 19 Mar	14 May	30 May
	EHS	8 Mar	)	14 May	4 June
			)		
27.5	VT	5 Mar	)	14 May	4 June
	EHS	11 Mar	)	8 May	30 May
			)		
35.0	VT	5 Mar	)	4 May	30 May
	EHS	11 Mar	)	14 May	4 June

Table 1.9 Kirton trial. Effect of planting density and stock on flower and plant characteristics in the fourth season (1991).

Planting density (t/ha)	Stock	Flowers per kg bulbs	Flower diameter (mm)	Stem length (mm)	Leaf length (mm)
5.0	VT	57.9	105	434	425
	EHS	61.6	105	398	406
12.5	VT	50.2	105	487	522
	EHS	55.8	104	442	525
20.0	VT	40.7	104	523	553
	EHS	44.1	105	520	541
27.5	VT	38.0	99	528	561
	EHS	39.2	101	518	574
35.0	VT	33.9	97	529	569
	EHS	33.3	98	543	582
SED (df = 24)		3.70	2.0	25.0	19.1
Summary of significant factors and interactions					
Stock		NS	NS	NS	NS
Density		***	***	***	***
SXD		NS	NS	NS	NS

Table 1.10 Kirton trial. Effect of planting density and stock on bulb yields after the second two-year growing cycle (1991)

Planting density * (t/ha)	Stock	Yield (kg/plot) in grades in total								% weight increase	Number/ plot
		<8	8-10	10-12	12-14	14-16	16-18	>18	Total		
5.0	VT	0.39	0.63	0.60	0.54	0.54	0.50	0.24	3.44	378	82.0
	EHS	0.27	0.39	0.56	0.89	0.56	0.50	0.39	3.56	394	63.3
12.5	VT	0.21	0.60	1.01	1.05	1.85	0.90	0.34	5.96	235	105.0
	EHS	0.23	0.64	1.01	1.43	1.63	0.77	0.08	5.79	225	111.3
20.0	VT	0.21	1.08	1.44	1.94	1.74	0.37	0	6.78	139	152.7
	EHS	0.32	0.99	1.25	1.94	1.55	0.27	0	6.32	123	146.0
27.5	VT	0.62	1.59	2.17	2.32	0.94	0.03	0	7.68	97	213.7
	EHS	0.65	1.33	2.54	2.18	0.57	0.03	0	7.31	88	213.3
35.0	VT	0.95	1.86	2.53	1.79	0.48	0	0	7.61	53	259.0
	EHS	0.94	2.04	2.86	1.47	0.35	0	0	7.66	54	260.3
SED (df = 24)		0.131	0.117	0.209	0.245	0.267	0.194	0.138	0.418	-	8.23
Summary of significant factors and interactions											
Stock		NS	NS	NS	NS	NS	NS	NS	NS		NS
Density		***	***	***	***	***	***	**	***		***
SXD		NS	NS	NS	NS	NS	NS	NS	NS		NS

* corresponding to planting weights (kg bulbs/2m long plot) of 0.71, 1.77, 2.84, 3.90 and 4.97

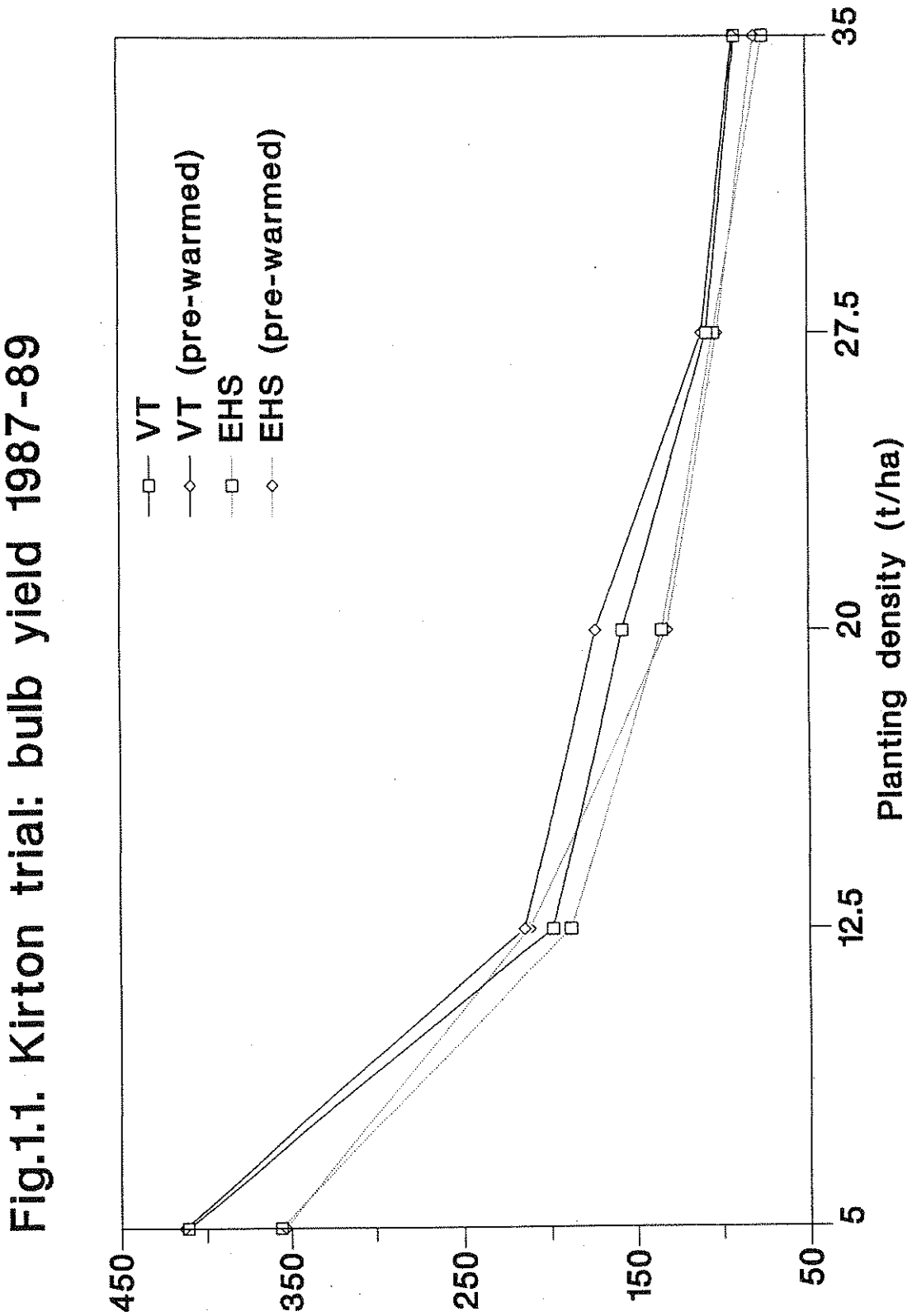


Fig.1.1. Kirton trial: bulb yield 1987-89
VT
VT (pre-warmed)
EHS
EHS (pre-warmed)
Percentage bulb weight increase
450
350
250
150
50
5
12.5
20
27.5
35
Planting density (t/ha)

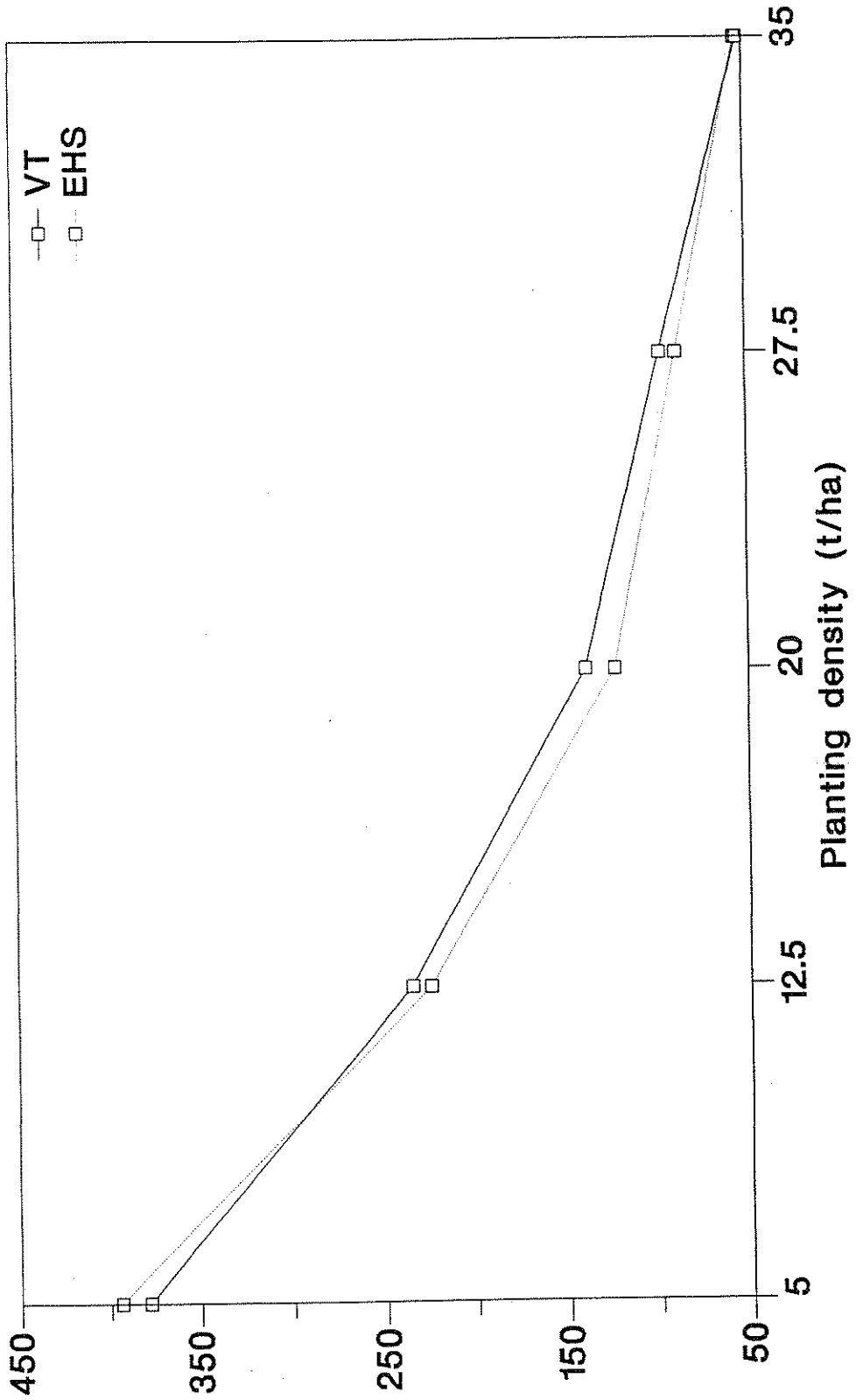


Fig.1.2. Kirton trial: bulb yield 1989-91

Rosewarne trial

1988 results. Flower data are given in Table 2.1. VT plots produced 12 per cent more flowers, overall, than EHS stocks. The yield of flowers per kg of bulbs was reduced at planting densities above 20t/ha. There were no interactions of stock with planting density, and no significant effects of pre-warming treatment. About 13 per cent of flowers showed typical HWT-damage following standard HWT, but this was virtually absent when pre-warming and HTHWT was used. Larger flowers were obtained from EHS stock than from VT stock, and when pre-warming was used: the extremes were 112 and 101mm. The major factor affecting stem length was planting density, with stems averaging 265mm at the lowest density and 296mm at the highest; pre-warming treatment interacted with stock, pre-warming reducing stem length more in VT than in EHS stocks. Flowering dates this year could not be determined accurately due to theft (see Materials and Methods).

