A study of bulb shape in onions (*Allium cepa* L.)

D. G. Grant and B. V. Carter

DSIR Crop Research, Pukekohe

Abstract

Considerable variation occurs in the bulb shape of onions. The shape can vary from flat to globe to torpedo with different markets having different requirements. Bulb shape has become an important aspect of New Zealand onion production with European markets now demanding a flattened globe shaped onion for ease of packaging.

A survey of commercial onion fields in the Pukekohe District during 1990 showed 20 percent of export grade onions had a shape index (the ratio of bulb height to diameter) of greater than the desired maximum of 1.2.

Experiments during the 1990-91 season showed that the percentage of shape rejects ranged between 2.6 and 14.5 in 13 Longkeeper onion strains. Significant differences between cultivars were found. Increasing the plant density from 50 to 75 plants/m^2 increased the bulb shape index and increased the percentage shape rejects. A second experiment showed that increasing the plant density from 50 to 100 plants/m^2 increased the bulb shape index and the percentage shape rejects. Delaying the sowing date from June to September resulted in a decrease in both shape index and percentage shape rejects.

Additional key words: *plant density, sowing date, shape index*

Introduction

Onions are an important export vegetable crop for New Zealand. In 1990 68,000 tonnes worth $NZ37.6m f.o.b. were exported. Bulb shape is an important characteristic for market acceptability for both appearance and ease of packaging. There is a preference for globe shaped onions for the brown storage types as in recent years both the European and British markets have down graded elongated or torpedo shaped bulbs. Elongated bulbs are now regarded by the New Zealand Onion Exporters' Association as one of the major problems affecting New Zealand's onion export industry (G. Russell, pers.comm.).

Both genetic and environmental influences can determine bulb shape. Genetic variation for onion bulb shape ranges from extremely flat to oblong or torpedo types. Crosses between extreme shapes tends to produce bulbs which are intermediate in shape between the two (Pike, 1986). Within a single cultivar, particularly open-pollinated onions, considerable variation may occur (Magruder *et al.*, 1941; McCollum, 1966). Bulb shape can also be modified by several environmental conditions including sowing time (Dowker and Fennell, 1974a), plant density (Mondal *et al.*, 1986) and sowing depth (Chipman and Thorpe, 1977).

Measurement of Bulb Shape

A useful primary indicator of bulb shape, although not describing subtle variations such as top-shapes, is the shape index. This is the ratio of bulb height to diameter (Nakamura, 1958; McCollum, 1966; Dowker and Fennell, 1974b).

In this study, bulb height was measured from the base of the neck to the root plate of an onion bulb. Bulb diameter is the measurement taken at the widest part of the bulb perpendicular to the neck/root axis.

Unacceptable bulb shape for New Zealand export onions has been defined as those bulbs having a shape index of greater than 1.2 (King *et al.*, 1990). This value was determined in 1990 by members of the New Zealand Onion Exporters' Association as the boundary between acceptable and unacceptable export shaped bulbs.

Preliminary Evaluation

A joint DSIR/MAF survey of onion crops was carried out in the Pukekohe district during the 1989/90 season (King *et al.*, 1990) to determine the incidence and level of the onion shape problem. Bulbs from a random sample of 50 onion sites were surveyed. This included 12 growers and 12 seed lines. It involved taking five

2 m^2 samples from each paddock. The level of unacceptably shaped bulbs of export grade (greater than 40 mm diameter) was determined from a 50 bulb sub-sample.

The results showed that for all seedlines sampled, 20 percent of export grade bulbs had a shape index of greater than 1.2. Some relationship was evident between bulb shape and plant density at densities greater than 65 plants/m^2 There were also differences between seedlines.

During the 1990/91 season two experiments were carried out. The first was to determine differences between longkeeper onion cultivars while the second was to investigate the interaction between sowing time and plant density with its influence on bulb shape.

Materials and Methods

Cultivar evaluation.

The cultivar experiment was sown at the DSIR Research Station at Pukekohe on August 2, 1990. Thirteen Longkeeper-type cultivars (listed in Table 1) were evaluated. The experimental design was a split plot randomised complete block design with 4 replications and onion cultivars as the main plots. These were split into two plant densities, 50 and 75 plants/m^2. Seed was sown with an Oyjord cone seeder drill and thinned at the 2 to 3 leaf stage to the required plant density. Plots were 6.2m long on a 5 row bed with rows 215mm apart. Each subplot was 1.5 m^2 in area and excluded the outside rows of the bed. Plant husbandry practices followed standard MAF recommendations for the district (MAF, 1979; Wilson, 1980).

