AHDB HORTICULTURE

Grower Summary

CP 103

The Application of Precision Agronomy to UK Production of Narcissus

Final 2017

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The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

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Project title:	The Application of Precision Agronomy to UK Production of Narcissus
Project number:	CP103
Project leader:	Rob Lillywhite, University of Warwick
Report:	Final, August 2017
Previous report:	N/A
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Location of project:	University of Warwick
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Date project commenced:	30/9/2013
Date project completed (or expected completion date):	The project was delayed by the ill health of the student, James Syrett. The original completion date was 30/9/2016, however, the final report was not delivered until August 2017.

GROWER SUMMARY

Headline

Current bulb planting practice of 17 t/ha at 15cm depth remains the overall recommendation although bulb density at planting can be increased to 27 t/ha where flower production is the priority.

Planting bulbs upright gives significantly better results in comparison to planting upside down, however, random orientation remains the most practical and economic approach.

Technology exists to improve pest and disease control in lifted bulbs but is not likely to be a cost effective investment in current market conditions.

Background

The UK narcissus industry lags behind other arable and horticultural sectors in terms of the technology it employs, despite leading the world in terms of its output. The heyday of narcissus research came in the 1950s to 1980s, mainly courtesy of the Rosewarne and Kirton research stations, when many of the agronomic parameters affecting yield and crop quality were established, as well as refinements in crop handling and pest and disease control. However, changes in production practices, markets and varieties have rendered much of the evidence and recommendations out of date and therefore, the findings of this period need to be examined, and if necessary revised, to reflect the current market and practices. Innovation and advances in production practices have been made in other industries, notably potatoes and onions, and it is hoped that some of these may be transferable to Narcissus production to address some of the problems facing the industry, or simply to boost productivity while lowering costs; a necessary intervention in a time when production costs are rising, but retailers are static on pricing.

Summary

This summary briefly describes three aspects of the research: grower audit, overseas innovations and field trials.

Grower audit

An audit of all UK Narcissus growers was undertaken between autumn 2013 and spring 2014. This served two purposes: firstly, to record current grower practices with a view to inform the development of the later research and, secondly, to act as a method of engagement with the industry. Thirty-one growers representing an estimated 88% of the UK daffodil area responded which was excellent and provided a robust overview of industry practices.

Variety

Growers were asked to report their top ten (or fewer) varieties by economic importance. The results show that the same varieties are preferred for both flower and bulb production with Carlton being the most popular by incidence (number of growers growing it) (Table 1). In fact, the same top five varieties are mostly the same for flower and bulb production. The number of varieties grown by individual growers varies considerably with some using up to fifty varieties to cover the full range of season and markets while others make do with just four.

Table 1. Variety preference by intended use. All regions and growers.

Number	**Flower production**		**Bulb production**	
	Variety	**Incidence**	**Variety**	**Incidence**
1	**Carlton**	**22**	**Carlton**	**15**
2	Golden Ducat	18	Dutch Master	13
3	Standard Value	17	Golden Ducat	12
4	Dutch Master	15	Golden	9
5	Tamara	14	Harvest	9
6	Golden Harvest	12	Tamara	9
7	Mando	11	Ice Follies	9
8	Ice Follies	9	Standard	7
9	Dellan	8	Value	7
10	California	8	Dellan	6
11	St Keverne	6	Mando	6
12	Sempre Avanti	5	Red Devon	6
13	Emblyn	5	White Lion	6
14	Jedna	5	California	5
15	Lothario	4	St Keverne	5
16	Barenwyn	4	Fortune	5
17	White Lion	3	Barenwyn	4
18	Counsellor	3	Jedna	4
19	Grand Soleil	3	Cheerfulness	4
20	D'or	2	Pink Pride	4
	Red Devon		Emblyn	
			Sempre Avanti	

Cornish growers typically use yellow division-1 and -2 varieties for flower production with little concern for bulb sales. There is a small trade in division-8 varieties (scented, multi-headed tazettas).