There did not appear to be differences in senescence dates between treatments.

1989 results. Table 2.2 gives flower and foliage data for this year. The effects of treatments on flower yields were more complex than in the first year. The advantage of VT stock was considerable, this producing 46 per cent more flowers overall than EHS stock. There was a significant effect of pre-warming, which resulted in 8 per cent more flowers than for untreated bulbs. There were interactions of pre-warming with stock, pre-warming having a greater effect in VT stocks, and with planting density, the advantage of pre-warming increasing with density. The yield of flowers per kg bulb fell from 51 (at 5t/ha) to 37 (35t/ha) in the VT stock and from 33 to 28 for the EHS stock.

Using VT bulbs and pre-warming produced larger flowers than using EHS stocks or not treating bulbs (extreme mean diameters, 122 and 109mm) (Table 2.2). Stem length increased with increasing planting density, the more so in VT stocks, while pre-warming treatment had no effect. Leaf length was greater in VT stocks and at the higher planting densities, but the leaves of VT stocks were narrower than those of EHS bulbs (Table 2.2).

The flowering dates of VT plots were significantly earlier than for EHS plots: by 6 March 1989, 69 per cent of flowers from VT plots had opened, but only 18 per cent on EHS plots. Higher planting densities also conferred earlier flowering (corresponding flowering percentages, 25 at 5t/ha to 47 at 35t/ha) as did using pre-warmed bulbs (48% against 35% in untreated bulbs).

There were no noticeable differences in senescence dates between stocks and treatments.

Bulb yields for 1989 are given in Table 2.3. The major effects were due to stock, planting density, and an interaction between the two. VT bulbs gave consistently greater yields (in total weight or number). Both weight and numerical yields increased with planting density, but in favour of the VT stock. At 5t/ha, percentage weight increases were 317 for VT stock and 187 for EHS stock, falling to 103 and 64, respectively, at 35t/ha (Fig. 2.1). Pre-warming gave more advantage to VT than to EHS stock, with numbers actually declining for the latter stock, although weights improved slightly.

The distribution of bulbs to grades (Table 2.4) showed that VT stocks gave a higher yield up to size 14cm, with a reversal for larger grades.

1990 results. Flower and leaf measurements are given in Table 2.5. VT bulb produced more flowers with longer stems and leaves than EHS stocks, and increasing the planting density had the same effects. Effects on flower size were slight and probably unimportant.

There was a suggestion of slightly earlier flowering and senescence in VT stocks compared with EHS ones (Table 2.6).

1991 results. Flower production and leaf measurements are presented in Table 2.7. VT bulbs produced slightly more flowers per kg bulbs planted than EHS bulbs, while flower production declined markedly with increasing planting densities. Stock and density interacted significantly, VT bulbs performing better than EHS bulbs at the extreme densities. Stem and leaf length were only slightly longer in VT bulbs than in EHS stocks, height increasing markedly at higher planting densities. There were no significant differences between treatments in flower diameter.

There were no differences between stocks in flowering dates, although 50 and 100 per cent flowering dates occurred up to a week earlier at the highest planting density than at the lowest. Rates of foliage senescence were similar in all treatment combinations.

Bulb yields are given in Table 2.8. VT bulbs gave a slight yield advantage over EHS bulbs in weight, particularly at the highest two planting densities, but no significant advantage in terms of numbers of bulbs harvested. The overriding effect was due to planting density, with overall percentage weight increases falling from 426 (at 5t/ha) to 56 (at 35t/ha) (Fig. 2.2). Less than 0.2 per cent of bulbs harvested were discarded due to rotting, with no significant effects of treatment detectable. There were no effects of stock on bulb yields in separate grades, except in the case of 12-14cm grade where more and heavier bulbs resulted from the VT stock. There were weak but significant interactions between stock and density on yields in grades, but without any obvious overall pattern.

Table 2.1 Rosewarne trial. Effect of planting density, stock and pre-warming on flower and plant characteristics in the first season (1988).

Planting density (t/ha)	Stock	Pre-warming treatment	Flowers per kg bulbs	Flower diameter (mm)	Stem length (mm)
5.0	VT	-	26.7	103	290
	VT	yes	28.9	107	267
	EHS	-	21.5	111	264
	EHS	yes	22.3	110	240
12.5	VT	-	23.3	98	300
	VT	yes	25.8	105	281
	EHS	-	22.8	110	285
	EHS	yes	22.2	113	290
20.0	VT	-	26.9	105	331
	VT	yes	27.3	110	328
	EHS	-	22.2	109	296
	EHS	yes	21.9	114	307
27.5	VT	-	23.6	101	300
	VT	yes	22.8	108	290
	EHS	-	20.6	109	300
	EHS	yes	20.0	111	293
35.0	VT	-	20.8	100	303
	VT	yes	22.3	104	280
	EHS	-	21.0	111	304
	EHS	yes	20.5	111	298
SED (df = 20)			1.78	3.3	18.1
SED between pairs of pre-warming treatments			1.46	2.9	7.5
Summary of significant factors and interactions					
Stock (S)			***	***	NS
Density (D)			**	NS	*
SXD			NS	NS	NS
Pre-warming (P)			NS	***	***
SXP			NS	NS	*
DXP			NS	NS	*
SXDXP			NS	NS	NS

Table 2.2 Rosewarne trial. Effects of planting density, stock and pre-warming on flower and plant characteristics in the second season (1989).

Planting density (t/ha)	Stock	Pre-warming treatment	Flowers per kg bulbs	Flower diameter (mm)	Stem length (mm)	Leaf length (mm)	Leaf width (mm)
5.0	VT	-	50.0	110	309	454	18.7
	VT	yes	52.6	118	300	425	17.4
	EHS	-	33.8	119	284	454	18.9
	EHS	yes	31.6	124	286	448	21.0
12.5	VT	-	51.1	111	366	475	17.3
	VT	yes	50.0	113	353	484	18.6
	EHS	-	30.0	121	314	451	19.6
	EHS	yes	33.8	125	327	449	17.7
20.0	VT	-	42.2	111	388	514	17.2
	VT	yes	53.1	112	399	508	17.2
	EHS	-	29.6	119	339	486	18.5
	EHS	yes	30.4	121	348	475	18.8
27.5	VT	-	38.1	107	403	526	16.4
	VT	yes	43.3	110	410	549	17.8
	EHS	-	29.6	119	374	494	18.4
	EHS	yes	28.3	121	360	524	19.1
35.0	VT	-	35.7	109	433	553	16.8
	VT	yes	39.1	110	430	584	16.6
	EHS	-	26.9	116	371	492	17.0
	EHS	yes	28.7	121	386	491	22.1
SED (df = 20)			3.04	2.4	9.8	22.0	1.50
SED between pairs of pre-warming treatments			2.52	2.3	9.6	19.3	1.51
Summary of significant factors and interactions							
Stock (S)			***	***	***	***	**
Density (D)			***	*	***	***	NS
SXD			*	NS	*	*	NS
Pre-warming (P)			**	***	NS	*	NS
SXP			*	NS	NS	NS	NS
DXP			NS	NS	NS	NS	NS
SXDXP			NS	NS	NS	NS	NS

Table 2.3 Rosewarne trial. Effect of planting density, stock and pre-warming on bulb yields after the first two-year cycle (1989).

Planting density * (t/ha)	Stock	Pre-warming treatment	Weight (kg/plot)	Percentage wt. increase	Number /plot
5.0	VT	-	3.09	308	50.3
	VT	yes	3.24	326	49.0
	EHS	-	2.36	211	33.3
	EHS	yes	2.15	163	26.7
12.5	VT	-	6.43	239	126.7
	VT	yes	6.59	247	121.7
	EHS	-	4.35	129	65.0
	EHS	yes	4.63	144	63.7
20.0	VT	-	8.09	166	183.0
	VT	yes	9.14	201	205.7
	EHS	-	5.98	97	102.3
	EHS	yes	6.27	107	96.0
27.5	VT	-	9.77	134	256.0
	VT	yes	10.44	150	271.3
	EHS	-	7.70	84	136.7
	EHS	yes	7.61	82	122.7
35.0	VT	-	10.23	92	294.7
	VT	yes	11.35	114	162.3
	EHS	-	8.51	60	338.3
	EHS	yes	8.87	67	156.3
SED (df = 20)			0.254	-	10.00
SED between pairs of pre-warming treatments			0.251	-	8.14
Summary of significant factors and interactions					
Stock (S)			***		***
Density (D)			***		***
SXD			***		***
Pre-warming (P)			***		NS
SXP			**		***
DXP			*		NS
SXDXP			NS		*

* corresponding to planting weights (kg bulbs/2m plot) of 0.76, 1.90, 3.04, 4.18 and 5.32

Table 2.4 Rosewarne trial. Summary of main-effect means for bulb yields by grade (1989)

Factor	Treatment		Yield in grades (kg per plot)					
			6-8	8-10	10-12	12-14	14-16	>16
Stock	VT		0.44	1.44	2.11	2.23	1.24	0.35
	EHS		0.06	0.39	0.97	1.56	1.78	1.09
		SED	0.024	0.049	0.075	0.071	0.113	0.094
Planting density	5.0		0.02	0.14	0.43	0.60	0.73	0.78
	12.5		0.06	0.49	1.04	1.22	1.70	0.98
	20.0		0.17	0.89	1.60	2.39	1.67	0.64
	27.5		0.36	1.38	2.06	2.56	1.79	0.70
	35.0		0.62	1.65	2.57	2.70	1.66	0.49
		SED	0.038	0.078	0.119	0.112	0.179	0.149
Pre-warming	-		0.21	0.87	1.59	1.86	1.48	0.63
	Yes		0.28	0.96	1.49	1.93	1.54	0.81
		SED	0.028	0.063	0.067	0.088	0.089	0.064
Summary of significant factors and interactions								
Stock (S)			***	***	***	***	***	***
Density (D)			***	***	***	***	***	*
SXD			***	***	***	***	***	*
Pre-warming (P)			*	NS	NS	NS	NS	**
SXP			**	*	NS	NS	NS	NS
DXP			NS	NS	NS	NS	NS	NS
SXDXP			*	NS	NS	NS	NS	NS

Table 2.5 Rosewarne trial. Effect of planting density and stock on flower and plant characteristics in the third season (1991).