Bulbs in each plot were pulled at 100 percent topdown to maximise yield and left to cure for three weeks. After harvesting and topping, bulbs were graded, counted and weighed. A 50 bulb sub-sample of export sized bulbs (>40mm) from each plot was used to calculate the shape index and the percentage of bulb numbers rejected because they had a shape index greater than 1.2. Data was analyzed using the Genstat statistical computer package.

Environmental influences on bulb shape.

Seed of the Pukekohe Longkeeper cultivar, M & R Regular Strain, was sown at the DSIR Research Station at Pukekohe on three separate dates: June 12, August 2, and September 12 1990. At the 2 to 3 leaf stage plots were thinned to three plant densities: 50, 75 and 100 plants/m^2). The harvested area of 3 m^2 excluded the outside rows of each bed. Procedures used for sowing, cutting out, harvesting, grading and measurements taken were the same as for the cultivar evaluation section.

Table 1. Total weight, export yield, percentage shape rejects and relative maturity (to M & R Early) for the cultivar evaluation trial.

Cultivar	Total Weight (kg/m^2)	Export Yield (kg/m^2)	Shape Rejects (%)	Relative Maturity (days)
Chapman '90	7.0	6.2	4.3	26
M & R Regular	6.8	6.0	5.5	32
Creamgold	6.3	5.6	4.8	31
Jesson Early Globe	6.3	5.5	4.3	16
Gold Regal	6.2	5.3	10.8	19
Wilcox '89	6.0	5.3	4.8	16
Early Creamgold	5.7	5.1	4.0	18
W & S Regular	5.6	4.8	8.5	29
Conroy PLK	4.7	4.2	2.6	15
M & R Early	4.9	3.9	14.5	0
Kiwi Gold	4.0	3.5	5.3	2
W & S Early	4.0	3.4	7.9	5
Crop Early Globe	3.7	3.1	7.0	-10
$LSD_{(0.05)}$	0.9	0.9	5.5	3.9

Results

Cultivar evaluation

The percentage of shape rejects averaged 7.3 for all cultivars at both plant densities. The percentage varied from 2.6 for Conroy's Longkeeper to 14.5 for M & R Early. From Table 1 there appears to be a relationship between yield and maturity with the lower yielding cultivars being earlier maturing while the higher yielding cultivars were mostly later in maturity. There were no bolters present in this trial. The percentage of double bulbs and rotted bulbs at grading was not a significant part of the total.

The effect of increasing plant density from 50 to 75 plants/m^2 resulted in a higher total weight of bulbs, an increased shape index and a greater percentage of shape rejects (Table 2). The percentage of shape rejects increased over all cultivars from 5.9 to 8.7 with the higher density. These influences were all significant while there was no effect on bolters, doubles, rots and other rejects. Increasing the plant density decreased the percentage of export bulbs and increased the percentage of picklers.

There were no significant cultivar x plant density interactions for the shape index, percentage shape rejects, total weight or export yield.

Table 2. Effect of Plant density on onion grades and other characters for all cultivars.

	Plant density/m^2		
	50	75	Significance
Shape Index	0.984	1.015	**
Total Weight (kg/m^2)	5.10	5.41	**
Export Yield (kg/m^2)	4.53	4.50	NS
Percentage Bulb Numbers:			
Export	78.0	64.1	**
Picklers	10.5	21.8	**
Bolters	0	0	NS
Doubles	0.6	0.4	NS
Rots	1.5	1.8	NS
Other Rejects	3.5	3.1	NS
Shape Rejects	5.9	8.7	**

Table 3. Effect of plant density on onion bulb characteristics

	Plant density/m^2			LSD
	50	75	100	(0.05)
Shape Index	1.023	1.042	1.061	0.012
Total Weight (kg/m^2)	6.19	7.33	7.54	0.35
Export Yield (kg/m^2)	4.89	5.64	5.46	0.64
Percentage Bulb Number:				
Export	67	62	51	5
Picklers	10	14	24	4
Doubles	3	1	0	0
Rots	7	6	4	1
Bolters	1	1	1	1
Other Rejects	4	4	5	1
Shape Rejects	8	12	15	4

Environmental influences

Increasing the plant density (Table 3) resulted in an increase in the percentage shape rejects and the shape index for the Pukekohe Longkeeper cultivar. There was also an increase in total weight, however export yield was less at the lower density.