The preference for different varieties does vary by area, though some are fairly universal. In conversation with the growers, it became clear that the discrepancy in the number and type of varieties grown was down to different market strategies. One grower estimated that a minimum of 16 varieties would be necessary to ensure a supply of cut flowers for the length of the season, plus another 16 as backup, should some flower unusually early or late. To this are added double varieties and *N. tazetta* hybrids for special interest sales. However, in contrast, one grower used just four varieties with the intention of supplying the peak sale season (between Mother's Day and Easter Sunday). Growers supplying bulb-only varieties must grow an even wider selection to be able to meet customer demand for specific varieties.

Table 2. Variety preference by location.

Number	Cornwall	Lincolnshire & Cambridgeshire.	Scotland
1	Tamara	Carlton	Carlton
2	California	Dellan	Golden Ducat
3	Golden Ducat	Fortune	Golden Harvest
4	Mando	Mando	Dutch Master
5	Carlton	Standard Value	Standard Value
6	Standard Value	Ice Follies	Ice Follies
7	Dutch Master	Tamara	Sempre Avanti
8	St. Keverne	Lothario	Red Devon
9	Jedna	Golden Ducat	Mount Hood
10	Dellan	Dutch Master	Pink Pride

Bulb sizes

Cornish growers sell mainly 10-12 and 12-14 cm grade bulbs, meaning they replant mostly the largest and smallest grades. Half of the growers reported discarding bulbs which were smaller than 8cm in diameter.

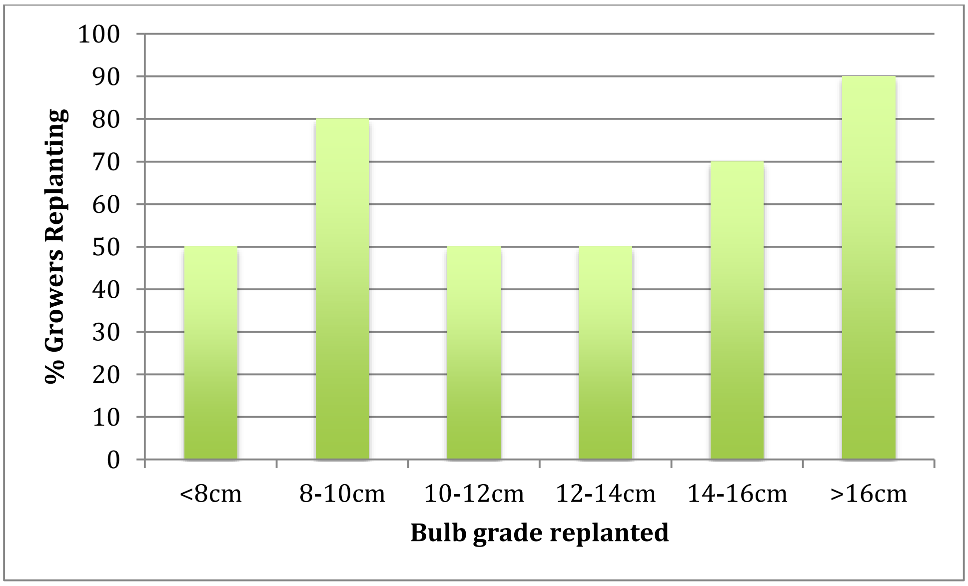

Figure 1. Bulb sizes replanted in Cornwall

Lincolnshire growers plant a more varied mixture of bulb grades, reflecting the variation in crop priorities (flowers or bulbs). One-quarter of them discarded bulbs smaller than 8cm in diameter.

