Tech. Bull. Fac. Agr. Kagawa Univ., Vol. 53, 71~77, 2001

EVALUATION OF BULB SHAPE AND FRESH-WEIGHT OF DIFFERENT ONION CULTIVARS

Atsushi HASEGAWA, Hiroyuki YABUKI, Takahiro NABEURA, Hiroshi FUKUI[1] and Tosyoshi IWATA[2]

Abstract

The relationship between bulb shape and fresh-weight were examined in 6-17 phenologically different onion varieties over a period of three consecutive years (1997-2000). Cultivars which are recommended for production in different agricultural areas of Southwestern Japan, were classified according to their maturity in early, mid-early and late varieties were examined. Onion bulb shape, expressed as the proportionality existent between the diameter and height, was found to be lower in the early local varieties, such as Kaizuka-wase (1.8 ± 0.04) and Shizuoka-wase (1.8 ± 0.03), thus reflecting their flattened form. In the later varieties, such as Osakamaru and Yamaguchi-kodaka, the value was 1.1 ± 0.02, demonstrating their complete globular shape. Conversely, for the F_1 varieties Apollo, Advance and OL, the ratio value was higher (1.3 ± 0.05) and was lower for Momiji (1.0 ± 0.01). In general, they presented less oblateness than the local varieties.

Amongst the local varieties, the highest bulb weights recorded were 365.8 and 356.9 g / bulb for Awaji-chyukou and Sensyu-nakate, respectively, while the remaining five cultivars weighed less than 300 g each. In contrast, with the exception of Momiji, all F_1 hybrids registered weight values superior to 300 g, beginning with Advance that yielded 470 g.

Significant varieties x year interactions were detected for all morphological traits, suggesting that phenotypic yield stability of a particular variety might be affected by the nutrient application schedule over the years. Modest fertilization reduction during the third year of cultivation may have been responsible for the observed lower values in morphological traits.

Keywords : bulb shape, fresh weight, onion

Introduction

The bulb onion (*Allium cepa* L.), originating from central Asia, has been historically used by many cultures in folk medicine as well as in traditional cuisine[1, 2]. Recently and similar to other crops, the new cultivars of onion have increased considerably concomitant with the disappearance of the old cultivars. The new orientations of breeding programs are focusing on disease resistance and storability, however may be loosing some favorable characteristics such as sweetness and pungency present in the old varieties. Kagawa is considered as one of the Japanese prefectures that produce a great yield of onion seed. Hybrid-onion cultivar predominates because of increased yield and uniformity. Production of hybrid onion seed is based on a system of cytoplasmic-genic male sterility (CMS)[3].

The primary aim of this study was to compare the productivity, bulb size and shape of the previously investigated varieties to determine their chemical composition.

Experiment 1

Relationships between bulb fresh-weight and shape in local varieties and F_1 hybrid from 1997-1998.

Materials and methods

The selected seedlings for this study represent a broad range of currently available commercial varieties with regional adaptive preferences, comprising local cultivars and improved F_1 hybrids. With the exception of the cultivar OL, that was raised in University Farm, the remaining hybrid cultivars, released by the Shippo Seed Company, Kagawa, Japan were utilized 50-55 days after sowing.

[1]Faculty of Agriculture, Kagawa University : 2393 Ikenobe, Miki, Kagawa, Japan
[2]Shippo Seed Company : 2421-2 Okamoto, Toyonaka, Mitoyo, Japan

Local breed are :

Early variety :	Kaizuka-wase, Shizuoka-wase, Aichi-ki-wase
Mid-early variety :	Imai-wase, Sensyu-nakate
Late variety :	Awaji-chukoudaka, Osakamaru, Yamaguchi-kodaka

F_1 Hybrid cultivars :

Early hybrid :	Shippo-wase 7
Mid-early :	Answer, Advance, Tarzan, Satsuki
Mid-late hybrid :	OL *
Late variety :	Apollo, Momiji 3, Momiji