Planting density (t/ha)	Stock	Flowers per kg bulbs	Flower diameter (mm)	Stem length (mm)	Leaf length (mm)
5.0	VT	23.6	110	245	266
	EHS	21.8	110	217	227
12.5	VT	27.2	110	300	289
	EHS	26.4	107	272	266
20.0	VT	28.9	110	323	316
	EHS	26.4	110	307	310
27.5	VT	30.8	107	335	340
	EHS	26.8	110	320	303
35.0	VT	30.3	100	351	351
	EHS	25.7	110	332	336
SED (df = 24)		1.36	2.2	16.5	13.7
Summary of significant factors and interactions					
Stock		***	NS	*	***
Density		***	*	***	***
SXD		NS	**	NS	NS

Table 2.6 Rosewarne trial. Effect of planting density and stock on flowering and senescence dates in the third season (1990)

Planting density (t/ha)	Stock	Flowering dates		Senescence dates	
		First	100%	5%	50%
5.0	VT	11 Mar	)	18 May	11 June
	EHS	11 Mar	)	21 May	11 June
			)		
12.5	VT	11 Mar	)	14 May	4 June
	EHS	11 Mar	)	21 May	8 June
			)		
20.0	VT	5 Mar	) 19 Mar	18 May	30 May
	EHS	11 Mar	)	18 May	4 June
			)		
27.5	VT	5 Mar	)	21 May	30 May
	EHS	11 Mar	)	21 May	30 May
			)		
35.0	VT	5 Mar	)	14 May	30 May
	EHS	11 Mar	)	18 May	30 May

Table 2.7 Rosewarne trial. Effect of planting density and stock on flower and plant characteristics in the fourth season (1991).

Planting density (t/ha)	Stock	Flowers per kg bulbs	Flower diameter (mm)	Stem length (mm)	Leaf length (mm)
5.0	VT	64.4	108	440	435
	EHS	57.9	106	436	430
12.5	VT	50.9	106	500	518
	EHS	50.9	103	493	524
20.0	VT	41.9	104	566	584
	EHS	40.4	105	536	559
27.5	VT	38.3	102	573	601
	EHS	40.7	105	561	580
35.0	VT	38.0	101	565	594
	EHS	32.9	104	561	579
SED (df = 24)		1.86	2.2	10.2	18.7
Summary of significant factors and interactions					
Stock		*	NS	*	NS
Density		***	NS	***	***
SXD		*	NS	NS	NS

Table 2.8 Rosewarne trial. Effect of planting density and stock on bulb yields after the second two-year cycle (1991)

Planting density * (t/ha)	Stock	Yield (kg/plot) in grades and in total								% Weight increase	Number/ plot
		<8	8-10	10-12	12-14	14-16	16-18	>18	Total		
5.0	VT	0.52	0.26	0.30	0.56	0.41	0.90	0.83	3.77	424	71.0
	EHS	0.31	0.44	0.59	0.49	0.41	0.80	0.77	3.80	428	67.7
12.5	VT	0.14	0.61	0.80	0.75	2.17	1.30	0.10	5.87	230	96.7
	EHS	0.23	0.78	0.78	1.13	1.49	1.00	0.27	5.68	219	106.3
20.0	VT	0.21	0.81	0.98	2.04	2.03	0.47	0.07	6.60	133	130.0
	EHS	0.20	0.87	0.97	1.64	2.21	0.70	0	6.59	132	128.0
27.5	VT	0.19	0.66	1.45	2.76	2.29	0.23	0	7.58	94	161.3
	EHS	0.52	1.12	1.57	2.27	1.42	0.20	0	7.10	82	177.0
35.0	VT	0.39	1.20	2.13	3.31	0.95	0	0	7.98	60	216.0
	EHS	0.45	0.90	1.38	2.75	1.91	0.07	0.03	7.49	51	184.3
SED (df = 24)		0.108	0.129	0.176	0.228	0.361	0.231	0.090	0.240	-	8.57
Summary of significant factors and interactions											
Stock		NS	NS	NS	*	NS	NS	NS	*		NS
Density		**	***	***	***	***	***	***	***		***
SXD		*	*	**	NS	*	NS	NS	NS		*

* corresponding to planting weights (kg bulbs/2m long plot) of 0.71, 1.77, 2.84, 3.90 and 4.97

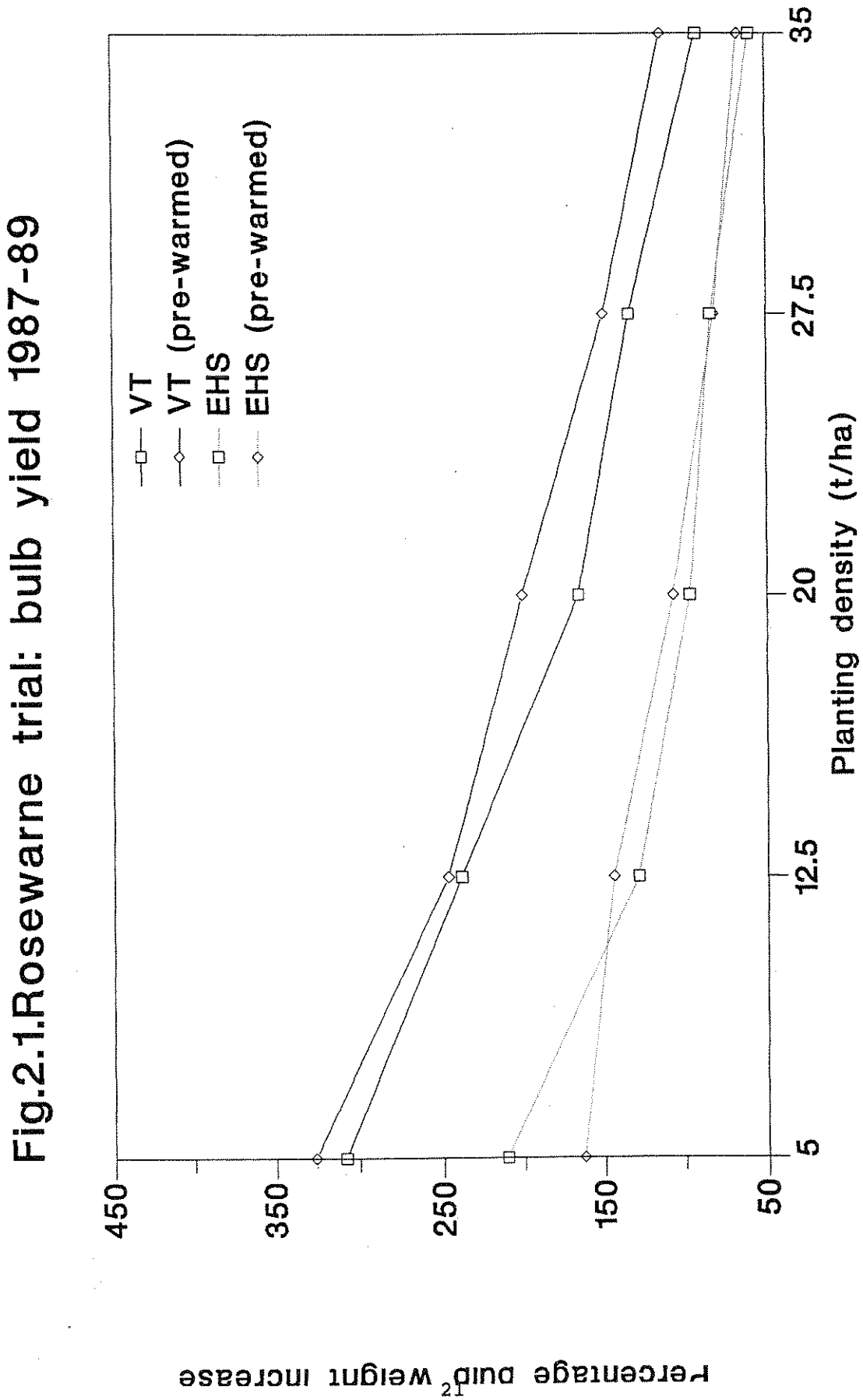


Fig.2.1.Rosewarne trial: bulb yield 1987-89
VT
VT (pre-warmed)
EHS
EHS (pre-warmed)
450
350
250
150
50
5
12.5
20
27.5
35
Planting density (t/ha)
Percentage bulb weight increase

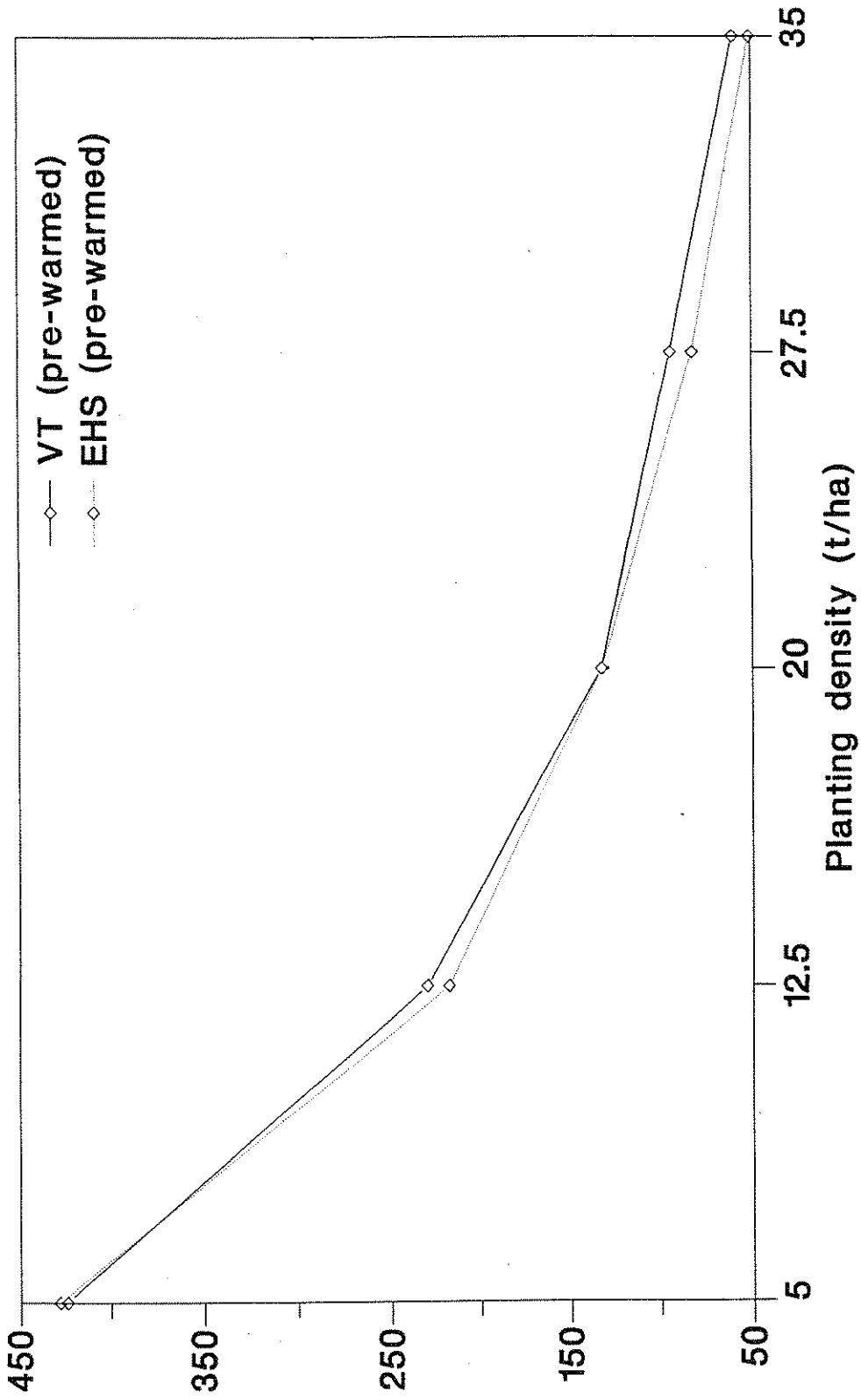


Fig.2.2 Rosewarne trial: bulb yield 1989-91
VT (pre-warmed)
EHS (pre-warmed)
Percentage bulb weight increase
450
350
250
150
50
5
12.5
20
27.5
35
Planting density (t/ha)

Kirton chip trial

1988 results. Bulbil production at the end of chip incubation is summarised in Table 3.1. There were only small differences between stocks of a given cultivar, suggesting that the overall productivity of VT and EHS bulbs was similar.