The effect of delaying the sowing date (Table 4) resulted in a decrease in percentage shape rejects and bulb shape index. Total weight and export yield decreased from June to September.

Table 4. Effect of sowing date on bulb characteristics.

	Sowing date			LSD
	June	August	Sept.	(0.05)
Shape Index	1.062	1.055	1.010	0.023
Total Weight (kg/m^2)	9.06	7.35	4.64	0.48
Export Yield (kg/m^2)	6.86	5.58	3.55	0.60
Percentage Bulb Numbers:				
Export	66	59	55	9
Picklers	9	12	26	6
Doubles	2	3	0	1
Rots	4	10	3	2
Bolters	2	0	0	1
Other Rejects	1	3	9	2
Shape Rejects	15	13	7	4

Discussion and Conclusions

The market requirement for globe shaped onion bulbs necessitates grading out off-shaped bulbs. This is an extra cost of production in terms of growing and grading costs. From the survey carried during the 1989/90 season out a large variation in both bulb shape and yield showed up in the onion crops sampled. From the experimental programme the following year the influence of different cultivars, plant densities and sowing dates was demonstrated. Onion growers can improve the bulb shape of their crop by their choice of cultivar, and by growing the crop at lower plant densities and sowing later in the year.

In a comparison of plant densities, the two plant densities used in the cultivar evaluation trial resulted in more shape rejects at the 75 plants/m^2 density than at 50 plants, while the environmental factor experiment showed that increasing the sowing rate from 50 to 100 plants increased the percentage of shape rejects.

Delaying the sowing time resulted in a decrease in the percentage shape rejects in the later sowing and also a decrease in total weight and export yield.

The improved shape index from lower densities and sowing later may be due to less competition for resources between plants. However, it must be noted there has to be a trade off for improved bulb shape with yield as lower densities and later sowing produced a lower export yield.

Significant differences occurred between cultivars in the percentage of bulbs rejected on shape This is similar to the results of a bulb shape survey carried out in the

previous season by MAF and DSIR. This suggests gains can be made in the breeding of improved cultivars. Onion breeders should be aiming to select seed bulbs for more desirable shapes and more uniformity in bulb shape.

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References

Chipman, E.W. and Thorpe, E. 1977. Effects of hilling and depth of plant spacing on the incidence of multiple hearts and shape of sweet Spanish onion bulbs. *Canadian Journal of Plant Science* **57**, 1219-1221.

Dowker, B.D. and Fennell, J.F.M. 1974a. Some responses to agronomic treatments of different genotypes of bulb onion, *Allium cepa* L. *Journal of Horticultural Science* **49**, 1-14.

Dowker, B.D. and Fennell, J.F.M. 1974b. Heritability of bulb shape in some North European onion varieties. *Annals of Applied Biology* **77**, 61-65.

King, D., Scheffer, J., Wishart, G., Littler, R., Grant, D. and Carter, B. 1990. A survey of the shape of Longkeeper type onions. Report to the New Zealand Exporters' Association. MAF Technology, Pukekohe and DSIR Crop Research, Pukekohe.

Magruder, R., Webester, R.E., Jones, H.A., Randall, T.E., Synder, G.B., Brown, H.D., Hawthorn, L.R. and Wilson, A.L. 1941. Descriptions of types of principal American varieties of onion. United States Department of Agriculture Miscellaneous Publication No. 435.

McCollum, G.D. 1966. Heritability and genetic correlation of some onion bulb traits. *Journal of Heredity* **57**, 105-110.

Ministry of Agriculture and Fisheries. 1979. Onion growing in Pukekohe. Ministry of Agriculture and Fisheries, Pukekohe, Leaflet PK 025.

Wilson, G.J. 1980. Weed control in onions at Pukekohe. Ministry of Agriculture and Fisheries, Pukekohe Horticultural Research Station Newsletter No. 4, 14pp.

Mondal, M.F., Brewster, J.L., Morris, G.E.L. and Butler, H.A. 1986. Bulb development in onion (*Allium cepa* L.). 1. Effects of plant density and sowing date in field conditions. *Annals of Botany* **58**, 187-195.

Nakamura, N. 1958. Studies on the breeding of *Allium cepa* L. 1. Estimating heritability. *Japanese Journal of Breeding* **8**, 155-160.

Pike, L.M. 1986. Onion Breeding. *In* Breeding vegetable crops. (ed. M.J. Basset). AVI Publishing Co. Westport, Conn.