*OL was a hybrid raised in Kagawa University Farm

The study was carried out at the Kagawa University Farm (34° 19' N, 134° 03' E), situated on soils derived from material parental granites, which are typical of much of Southwestern Japan. The climate is Mediterranean, characterized by hot summers and cold winters with some frost events from November to April. Mean annual rainfall measures about 1147 mm, with more than 80% of the total rain predominantly falling from June to October. The mean maximum temperature for the hottest month (Aug.) is 31.5 ℃ and the mean minimum temperature for the coldest (Jan.) is 0.7 ℃[4]. Field trials were conducted from November to May over a three year period (1997-2000). Land was prepared on 12 Nov. 1997, according to the local practice of cultivator plough and then furrow construction. All plots were rotatilled two weeks before planting to incorporate soil amendments. Soil was amended with the addition of cattle manure at a ratio of 1.5 tons per are, plus 10 kg of limestone ($CaCO_3$) as a basic soil ameliorate and 7 kg of an organic fertilizer (A786 ; 7N-8P-6K) top-dressed prior to planting. On 14 Nov., 50 seedlings of each variety were transplanted to beds consisting of 90 cm wide furrows spaced 25 cm apart, and contained three inner rows. Transplants were spaced 12 cm apart within the row. Standard cultural practices including hilling, intertillage, manual weed control as well as the application of extra fertilization with an organic fertilizer (A 786, 7/are) were performed in late January and early March. Harvesting day ranged from 21 May for early and mid-early varieties to 28 May for the mid-late and late varieties.

Experiment 2

Relationships between bulb fresh-weight and shape of F_1 hybrid from 1998-1999.

Materials and Methods

The varieties, utilized for the second year of the sequential experiment are shown to continuation. Seven hybrid varieties were acquired from a seed supplier, Shippo Seed Company, Japan.

F_1 Hybrids are conformed by

Early hybrid :	Shippo-wase 7
Mid-early :	Answer, Advance, Tarzan, Satsuki
Mid-late hybrid :	Shippo-ama 70 OL*
Late hybrid :	Apollo, Momiji 3

*OL seedling was raised in Kagawa University Farm.

The field was moldboard plowed and harrowed on 16 Nov. 1998, incorporating a mixture cattle manure at a ratio of 1.5 ton per are, plus 10 kg of limestone ($CaCO_3$) and 7 kg of an organic fertilizer (A786), followed by furrow construction on 18 November. Beds consisted of 90 cm wide furrows spaced 25 cm apart, and contained three inner rows in which seedlings were separated 12 cm. Hilling, intertillage, manual weed control and fertilization (A786, 7 kg/are) were performed on 27 January and 17 March, including an additional hilling.

Experiment 3

Relationships between bulb fresh-weight and shape of F_1 hybrid from 1999-2000.

Materials and Methods

This experiment utilized the same varieties described for the experiment 2. On 6 Nov. 1999 tillage and furrowing were performed.

Amended soil was slightly modified with the basal application of manure compost at a ratio of 0.5 ton per are, 13 kg of lime stone ($CaCO_3$) and 10 kg of an organic based fertilizer (A786) top-dressed prior to planting. Furrows were 60 cm wide, spaced 25 cm, and contained two inner rows. Transplanting was done to achieve a final density of 75-100 seedlings per are, where each variety was replicated

two times, with a spacing of 12 cm between plants. Cultural practices including intertillage, manual weed control, and complementary fertilization with an organic fertilizer (A786) at five kg/are were performed on 1 February and 3 March. In 3 March, an additional fertilization at 10 kg/are of organic fertilizer (A786) and hilling were made. On 19 May, all varieties were harvested. In this trial, the complementary fertilization was top- dressed only once.

Statistical analyses

After harvesting, an equal representation of 40 bulbs per replicate in each of the variety was randomly selected, and the diameters and heights of each bulb were measured using a caliper, followed by separate measurements of weight that were expressed in grams. The resulting measurements were recorded and used to estimate the volume of each bulb, using the formula for a prolate ellipsoid. An analysis of variance was performed separately on the data sets obtained each year, using MSTAT-C in a randomized complete block design with five replications. Each replication consisted of eight onion samples in each variety. Duncan's multiple range test was used to compare mean variety at different attributes. A combined analysis of variance was performed on the data of seven common varieties cultivated to determine the significant effect of year and their interaction on yield components.