1989 results. Leaf production (measured in April and June) is given in Table 3.2. There were no significant effects of stock on leaf numbers or length in either cultivar (one very low leaf length for the April measurements of EHS Fortune was considered spurious).

1990 results. Leaf records for April appear in Table 3.2. In both cultivars, leaf numbers were much higher for EHS than for VT stocks. EHS stocks also had longer leaves (significantly so in cv Fortune), so that differences may have resulted from earliness rather than vigour (although the similarity of leaf records for the two stocks in 1989 tended to discount the earliness factor).

Bulb yields after two years' growth are given in Table 3.3. In Carlton, total yields (by weight) tended to be slightly higher for EHS stocks than for VT bulbs, although the stock factor just failed to achieve statistical significance at the 5 per cent level; EHS bulbs produced significantly more bulbs in the 10-12cm grade. In Fortune, by contrast, VT stocks gave significantly greater total yields, enhancing the weights of bulbs in grades over 8cm. Fig. 3.1 summarises the percentage bulb weight increases. There were no statistically significant effects of stock on total bulb numbers in either cultivar; numbers in grades were not analysed separately because of the high correlation between weights and numbers.

1991 results. Flower and leaf measurements are given in Table 3.4. There were no distinct effects of stock on flower number or size or stem or leaf length in Carlton, but in Fortune VT bulbs produced more flowers than EHS ones. Leaf and stem lengths tended to increase with planting density but indications of smaller flowers at high planting densities were slight.

Flower and senescence dates were similar in all treatments for both cultivars.

Bulb yield after the third growing season are given in Table 3.5. For Carlton, there were no significant effects due to stock on weight or numerical yields in total or in individual grades. At 1.25t/ha, EHS stocks gave greater percentage weight increases than VT stocks, but at all higher planting densities this was reversed (Fig. 3.2). For Fortune, VT stocks yielded a significantly greater total weight of bulbs, and of bulbs in the two largest grades, but a lower weight of bulbs in the smallest (<8cm) grade. The shift in distribution to grades in Fortune resulted in significantly greater numbers of bulbs lifted from the plots of EHS bulbs compared with VT stocks. About 2 and 1 per cent of bulbs were removed at harvest because of rotting in the two cultivars, respectively, and no effects due to treatments were discernible.

Table 3.1 Kirton chip trial. Bulbil production at the end of incubation in two cultivars and two stocks

Cultivar	Stock	Bulbils/ chip	Mean bulbil length (mm)	% non-productive chips	
				Sound	Rotted
Carlton	VT	1.10	10.8	7	5
	EHS	1.11	12.1	2	6
Fortune	VT	1.06	13.4	4	7
	EHS	0.99	12.5	6	7

Table 3.2 Kirton chip trial. Effect of stock and planting density on leaf production over the first two seasons (1989-1990)

Planting density (t/ha)	Stock	April 1989		June 1989		April 1990	
		Leaves/ plot	Leaf length (mm)	Leaves/ plot	Leaf length (mm)	Leaves/ plot	Leaf length (mm)
Carlton							
1.25	VT	19.0	24	44.0	195	116.7	329
	EHS	26.0	39	49.7	195	350.0	342
2.50	VT	44.3	28	93.7	190	126.0	325
	EHS	46.0	32	91.3	180	331.7	335
3.75	VT	86.0	34	146.7	187	234.3	348
	EHS	76.7	36	140.0	200	455.3	344
5.00	VT	117.3	36	190.3	193	230.0	340
	EHS	106.0	37	180.0	205	469.7	363
SED (df = 14)		9.89	5.4	8.26	9.4	15.91	11.1
Summary of significant factors and interactions							
Stock		NS	NS	NS	NS	***	NS
Density		***	NS	***	NS	***	NS
SXD		NS	NS	NS	NS	NS	NS
Fortune							
1.25	VT	40.7	64	48.3	192	103.0	361
	EHS	39.0	67	46.7	220	302.3	369
2.50	VT	83.7	79	100.0	213	100.0	324
	EHS	70.7	(51)	92.0	208	285.0	345
3.75	VT	110.7	77	145.0	210	187.0	366
	EHS	107.0	72	133.0	202	348.0	385
5.00	VT	142.3	76	168.3	215	185.7	343
	EHS	140.0	65	179.7	198	381.0	377
SED (df = 14)		10.81	6.4	9.26	11.6	23.18	15.6
Summary of significant factors and interactions							
Stock		NS	**	NS	NS	***	*
Density		***	NS	***	NS	***	*
SXD		NS	*	NS	NS	NS	NS

( ) indicates a possibly spurious value

Table 3.3 Kirton chip trial. Effect of stock and planting density on bulb yields after the first two years (1990)

Planting density * (t/ha)	Stock	Yield (kg/plot) in grades and total					% Weight increase	Number/ plot
		<8	8-10	10-12	>12	Total		
Carlton								
1.25	VT	0.20	0.22	0.18	0.05	0.64	256	40.0
	EHS	0.16	0.24	0.23	0.10	0.73	306	41.7
2.50	VT	0.43	0.29	0.15	0.01	0.89	147	83.3
	EHS	0.39	0.38	0.28	0.04	1.09	203	85.3
3.75	VT	0.71	0.40	0.17	0.04	1.32	149	142.7
	EHS	0.63	0.40	0.19	0.07	1.29	143	122.7
5.00	VT	0.84	0.49	0.18	0.03	1.53	115	179.7
	EHS	0.84	0.50	0.24	0.06	1.65	132	170.7
SED (df = 14)		0.061	0.050	0.059	0.055	0.089	-	6.77
Summary of significant factors and interactions								
Stock		NS	NS	*	NS	*		NS
Density		***	***	NS	NS	***		***
SXD		NS	NS	NS	NS	NS		NS
Fortune								
1.25	VT	0.12	0.15	0.09	0.09	0.45	150	27.7
	EHS	0.14	0.12	0.09	0.05	0.40	122	36.7
2.50	VT	0.24	0.32	0.23	0.15	0.94	161	61.7
	EHS	0.26	0.19	0.09	0.03	0.58	61	63.3
3.75	VT	0.43	0.46	0.31	0.08	1.29	143	104.3
	EHS	0.41	0.30	0.13	0.02	0.86	62	104.0
5.00	VT	0.61	0.49	0.32	0.10	1.52	114	137.3
	EHS	0.64	0.34	0.11	0.03	1.12	58	144.3
SED (df = 14)		0.065	0.089	0.067	0.043	0.127	-	11.75
Summary of significant factors and interactions								
Stock		NS	*	***	**	***		NS
Density		***	**	*	NS	***		***
SXD		NS	NS	NS	NS	NS		NS

* corresponding to planting weights (kg bulbs/2m long plot) of 0.18, 0.35, 0.53 and 0.71

Table 3.4 Kirton chip trial. Effect of stock and planting density on flower and leaf characteristics in the third season (1991).

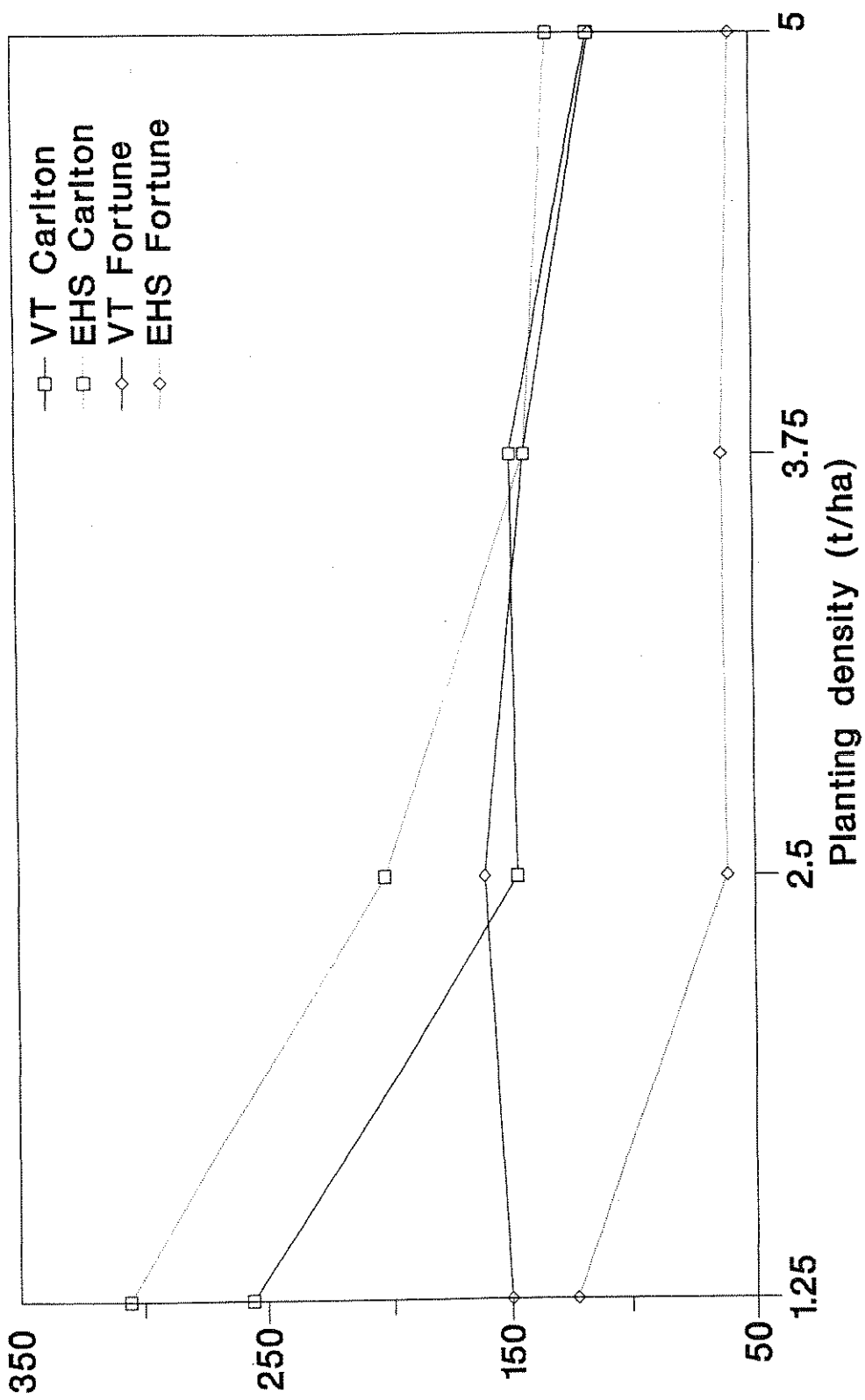
Planting density (t/ha)	Stock	Flowers per kg bulbs	Flower diameter (mm)	Stem length (mm)	Leaf length (mm)
Carlton					
1.25	VT	4.0	100	227	223
	EHS	6.3	90	243	230
2.50	VT	14.0	90	243	243
	EHS	13.0	90	238	230
3.75	VT	18.3	90	246	257
	EHS	20.0	93	263	260
5.00	VT	29.7	90	254	277
	EHS	24.7	90	239	250
SED (df = 14)		1.42	1.7	11.6	8.4
Summary of significant factors and interactions					
Stock		NS	NS	NS	NS
Density		***	**	NS	***
SXD		*	***	NS	*
Fortune					
1.25	VT	5.0	80	313	277
	EHS	5.0	83	308	283
2.50	VT	12.0	80	325	277
	EHS	10.7	83	314	293
3.75	VT	18.0	80	330	283
	EHS	11.7	83	324	280
5.0	VT	22.3	80	345	303
	EHS	18.0	80	332	293
SED (df = 14)		2.62	2.4	11.9	7.5
Summary of significant factors and interactions					
Stock		*	NS	NS	NS
Density		***	NS	*	*
SXD		NS	NS	NS	NS