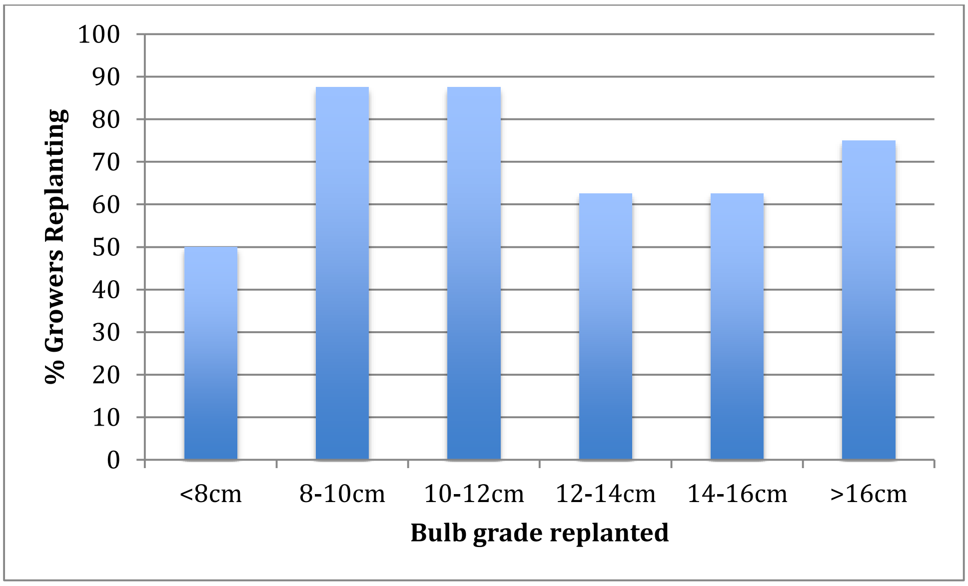

Figure 2. Bulb sizes replanted in Lincolnshire

Scottish growers are highly driven by bulb sales, so planting stock favors the smallest and largest grades. Only one grower discards bulbs smaller than 8cm in diameter.

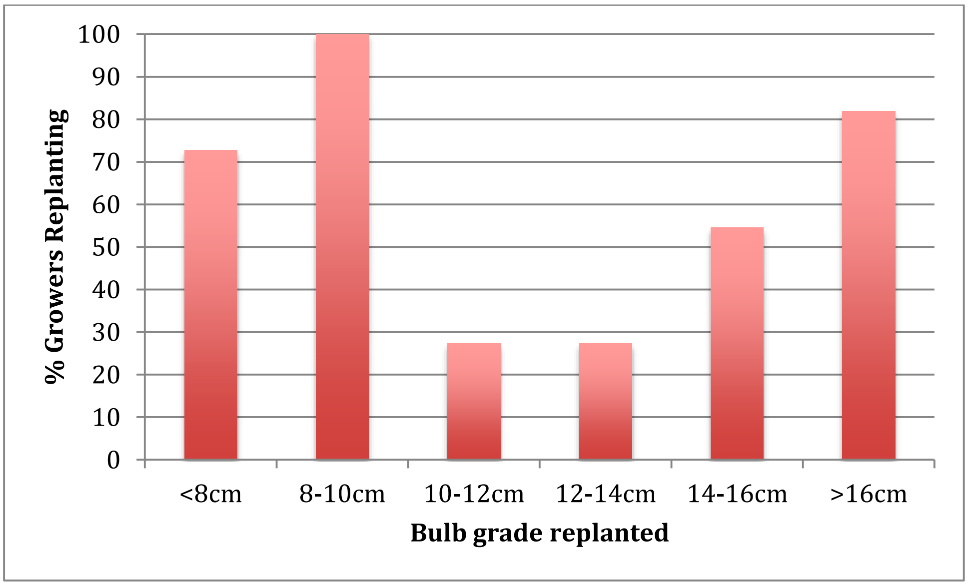

Figure 3. Bulb sizes replanted in Scotland

Hot-water Treatment (HWT)

Growers were asked to report on their HWT systems (front or top loading) and on the temperature used in HWT. They were also asked to indicate the choice or type of chemical additives used (fungicides, biocides/sterilants and adjuvants).

In Cornwall, bulbs are often pre-warmed at 30°C for one week before pre-soaking at 30°C and then HWT at between 46 and 47°C. Ambient-stored bulbs are treated at 44.4°C. Pre-warming (which subsequently allows higher HWT temperatures) reduces flower damage, allowing first year flowers to be harvested, which is the priority in Cornwall. Bulbs treated at the lower temperature are generally smaller grades that are not required to yield flowers in the subsequent growing season. Seven out of ten growers reported using front-loading HWT tanks, mostly holding eight boxes, while three use top-loading tanks, holding 2-3 bins each. HWT fungicide choice varied but an iodophore (an iodine based biocide), e.g. Fam 30, a wetter and acidifier are fairly consistent.

All growers in Lincolnshire and Cambridgeshire reported conducting HWT at 44.4°C. First year flowers are seldom harvested in the region, and so this temperature reflects the balance to be struck between flower yield and quality of bulbs, since the region exports more high-quality bulbs compared to Cornwall. Only two growers reported pre-warming, at 17 and 20°C respectively, where first year flowers were expected. There was an even split between top- and front-loading tanks.

In Scotland, Grampian Growers hot-water treats all of the bulbs for the growers in their co-operative. This is conducted at 47°C, following a 30°C pre-warm. The elevated treatment temperature is explained by the priority of the region which is bulb quality. The region frequently misses the peak flower market, but produces pest and disease-free bulbs for export overseas, especially for forcing in the Netherlands.

Research priorities

Growers were asked to identify their priority research needs. Cornish growers identified electronic screening of bulbs (8/10), followed by manual labour costs, energy costs, and the availability of land (7/10). In Lincolnshire, the priorities were different with growers identifying energy costs and manual labour as the most important (6/8), followed by drying efficiency (4/8). In Scotland, the cost of manual labour (11/11) and energy costs (10/11) were the most common. These results suggest that lowering input costs, especially energy, remains a priority while bulb quality, likely to be the incidence of rots, is important in Cornwall.

Overseas innovations

A visit was made to the Netherlands in August 2015 to tour their industry and to try and identify any innovations that might have application in the UK. The primary aim was to visit companies who specialise in equipment and technologies and to assess their function and suitability for UK use, and to examine those which were in use by Dutch growers. The companies visited included: Akerboom, Sercom, Cremer and Warmerdam Spoelbedrijf. Visits were also made to bulb growers and the FloraHolland flower auction. Among the technologies viewed, the following took had perhaps the most promise for UK growers.

Foam disinfection cabinet: A recent introduction is the use of a foam based fungicide within the storage box to control Fusarium and other fungal diseases. Boxes are pressure filled with foam and allows to stand for 24 hours prior to use. If nematodes are not a problem, this looks like a quick and cheaper solution to HWT. However, anecdotal evidence suggests that with small bulb sizes, the foam may not penetrate the box and therefore some bulbs remain untreated. There is also some concern that bulbs may 'clump' together due to the sticky nature of the foam.

Controlled environment for pest control: This stores bulbs in controlled atmospheric conditions (ultra-low oxygen [1%] and high carbon dioxide [4%]) to kill nematodes inside the bulbs without damaging the bulbs themselves. This has mainly been used on lily and tulip bulbs but could easily be adapted for Narcissus. Timing would have to be examined to identify the optimum period but a combination of this and foam disinfectant would provide a 'clean and low-chemical' alterative to HWT, and reduce costs associated with disposing of large volumes of pesticide waste.

The visit demonstrated that Dutch growers are technologically advanced in comparison to most UK growers although that is likely to the result of supplying into a demanding high-value market rather than for any other reason. While many of the technologies they employ are unlikely to be applicable to the UK Narcissus industry, some show promise for either reducing production costs or improving the quality of bulb stocks.

Field trials

A series of field trials was established to examine the effect of bulb density at planting, bulb depth at planting, bulb orientation at planting, different potassium fertiliser treatments and irrigation; field trials were conducted on multiple varieties (Carlton, Dutch Master, Standard value, Golden Ducat, Ice Follies and Actaea) at different locations. The experimental design comprised one main site (Wellesbourne in Warwickshire) with three satellite sites situated on commercial holdings (Truro in Cornwall; Spalding in Lincolnshire; and Laurencekirk in Aberdeenshire).

Warwick Crop Centre in Wellesbourne, Warwickshire hosted the full range of treatments, while the satellite sites hosted selected treatments. Each treatment was replicated three times in a randomised complete block design. Fertilisation and crop protection on the satellite sites was administered by the growers in accordance with their own practices.