Table 3.5 Kirton chip trial. Effect of stock and planting density on bulb yields after the third season (1991)

Planting density * (t/ha)	Stock	Yield (kg/plot) in grades and in total						% Weight increase	Number/ plot
		<8	8-10	10-12	12-14	14-16	Total		
Carlton									
1.25	VT	0.03	0.08	0.13	0.17	0.02	0.43	126	17.0
	EHS	0.01	0.08	0.14	0.22	0.07	0.52	174	16.0
2.50	VT	0.06	0.17	0.34	0.44	0.02	1.01	166	35.7
	EHS	0.08	0.17	0.33	0.30	0.02	0.90	137	38.0
3.75	VT	0.14	0.25	0.60	0.34	0.05	1.39	144	60.0
	EHS	0.10	0.19	0.44	0.47	0.11	1.30	128	52.7
5.00	VT	0.09	0.32	1.00	0.52	0.02	1.95	157	70.0
	EHS	0.14	0.43	0.78	0.33	0.06	1.74	129	75.3
SED (df = 14)		0.031	0.060	0.082	0.102	0.043	0.102	-	4.41
Summary of significant factors and interactions									
Stock		NS	NS	*	NS	NS	NS		NS
Density		***	***	***	*	NS	***		***
SXD		NS	NS	NS	NS	NS	NS		NS
Fortune									
1.25	VT	0.01	0.06	0.14	0.25	0.09	0.55	189	15.3
	EHS	0.04	0.06	0.22	0.16	0	0.48	153	19.0
2.50	VT	0.04	0.14	0.38	0.36	0.12	1.04	174	36.0
	EHS	0.09	0.12	0.53	0.30	0	1.03	171	41.7
3.75	VT	0.06	0.25	0.54	0.49	0.07	1.40	146	51.7
	EHS	0.15	0.37	0.49	0.24	0.02	1.27	123	63.3
5.00	VT	0.11	0.30	0.82	0.61	0.08	1.91	151	73.0
	EHS	0.19	0.38	0.93	0.28	0	1.79	136	85.7
SED (df = 14)		0.029	0.044	0.077	0.107	0.043	0.050	-	4.03
Summary of significant factors and interactions									
Stock		***	NS	NS	**	*	**		***
Density		***	***	***	*	NS	***		***
SXD		NS	NS	NS	NS	NS	NS		NS

* corresponding to planting weights (kg bulbs/2m plot) of 0.19, 0.38, 0.57 and 0.76

Fig.3.1. Kirton chip trial: bulb yield 1988-90



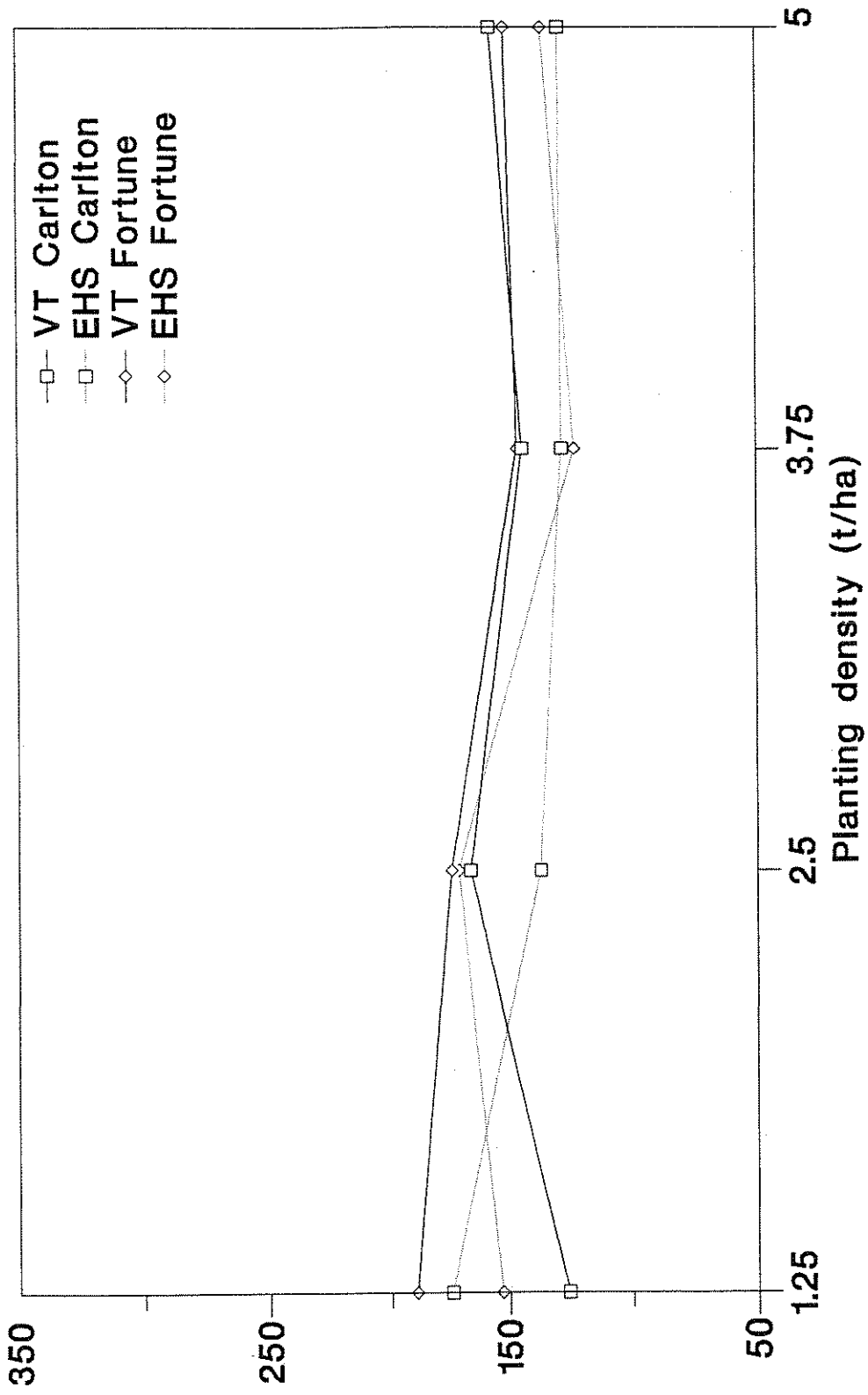


Fig.3.2. Kirton chip trial: bulb yield 1990-91

Rosewarne chip trial

1988 results. Foliage records are summarised in Table 4.1: both varieties had produced more and taller leaves in VT stocks than in EHS stocks by the time of recording.

1989 results. Leaves remained more numerous, taller and wider in VT stocks than in EHS stocks, the effect being stronger in Carlton than in Fortune (Table 4.1). Foliage height increased slightly with increasing planting density.

Bulb yields two years after chipping are given in Table 4.2. Both cultivars showed considerable advantage of VT stock over EHS stocks in total weight yields. In Carlton, VT stocks produced greater weights of bulbs in grades >7cm, EHS stocks more in grades <6cm. In Fortune, VT bulbs produced more yield than EHS bulbs in all grades >5cm. Significant interactions between stock and density resulted from greater growth in VT bulbs at higher densities, especially in Carlton (Fig. 4.1). The increase in the total numbers of bulbs harvested was smaller than the weight increase in Carlton and not significant in the case of Fortune.

1990 results. Flower and leaf data are presented in Table 4.3. In Carlton, VT stocks produced slightly more flowers than EHS stocks, although this effect just failed to reach significance at the 5 per cent level. In Fortune, VT stocks produced significantly more flowers. Flower diameter was significantly greater in VT than EHS stocks in Carlton (no measurements were possible in cv Fortune). Stem and leaf lengths were greater in VT stocks, and increased with planting density, in both cultivars. On average VT stocks of both cultivars were a few days earlier to flower than EHS stocks, while senescence dates were similar in all cases.

Bulb yields are shown in Table 4.4 and Fig. 4.2. In Carlton, yields were not significantly different between VT and EHS stocks. VT Fortune produced significantly greater total weights than EHS stocks, mainly by increasing the yield of bulbs in the larger (>12cm) grades, and by increasing yields of smaller bulbs at the higher densities. Less than 0.5 per cent of bulbs were rejected due to rots at harvest, and no effects due to treatments were evident.