The yield and quality of flowers was assessed in spring 2015 and 2016 (not commercial sites). The bulbs were lifted in early summer 2016. The plot size was 1.5m long x 1.0 wide. All bulbs were lifted, allowed to dry naturally under-cover for a few days and then cleaned to remove any soil particles. A total plot weight was taken and the bulbs were then sorted by size.

First year flower harvest

Although first year flowers are not generally expected to be as good, or as reliable an indicator, as second or third year flowers, the results show some clear trends. The most robust results, both in terms of numbers and statistical significance, were provided by the orientation treatments. This is perhaps not unsurprising, since common sense would predict that planting bulbs the wrong way up would be detrimental to flower production. However, it is satisfying that common sense is backed up by the evidence. Across all three locations, orientating the bulbs upright at planting resulted in better outcomes in comparison to both inverting them and random orientation. The difference between upright and inversion was large, mostly statistically significant and compelling. There was less of a difference between upright and random orientation but upright planting still resulted in improved performance.

Density also provided some clear results. Planting at 22 t/ha or greater produced more stems that were generally both longer and heavier. This suggests that typical commercial density of 17 t/ha may not be optimal for flower production, particularly in Cornwall, and that planting density could be increased if flower production is prioritised. Depth provided less compelling evidence. The results suggest that 10cm can be detrimental to stem length but there is little difference between 15 and 20cm.

However, the results from year one flower harvests should be treated with some caution. Although the evidence for better performance for correct orientation and higher density is robust, year one harvests are more variable than the following years. However, even allowing for that fact, the results are promising since they are mostly consistent across the three locations.

Second year flower harvest

The second year flower harvest at Warwickshire was more consistent than the first with the most noticeable difference being the lack of short, spindly flowers produced from the sides of the bulbs; there was an abundance of these in year 1. The result was that second year data had slightly higher means and smaller variance compared to the first.

The results show that overall there were no significant differences between the treatments although some trends were apparent. In terms of planting orientation, there was little to choose between random and upright orientation but both produced significantly more stems compared to inverted planting. Planting at 10cm negatively impacted stem length in ‘Dutch Master’ although there was little difference between planting at 15cm and 20cm. The effect of planting density on stem length is difficult to interpret due to an unusual response at 22 t/ha but overall it’s likely that planting density did not influence stem length.

Year two bulb harvest

All four locations provided different soil and climatic conditions and this is reflected in the variation in the results. Means for the harvest variables demonstrate that the same starting conditions resulted in very different outcomes (Table 3). The difference between the lowest and highest bulb weight was 23.2 t/ha and in effect the bulb yield in Scotland was double that of Cornwall with the sites in Warwickshire and Lincolnshire fitting in between. This huge difference is driven primarily by soil quality with bulb quality and environmental conditions being contributing factors. This division has long been recognised by growers but it is satisfying to see it represented in the results. The fertile soils present in Scotland and Lincolnshire provided a good environment for increasing bulb stocks, with rates of increase being 161% and 127% respectively, which is in complete contrast to the sites at Warwickshire and Cornwall where increases were far smaller. In terms of site performance for bulb production, Scotland provided the highest yields, followed by Lincolnshire, Warwickshire and Cornwall; however, a more pragmatic view is that Scotland and Lincolnshire performed well while Warwickshire and Cornwall were poor.

Table 3. Summary statistics for bulb harvest results by location.

Location	Number of observations	Mean of variables		
		Bulb weight (t/ha)	Increase in bulb yield (t/ha)	Increase in bulb yield (%)
Warwickshire	24	25.9	7.7	43
Scotland	24	46.7	28.4	161
Lincolnshire	22	39.5	21.4	127
Cornwall	16	23.5	5.2	29

Bulb depth at planting

The combined bulb harvest results from across all sites for the depth treatments are presented in Table 4. Despite the huge difference in bulb yield between the sites and the relatively poor performance at 15cm in Cornwall, there is a recognisable relationship between planting depth at harvest and bulb yield at two years. Bulb yield and the increases in yield increase with deeper planting. The gains are marginal, ranging between 5% and 17%, but are real and deeper planting, up to 20cm, can be recommended.