Table 4.1 Rosewarne chip trial. Effect of stock and planting density on leaf production over the first two seasons (1988-1989)

Planting density (t/ha)	Stock	1988		1989		
		Leaves/ plot	Leaf length (mm)	Leaves/ plot+	Leaf length(mm)	Leaf width (mm)
Carlton						
2.5	VT	176.9	164	364	352	8.7
	EHS	77.4	83	246	295	6.4
5.0	VT	400.0	169	910	356	8.4
	EHS	169.0	98	379	330	6.7
7.5	VT	506.3	169	1130	370	7.6
	EHS	225.0	82	623	318	6.4
10.0	VT	590.5	157	1292	377	7.9
	EHS	278.9	89	802	339	6.6
SED (df = 14)		18.9	7.0	-	14.8	0.41
Summary of significant factors and interactions						
Stock		***	***		***	***
Density		***	NS		*	NS
SXD		**	NS		NS	NS
Fortune						
2.5	VT	134.6	177	300	351	7.3
	EHS	108.2	146	301	332	6.1
5.0	VT	249.6	166	524	393	7.7
	EHS	225.0	139	561	342	7.1
7.5	VT	396.0	166	791	374	7.8
	EHS	342.3	122	700	338	6.1
10.0	VT	524.4	194	1230	378	7.5
	EHS	364.8	128	748	379	7.2
SED (df = 14)		63.6	9.1	-	16.5	0.55
Summary of significant factors and interactions						
Stock		NS	***		*	**
Density		***	*		*	NS
SXD		NS	*		NS	NS

+ unreplicated observation only

Table 4.2 Rosewarne chip trial. Effect of stock and planting density on bulb yields after the first two years (1989)

Planting density * (t/ha)	Stock	Yield (kg/plot) in grades and in total								% weight increase	Number/ plot
		<5	5-6	6-7	7-8	8-9	9-10	>10	Total		
Carlton											
2.5	VT	0.01	0.06	0.21	0.48	0.59	0.34	0.68	2.37	524	147
	EHS	0.10	0.11	0.22	0.30	0.20	0.08	0.03	1.05	176	130
5.0	VT	0.07	0.32	0.64	0.88	0.81	0.62	0.36	3.71	388	301
	EHS	0.20	0.24	0.45	0.47	0.50	0.19	0.07	2.12	179	279
7.5	VT	0.13	0.48	1.02	1.13	1.07	0.63	0.31	4.77	318	439
	EHS	0.34	0.30	0.56	0.55	0.46	0.16	0.02	2.38	109	383
10.0	VT	0.10	0.59	1.15	1.25	1.08	0.54	0.20	5.00	229	530
	EHS	0.46	0.44	0.74	0.68	0.37	0.21	0.02	2.93	93	505
SED (df = 14)		0.222	0.072	0.109	0.070	0.087	0.083	0.105	0.159	-	11.5
Summary of significant factors and interactions											
Stock		***	*	***	***	***	***	***	***		***
Density		***	***	***	***	***	*	*	***		***
SXD		***	NS	*	**	*	NS	*	***		NS
Fortune											
2.5	VT	0.02	0.04	0.17	0.32	0.40	0.52	0.48	1.77	366	128
	EHS	0.08	0.09	0.26	0.31	0.36	0.14	0.02	1.29	239	150
5.0	VT	0.08	0.14	0.47	0.69	0.71	0.64	0.40	3.25	328	262
	EHS	0.14	0.24	0.57	0.64	0.30	0.12	0.03	2.30	203	268
7.5	VT	0.13	0.21	0.55	0.84	1.06	0.85	0.58	4.18	267	379
	EHS	0.23	0.35	0.80	0.77	0.40	0.15	0.04	2.70	137	397
10.0	VT	0.18	0.38	1.06	1.42	1.19	0.75	0.27	4.99	228	544
	EHS	0.38	0.47	0.84	0.73	0.41	0.18	0.09	3.21	111	507
SED (df = 14)		0.045	0.061	0.099	0.118	0.118	0.145	0.156	0.267	-	11.4
Summary of significant effects and interactions											
Stock		***	**	NS	**	***	***	***	***		NS
Density		***	***	***	***	***	NS	NS	***		***
SXD		NS	NS	*	**	**	NS	NS	*		*

* corresponding to planting weights (kg bulbs chipped/2m plot) of 0.38, 0.76, 1.14 and 1.52

Table 4.3 Rosewarne chip trial. Effect of stock and planting density on flower and leaf production in the third season (1990).

Planting density (t/ha)	Stock	Flowers per plot	Flower diameter (mm)	Stem length (mm)	Leaf length (mm)
Carlton					
2.5	VT	14.0	90	247	265
	EHS	13.3	89	234	240
5.0	VT	27.0	94	296	309
	EHS	24.7	90	266	267
7.5	VT	39.0	93	310	303
	EHS	32.4	88	282	283
10.0	VT	42.7	93	331	325
	EHS	41.9	90	281	279
SED (df = 14)		2.72	1.7	8.8	8.8
Summary of significant factors and interactions					
Stock		NS	***	***	***
Density		***	NS	***	***
SXD		NS	NS	NS	NS
Fortune					
2.5	VT	15.3	-	257	317
	EHS	12.7	-	237	305
5.0	VT	27.3	-	281	352
	EHS	17.0	-	245	333
7.5	VT	36.0	-	288	363
	EHS	18.4	-	263	342
10.0	VT	29.7	-	314	371
	EHS	27.4	-	285	357
SED (df = 14)		3.90		9.3	8.0
Summary of significant factors and interactions					
Stock		***		***	***
Density		***		***	***
SXD		*		NS	NS

-, not determined due to wind damage

Table 4.4 Rosewarne chip trial. Effect of stock and planting density on bulb yields three years after chipping (1990)

Planting density * (t/ha)	Stock	Yield (kg/plot) in grades and in total						% weight increase	Number/ plot
		<8	8-10	10-12	12-14	14-16	Total		
Carlton									
2.5	VT	0	0.02	0.09	0.78	0.26	1.16	231	23.7
	EHS	0	0.01	0.25	0.84	0.08	1.18	237	26.7
5.0	VT	0.03	0.11	0.80	0.92	0.05	1.90	168	51.3
	EHS	0.01	0.05	1.01	0.92	0	1.99	180	55.7
7.5	VT	0.06	0.47	1.60	0.22	0	2.35	122	81.3
	EHS	0.01	0.54	1.92	0.14	0	2.58	143	89.6
10.0	VT	0.06	0.71	2.19	0.19	0	3.15	122	112.7
	EHS	0.04	0.77	2.00	0.01	0	2.78	96	106.1
SED (df = 14)		0.015	0.073	0.141	0.160	0.06	0.173	-	4.99
Summary of significant factors and interactions									
Stock		*	NS	NS	NS	*	NS		NS
Density		**	***	***	***	**	***		***
SXD		NS	NS	NS	NS	NS	NS		NS
Fortune									
2.5	VT	0	0.05	0.22	0.74	0.11	1.12	220	25.0
	EHS	0	0.02	0.48	0.56	0	1.06	203	27.0
5.0	VT	0.02	0.02	0.96	0.96	0.03	1.99	180	54.0
	EHS	0.01	0.12	1.26	0.51	0	1.90	168	58.3
7.5	VT	0.03	0.18	1.82	0.61	0	2.63	148	80.3
	EHS	0.07	0.06	1.78	0.02	0.01	1.94	83	94.5
10.0	VT	0.06	0.54	2.55	0.09	0	3.24	128	114.7
	EHS	0.02	0	1.94	0.06	0.01	2.03	43	116.0
SED (df = 14)		0.018	0.075	0.122	0.080	-	0.122	-	3.64
Summary of significant effects and interactions									
Stock		NS	**	NS	***		***		*
Density		**	**	***	***		***		***
SXD		*	***	***	***		***		NS

* corresponding to planting weights (kg bulbs/2m plot) of 0.35, 0.71, 1.06 and 1.42

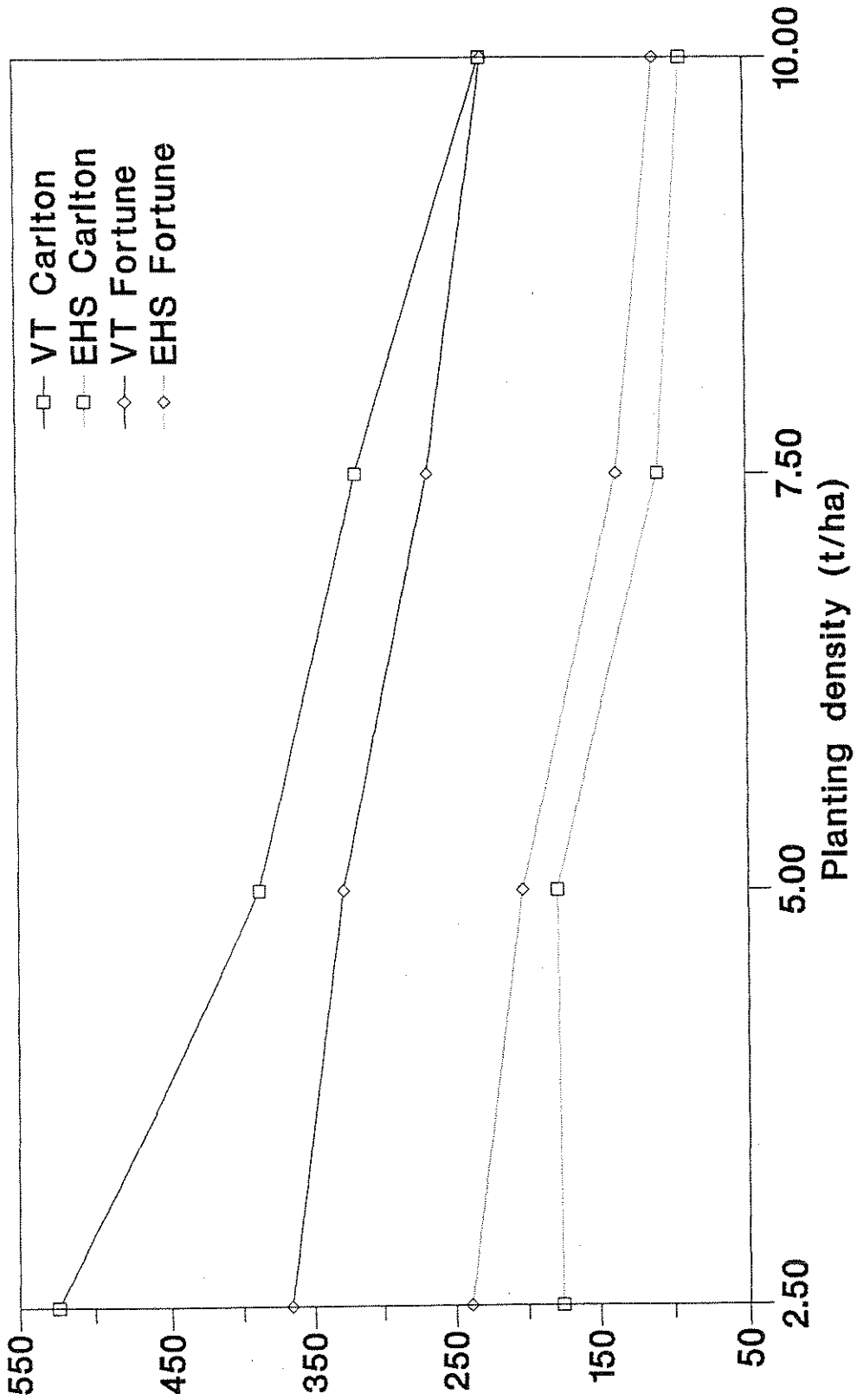


Fig.4.1. Rosewarne chip trial: bulb yield 1987-89

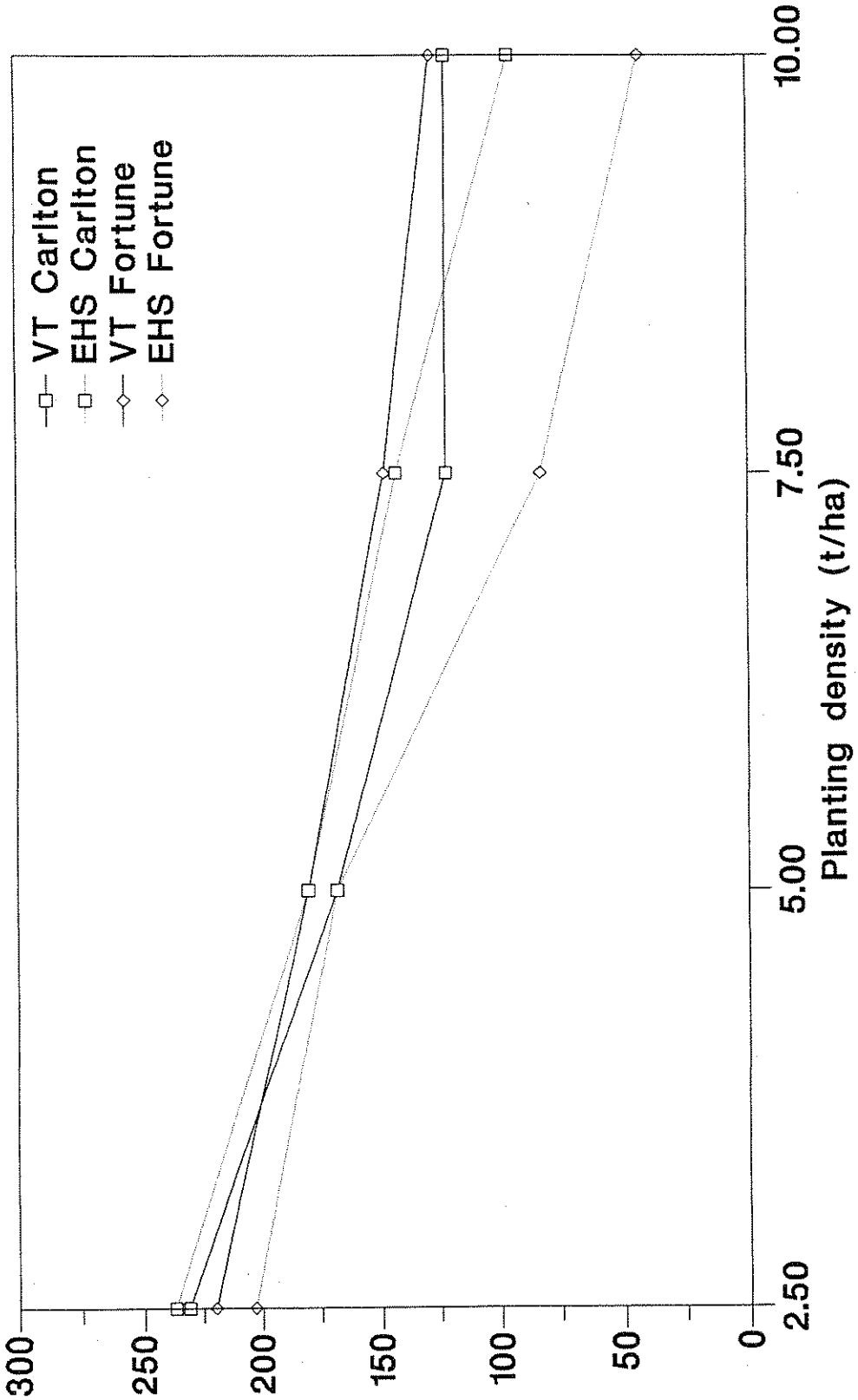


Fig.4.2. Rosewarne chip trial: bulb yield 1989-90

Virus testing

The results of virus tests on leaves taken from all four trials in 1990 are given in Table 5.1. Except for one sample (out of a total of 60 VT plants tested), VT stocks remained free of detectable viruses. Most samples of EHS stocks had positive virus results, narcissus mosaic virus being most commonly detected.

Table 5.1 Results of virus tests for all four trials from leaf samples taken in 1990

Stock	Number of samples (per 10) free of detectable viruses (VF) or with positive tests*					
	VF	NMV	PotY	NTNV	TRV	Multiple
Kirton trial (Carlton)						
VT	10	0	0	0	0	0
EHS	1	8	4	1	0	4
Rosewarne trial (Carlton)						
VT	9	1	0	0	0	0
EHS	2	7	4	0	0	3
Kirton chip trial (Carlton)						
VT	10	0	0	0	0	0
EHS	5	5	0	0	0	0
Rosewarne chip trial (Carlton)						
VT	10	0	0	0	0	0
EHS	2	6	2	0	0	1
Kirton chip trial (Fortune)						
VT	10	0	0	0	0	0
EHS	2	6	2	0	1	2
Rosewarne chip trial (Fortune)						
VT	10	0	0	0	0	0
EHS	1	8	1	0	0	0

* NMV, narcissus mosaic virus; PotY, potato Y virus; NTNV, narcissus tip necrosis virus; TRV, tobacco rattle viruses; multiple, more than one of these.

Discussion

Surprisingly few critical comparisons of the performance of narcissus bulbs with different virus status have been conducted, probably because of the difficulties associated with experimentation. These include obtaining sufficient of the valuable VT bulbs for destructive trialling, preventing re-infection under commercial field conditions, and eliminating the effects due to different cultural regimes and propagation of VT and ordinary stocks that can persist into field testing. Bulbs from different areas, eg Dutch and English or Scottish and Lincolnshire, appear to need three to four years to acclimatise before growth is synchronised (Abiss and Craze, 1948; Sutton et al., 1988). Recently twin-scaled bulbs appear to produce more but lighter bulbs, and the effects of twin-scaling on growth may not dissipate for seven years (Sutton et al., 1988). Because of these difficulties and lack of resources to overcome them, and because quickly obtained results have been preferred in practice to long-term but more scientifically critical trials, the design of most VT/non-VT evaluations has been simplistic. Plots of bulbs of both types, matched for bulb grades, weights and numbers, and previously acclimatised for a minimal number of years, have been grown side by side and growth measured.

Stone (1973) reported that VT bulbs of cv Grand Soleil d'Or had more and larger florets with brighter coronas than bulbs with arabis mosaic virus (AMV) and narcissus degeneration virus, and the critical weights for flowering were 25 and 40g, respectively: differences between VT bulbs and those with only AMV were less marked. Field evaluations of these bulbs were described by Tompsett (1983). In the early trials, beginning 1971, VT bulbs showed substantial advantages in numbers of stems and florets, flower and leaf size, and bulb yields, over ordinary commercial stocks; VT bulbs also performed relatively better when plots were not 'burnt-over', and when twin-scaled. However, in later trials, from 1977 onwards but still using bulbs from a gauze house, the yield advantage of VT bulbs appeared more modest, and crop appearance was similar in the two stocks. Improvements in the commercial husbandry of the crop, particularly in the use of fungicide spray programmes, were considered responsible for this change. These facts imply that the VT bulbs were better able to withstand the challenge of fungal disease or other non-optimum cultural conditions.

Sutton et al. (1986, 1988) described trials (planted adjacent to commercial stocks) in which VT stocks (at least five years from twin-scaling and field-acclimatised for three years) were compared with visually healthy stocks, probably containing a significant proportion of plants with narcissus mosaic and tip necrosis viruses. In the first year of the trials, the stocks flowered in geographical order, more southerly ones first. Later, VT stocks were earlier to emergence, flowering and senescence. VT stocks consistently out-yielded commercial stocks in bulb yield by 15 to 20 per cent. In some trials there were differences between stocks in the number of leaves per bulb, suggesting differences in bulb structure (number of growing points). Adjusting data for leaf number differences reduced the differences between sources (farms or twin-scaling procedures) for VT and commercial stocks, and VT bulbs still maintained an advantage of 9 to 20 per cent over commercial stocks. VT stocks produced heavier, not more, bulbs. Differences between VT and commercial stocks in flower size and stem length were not consistent.

Prior to the HDC-funded evaluations of VT bulbs described in this report, evaluations of cultivars Carlton, Fortune, Ice Follies and White Lion had been carried out by ADAS at Rosewarne and Kirton between 1983 and 1987. Bulb yields from these trials are summarised in Table 6.1. For Carlton, trials at Rosewarne showed the highest percentage weight increases for VT stocks, followed by a local grower's (non-VT) stock, with EHS (non-VT) stocks giving the lowest yield. VT bulbs also produced more flowers, but differences in crop height, flower size and flowering date were not of significance (ADAS, 1986; HDC, 1988a; Tompsett, undated a). In similar trials at Kirton, however, the relative bulb increase of VT and local non-VT stocks varied (ADAS, 1987; HDC, 1988a, 1989a; Tompsett, undated a). EHS stocks out-performed VT stocks in some trials, and were markedly superior to the local grower's stock used as a comparison. VT stocks tended to yield more smaller

bulbs. Similar, collaborative trials in Kincardineshire (HDC, 1988a) showed that the weight increase of three different VT stocks varied, one performing better, and one worse, than either local or Lincolnshire commercial (non-VT) stocks.

For Fortune, trials at Rosewarne again showed greatest bulb increases from VT stocks, intermediate yields from a local grower's (non-VT) stock, and poorest from EHS (non-VT) stocks. Differences between stocks in flower yield, quality and date were small, and differences in emergence and senescence dates were not consistent between seasons. VT Fortune blooms were determined to have more deeply coloured perianths and coronas than non-VT stocks (ADAS, 1987; HDC, 1988b; Tompsett, undated b). Trials at Kirton showed that bulb yields from VT stocks were slightly greater than EHS (non-VT) stocks and much greater than commercial (non-VT) stocks (HDC, 1989a). Ice Follies and White Lion tested at Rosewarne gave similar results to that site's results for Carlton and Fortune, in terms of bulb yields. The VT stock gave greatest yields and the EHS (non-VT) stock the lowest. Other differences in growth (such as flower numbers or senescence dates) were small or inconsistent. At Kirton, the relative performance of VT and non-VT Ice Follies varied, with no consistent effect. White Lion was not tested at Kirton (ADAS, 1987; HDC, 1989a; Tompsett, undated c, d).

How do the results from these earlier trials compare with those from the latest, HDC-funded trials? Considering first the results of the whole-bulb trial with cv Carlton, flower yields in the Kirton trial showed no consistent effects due to VT or non-VT stocks: in the first year, non-VT stocks showed a marked advantage, but this was reversed in the second year and differences in subsequent years were small. In contrast, the Rosewarne trial showed an advantage for the VT stock in all four years, although much less so in the second half of the trial after it had been moved to Kirton. Flower diameters and stem lengths were slightly greater in VT than in non-VT plants in most cases. When differences in flowering and senescence dates were observed, there was generally a few days' earliness in VT than in non-VT stocks. Bulb yields, which represent the crux of the matter more than details of flowering date or quality, are summarised in Figures 1.1 to 2.2. Bulb yields were greater in VT than in non-VT stocks: for the first two years of the trial, when trials were grown at their respective sites, the much greater advantage of VT bulbs at Rosewarne than at Kirton was striking. At Rosewarne, the additional percentage bulb weight increase due to VT bulbs was about 50 at the highest planting density, increasing to about 100 at the lowest density. VT bulbs appeared better able to take advantage of low planting densities than non-VT bulbs. In the Kirton trial, the same interaction with planting density was apparent, but the additional advantage of VT bulbs was only about 50 per cent at the lowest planting density. Responses from the comparable Scottish trial (Fig. A.1) were similar to those at Kirton, except that in Scotland there was an exaggeration of the benefits of VT stocks at the medium (20t/ha) planting density. Grown at Rosewarne, all stocks showed relatively little benefit of low-density growing, compared with growing at Kirton, and it is conjectured that environmental factors, such as wind or soil surface temperatures, could have been responsible. Pre-warmed bulbs showed the expected small yield advantage over non-pre-warmed bulbs at both sites and in both types of stock. Growing at Kirton for the second two-year period, results for both trials were very similar: both stocks showed a similar response to planting density, and the percentage weight increase of VT stocks was only a few per cent greater than that of non-VT bulbs. These results, then, confirm the earlier ones, that, compared with local non-VT stocks, using VT bulbs at Rosewarne confers a much greater advantage than at Kirton. The changed responses when the Rosewarne trial was moved to Kirton imply support for the view that different responses of the VT and non-VT stocks to climatic factors are responsible for this effect.