Table 4. Bulb harvest results for depth treatment across all four sites.

Depth	Number of observations	Mean of variables		
		Bulb weight (t/ha)	Increase in bulb yield (t/ha)	Increase in bulb yield (%)
10	32	31.3	14.3	84
15	32	33.7	16.7	98
20	32	35.4	18.4	108

Bulb density at planting

The combined bulb harvest results from across all sites for the density treatments are presented in Table 5. The results are textbook in nature and mostly to expectation despite poor yield at 17 t/ha in Cornwall. Total bulb yield at harvest increased with planting density as did yield relative to the starting density.

Table 5. Bulb harvest results for density treatment across all four sites.

Planting Density (t/ha)	Number of observations	Mean of variables		
		Bulb weight (t/ha)	Increase in bulb yield (t/ha)	Increase in bulb yield (%)
12	43	28.7	16.7	139
17	43	33.7	16.7	98
22	43	40.5	18.5	84
27	43	44.2	17.2	64

Bulb yield varied by region and was mostly a function of soil quality (Figure 4). The heavier moisture-retentive soils in Aberdeenshire and Lincolnshire significantly out-yielded the poorer quality soils at Warwickshire and in Cornwall. The largest increase, of approximately 250%, was observed when using a planting density of 12 t/ha in Lincolnshire, and the smallest, less than 50% and on one occasion negative, was observed using a planting density of 17 t/ha or greater in Cornwall. This result highlights the polarisation of the industry between flower and bulb producing areas.