Considering the chipped bulb trial with Carlton and Fortune, there were again some similarities with other results. There were large differences between VT and non-VT stocks in leaf numbers, but these differences were not entirely consistent, and may have been confused by differences in earliness of leaf growth; however, the overwhelming effect was the greater leaf production of VT Carlton in the Rosewarne trial. It is more useful to consider flower and bulb

Table 6.1 Summary of bulb yields (percentage weight increases after two years' growing) from MAFF-funded VT bulbs evaluation trials at Rosewarne and Kirton*

Variety	Stock	Percentage weight increase						
Carlton		Rosewarne			Kirton			
		83/85	85/87	86/88	83/85	84/86	85/87	86/88
	VT	307	251	240	(108)	172	257	208
	EHS	267	217	192	150	181	228	242
	Grower	294	236	209	93	-	223	92
		% advantage of VT over EHS stock						
		15	16	25	(-28)	-5	13	-14
Fortune		Rosewarne			Kirton			
		84/86	86/88		86/88			
	VT	257	178		196			
	EHS	173	120		184			
	Grower	209	142		152			
		% advantage of VT over EHS stock						
		49	48		7			
Ice Follies		Rosewarne			Kirton			
		86/88			83/85	84/86	85/87	86/88
	VT	249			(73)	196	241	217
	EHS	213			133	200	243	233
	Grower	208			132	-	251	184
		% advantage of VT over EHS stock						
		17			(-45)	-2	-1	-7
White Lion		Rosewarne						
		84/86	86/88					
	VT	197	163					
	EHS	174	155					
	Grower	184	149					
		% advantage of VT over EHS stock						
		13	5					

* For references, see Discussion. It has been suggested that the values quoted in parenthesis were abnormally low due to the late HWT of these stocks.

yields. In all cases, VT stocks produced more flowers per kg than non-VT bulbs in the third year, implying that larger bulbs or more flower-bearing bulb units were produced in VT stocks. The graphical representations of bulb yield (Figs 3.1 to 4.2) are less clear than is the case for the whole bulb trials, probably because chipped crops are less uniform and optimum low planting densities and limiting high planting densities were not sufficiently tested. Bulb increases were greater for VT than non-VT stocks, consistently so for Fortune (at both sites) but mainly for the Rosewarne trial in the case of Carlton.

Most data is available for Carlton, and it is necessary to consider why the advantage of VT stocks has been consistently greater at Rosewarne than at Kirton. Possible explanations include differences in vigour of the local (non-VT) stocks, differences due to growing practices, or climatic or other local factors which enable the VT stocks better to take advantage of growing conditions in the south-west. Regarding the first two of these factors, it can be seen (from Figs 1.1 to 2.2) that the Rosewarne non-VT stocks grew relatively poorly at Rosewarne, compared with all other cases, whereas in the second half of the trial, the bulb yield-planting density curves were similar for both Rosewarne and Kirton, and VT and non-VT, bulbs. As regards climatic and other growing conditions, the growing season is two to four weeks' earlier in the south-west than in Lincolnshire (Rees, 1972), and the VT stocks may be better able to take advantage of this. In some (but not all) instances, VT stocks were found in these trials to be earlier in growth than their non-VT counterparts. Although little is known of the effects of virus-infection on growth patterns of narcissus, Rees (1966) showed that the leaf index curve of symptomless plants of cv Minister Talma was shifted about 2 weeks earlier than those of plants with narcissus mosaic virus or the combination of narcissus yellow stripe and tobacco rattle viruses. Also, generally healthier VT plants (having been propagated under virus vector-proof conditions necessitating the use of intensive fungicidal as well as insecticidal sprays) may be better able to stand the challenge of narcissus leaf diseases which are prevalent in south-west England but of less concern in the east. Whatever the explanation, cultivar-related factors are also involved, as the response of Fortune is more consistent than that of Carlton.

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APPENDIX: ABERDEEN TRIAL

Introduction

A further trial comparing VT and non-VT stocks of whole bulbs of Carlton, grown at different planting densities, was carried out at the North of Scotland College of Agriculture, Auchincruive. Results from this trial are reported briefly in this Appendix; for earlier summaries see HDC (1988b,1989b). Trials with chipped bulbs at this site were unsuccessful, plant emergence being poor.

Materials and methods

VT bulbs of cv Carlton originated from Rosewarne stocks and were acclimatized at Auchincruive before use in the trial. Non-VT bulbs were good local commercial stocks.

Bulbs of each stock were planted at 5.0, 12.5, 20.0, 27.5 and 35.0 t/ha. Each plot consisted of 32 bulbs weighing 1.56kg (composed of 10 8-10cm grade bulbs, 10 10-12cm grade and 12 12-14cm grade bulbs), plot length being adjusted to give the required planting density. Trial design was of three blocks, within which planting density was randomised and VT and non-VT plots were aranged as split-plots; the recorded plots were guarded by further bulbs planted at appropriate densities. The trial was planted on 8 September 1987 and lifted on 4 July 1989. Locally appropriate husbandry practices were used.

Records taken were similar to these in the English trials, and are as specified in the Tables.

Results

1988 results. Flower and foliage records are summarised in Table A.1. There were no statistically significant effects due to stocks on leaf number or width, or leaf lengths. Stem lengths were generally greater in VT stocks than in non-VT stocks. The non-VT bulbs produced slightly but significantly more flowers than VT stocks. As expected, increasing the planting density led to increases in stem and leaf length.

1989 results. Table A.2 gives details of foliage and flowers records. Leaf lengths (recorded in February) were significantly greater in VT than in non-VT plants, but stock did not affect the number of leaves or flowers. As expected, increasing planting density decreased leaf and flower numbers while increasing plant height.

Leaf senescence (Table A.2) was earlier in non-VT stocks and in higher planting densities.

Bulb yields are shown in Table A.3. Total yields (by weight) were greater for the VT stock than for the non-VT stock, this effect being observed at all planting densities but especially at 20t/ha (Fig. A.1). Analysis of numerical bulb yields showed that stock had little effect. Planting density exerted the major effect on bulb yields.

Discussion

This trial suggested greater vigour of VT stocks in terms of early-season leaf growth, delayed senescence, and greater bulb yields. At a typical recommended planting density of 20t/ha, VT stocks gave a 269 per cent weight increase, whereas in non-VT stocks the increase was only 168. Such a performance of VT Carlton is in line with that reported in the trials at Rosewarne, whereas yields of VT bulbs at Kirton were much lower.

Table A.1 Auchincruive trial. Effect of planting density and stock on leaf and flower characteristics in the first season (1988).

Planting density (t/ha)	Stock	Leaves/plot		Leaf length(mm)			Leaf width(mm)	Stem length(mm)	Flowers / plot
		March	June	March	April	May	June	at cropping	
5.0	VT	140	159	107	241	435	24	202	41.0
	Non-VT	137	162	93	222	413	23	191	44.0
12.5	VT	135	159	101	238	444	24	208	41.3
	Non-VT	146	167	100	246	465	24	213	42.7
20.0	VT	132	166	103	243	474	23	226	40.7
	Non-VT	127	162	94	243	496	23	212	43.7
27.5	VT	133	153	100	246	474	23	227	40.0
	Non-VT	131	163	98	250	491	24	220	39.0
35.0	VT	121	155	96	254	480	22	231	39.3
	Non-VT	119	162	93	244	500	23	220	42.7
SED(df=10)		7.8	8.7	5.6	10.0	12.7	0.8	8.9	1.32
SED*		7.5	8.0	7.0	9.2	14.0	0.9	5.1	1.50
Summary of significant factors and interactions									
Stock(S)		NS	NS	NS	NS	NS	NS	**	*
Density(D)		*	NS	NS	NS	***	*	*	*
S x D		NS	NS	NS	NS	NS	NS	NS	NS

* this SED for comparisons within a planting density

Table A.2 Auchincruive trial. Effect of planting density and stock on leaf and flower characteristics in the second season (1989).

Planting density (t/ha)	Stock	Leaves/ plot (May)	Leaf length(mm) (February)	Flowers /plot	Senescence Score*
5.0	VT	650	107	83.0	1.0
	Non-VT	628	95	92.7	1.3
12.5	VT	492	148	70.7	1.3
	Non-VT	474	123	75.7	2.0
20.0	VT	385	184	64.3	2.0
	Non-VT	388	169	64.3	2.3
27.5	VT	341	172	62.7	2.0
	Non-VT	350	157	60.3	2.7
35.0	VT	312	182	57.3	2.3
	Non-VT	298	187	57.3	2.7
SED(df=10)		25.9	12.3	3.41	0.34
SED**		20.5	10.1	3.90	0.33
Summary of significant factors are interactions					
Stocks(S)		NS	*	NS	*
Density(D)		***	***	***	**
S x D		NS	NS	NS	NS

* foliage senescence assessed on 4 June on a scale from 1 (little senescence) to 3 (highly senesced).

** this SED for comparison within a planting density.

Table A.3 Auchincruive trial. Effect of planting density and stock on bulb yields after two years (1989).

Planting density (t/ha)	Stock	Yield (kg/plot) in grades and in total							% weight increase	Yield (no/plot)
		<8	8-10	10-12	12-14	14-16	>16	Total		
5.0	VT	1.37	0.73	0.69	0.64	1.27	3.32	8.02	414	148
	Non-VT	1.20	0.47	0.74	0.62	1.22	3.64	7.89	406	142
12.5	VT	0.39	0.68	0.33	0.63	1.65	2.05	5.73	267	89
	Non-VT	0.39	0.73	0.19	0.87	1.59	1.58	5.34	242	92
20.0	VT	0.62	0.62	0.81	1.34	1.72	0.64	5.76	269	110
	Non-VT	0.29	0.60	0.33	1.16	1.13	0.67	4.18	168	73
27.5	VT	0.34	0.45	0.48	1.01	1.02	0.54	3.93	152	70
	Non-VT	0.29	0.47	0.55	0.92	0.91	0.32	3.47	122	68
35.0	VT	0.36	0.38	0.37	1.02	1.00	0.31	3.43	120	67
	Non-VT	0.37	0.41	0.80	0.88	0.58	0.10	3.14	101	67
SED(df=10)		0.145	0.112	0.190	0.303	0.226	0.348	0.628	-	16.3
SED*		0.148	0.099	0.174	0.220	0.199	0.283	0.554	-	15.9
Summary of significant factors and interactions										
Stock(S)		NS	NS	NS	NS	*	NS	*		NS
Density(D)		***	*	NS	NS	**	***	***		**
S x D		NS	NS	*	NS	NS	NS	NS		NS

* this SED for comparison within a planting density

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Fig.A.1. Auchincruive trial: bulb yield 1987-89