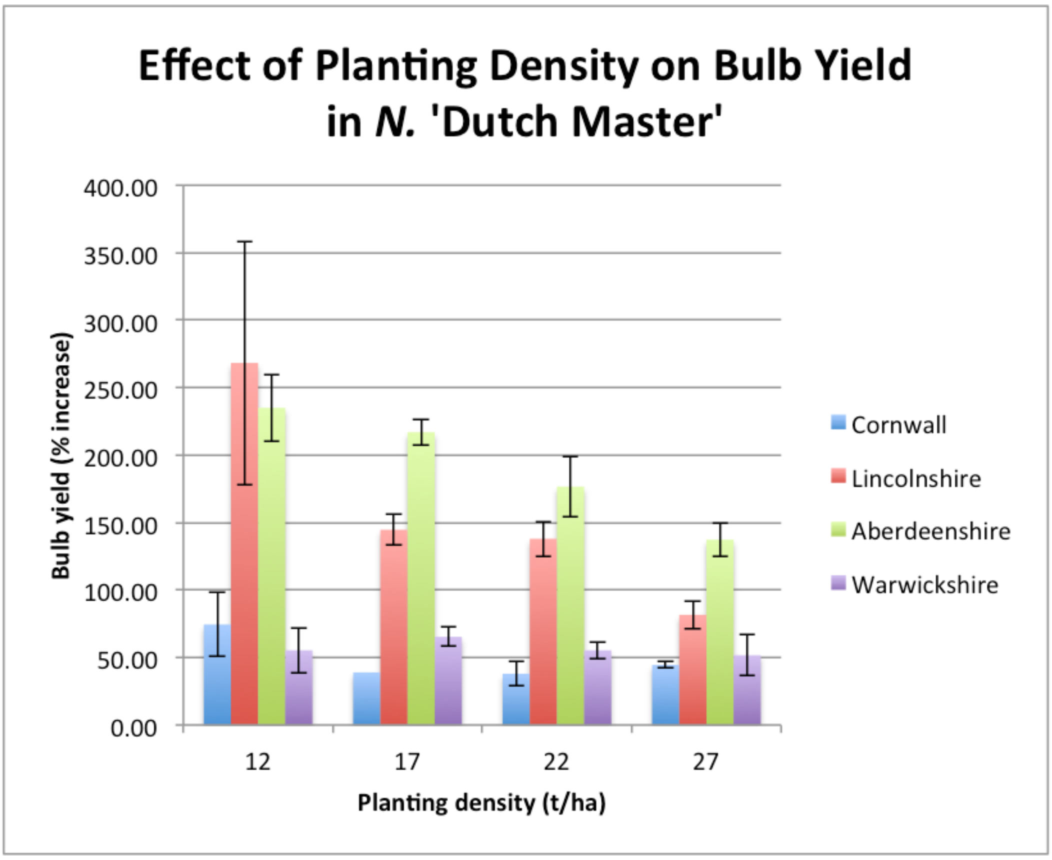

Figure 4. The effect of planting density on bulb yield

Bulb orientation at planting

The combined bulb harvest results from across all sites for the density treatments are presented in Table 4. The results are clear if not statistically significant; planting bulbs upright and with random orientation produces better yields and increases in yield. Field observations back this up. Inverted bulbs at harvest had either shorter twisted stems or in many cases, the stem had failed to reach the soil surface.

Table 4. Bulb harvest results for orientation treatment across all four sites.

Orientation	Number of observations	Mean of variables		
		Bulb weight (t/ha)	Increase in bulb yield (t/ha)	Increase in bulb yield (%)
Upright	32	33.8	16.8	99
Random	32	33.7	16.7	98
Inverted	32	29.2	12.2	72
All sites, all three orientations; p=		0.511	-	0.511
All sites, upright and inverted; p=		0.284	0.284	0.284

Summary of field trials

The trial design involved multiple replicated treatments across four sites in Warwickshire, Cornwall, Lincolnshire and Scotland. The trial was based on two flower harvests, spring 2015 and spring 2016, and a final bulb harvest in early summer 2016. Unfortunately, some data was not collected (the spring 2015 flower harvest in Lincolnshire and all the commercials flower harvests in spring 2016). This obviously detracts from the results and the conclusions and recommendations that follow. While the data used is robust, it is incomplete, and this should be borne in mind when taking decisions based on the contents of this report. This is of greater concern for flower production than it is for bulb production where the full dataset was available.

Three planting depths were examined: 10, 15 and 20cm. Planting depth did affect first year flower production with the best results found at 15cm and 20cm. Planting depth was also a factor in bulb yield with the best results again at 15cm and 20cm.

Four densities were examined: 12, 17, 22 and 27 t/ha. Planting at 22 and 27 t/ha produced the most flowers with the heaviest stems which suggests that where flower production is the priority, the typical planting density of 17 t/ha could be increased. Where multiplication of bulbs stocks is the priority, 17 t/ha at planting is probably optimal.

Three orientations at planting were examined: upright, random and inverted. Orientation had a profound and mostly significant effect on first year flower production with bulbs planted upright producing the most, longest and heaviest stems. Upright produced a small advantage in comparison to random planting and a large advantage in comparison to inverted planting. This advantage was carried through to bulb yield.

These trials assumed that typical grower practice is to plant bulbs at a depth of 15cm, a density of 17 t/ha and using random orientation. The results show that this approach provides perfectly acceptable results across both flower and bulb production as shallower planting and reduced bulb density are likely to depress yield. However, the results also show that slightly deeper planting at higher densities will benefit flower production in particular and for those growers who target flower production rather than bulb production, this would seem to be advantageous.

Bulb orientation at planting is different as it is very rarely under a grower’s control. Typical practice is to tumble bulbs into rows and orientation at planting is therefore random. The results show that this is an area where innovation, if possible, would pay dividends. Upright planting, unsurprisingly, always offers an advantage in comparison to random or inverted orientation. The difficultly is achieving it, as currently no machinery or technology is in commercial production to deliver this outcome.

In many respects, these results are not new but they are a confirmation of existing grower practices. As the Narcissus industry becomes further polarised into bulb and flower production, rather than a combination of both, they do offer growers some evidence on which to change their practices to focus on one or the other.

Action Points

- In-box post-HWT fungicidal foam appears to be a promising innovation that might replace, or supplement, the use of fungicides in HWT. It is recommended to carry out a comparison of approaches to compare the efficacy of different approaches and products.
- The use of controlled atmospheric storage to control pests (nematodes, mites and bulb fly) should be investigated. Reduced oxygen conditions might provide a clean and dry alternative to HWT.