Results and Discussion

Results of the nine F_1 hybrid cultivars and the eight local varieties in experiment 1 are summarized in Table 1. For the local varieties, the proportion between bulb diameter and height was found to be large, indicating the flattened shape that prevails in these varieties. This was particularly notorious in the early varieties, without any difference between the Kaizuka-wase (1.8 ± 0.04) and Shizuoka-wase (1.8 ± 0.03). Conversely in the late varieties, such as Osakamaru and Yamaguchi-kodaka, this ratio was 1.1 ± 0.02 reflecting the nearly complete spherical form. Our results demonstrate a clear tendency in the local varieties, where the bulb shape is more flattened than those precocity hybrids. Although some varieties of F_1 hybrid, such as Apollo, Advance and OL, presented flattened shape with higher values 1.3 ± 0.05, the remaining varieties ranged from 1.1 to 1.2. In the Momiji variety the value was 1.0 ± 0.01, exhibiting a near globular shape.

Regarding bulb weight, the local varieties that presented the heaviest weights were Awaji-chukodaka and Sensyunakate at 363.8 and 356.9 g / bulb, respectively. The other

Table 1. Comparison of the principal morphological features of local varieties and F_1 hybrids of *Allium cepa* evaluated during 1998.

	Variety	Attribute[z]				
		Diameter (cm)	Height (cm)	Diameter / Height Ratio	Weight (g)	Base Plate Diameter (cm)
Local Varieties	Kaizukawase	8.8 defgh	4.8 j	1.8 a	220.9 g	1.3 fg
	Shizuokawase	8.7 efghi	4.8 j	1.8 a	206.4 g	1.1 h
	Aichikiwase	9.1 cdefg	7.3 ef	1.3 efg	307.8 ef	1.6 bc
	Imaiwase	8.6 ghi	6.1 h	1.4 c	234.0 f	1.3 g
	Sensyunakate	9.7 b	7.3 ef	1.3 d	359.6 bcd	1.5 de
	Awajityukodaka	9.6 bc	7.7 cd	1.3 efg	363.8 bc	1.9 a
	Osakamaru	7.7 jk	6.8 g	1.1 h	213.3 g	1.4 ef
	Yamaguchikodaka	7.5 k	7.0 fg	1.1 hi	216.4 g	1.5 cd
F_1 Hybrids	Shippowase 7	9.1 cdefg	7.4 def	1.2 fg	318.0 cdef	1.3 fg
	Answer	9.3 bcde	7.7 cd	1.2 g	352.7 bcde	1.4 ef
	Advance	10.4 a	8.3 a	1.3 efg	470.0 a	1.6 bcd
	Tarzan	9.2 bcdef	8.2 ab	1.1 h	355.7 bcde	1.5 de
	Satsuki	8.7 fghi	7.9 bc	1.1 h	312.5 def	1.6 cd
	Apollo	9.4 bcd	7.2 ef	1.3 def	326.3 cde	1.4 ef
	Momiji 3	8.9 defgh	8.4 a	1.1 hi	338.8 bcde	1.5 de
	Momiji	8.2 ij	8.2 ab	1.0 i	273.0 f	1.8 a
	OL	9.8 b	7.4 de	1.3 de	378.9 b	1.7 b

[z] Each value represents means of 5 observations in complete randomized block design for each characteristic.
[y] Mean separation within column by Duncan's multiple range test, 5%.

Table 2. Comparison of the principal morphological features of eight recognized cultivars of *Allium cepa* evaluated during 1999.

Variety	Attribute[z]			
	Diameter (cm)	Height (cm)	Diameter / Height Ratio	Weight (g)
Shippowase 7	1.3 a	8.0 c	1.3 b	448.8 a
Answer	8.8 de	7.6 d	1.2 d	294.1 d
Advance	10.1 a	8.4 a	1.2 cd	439.4 a
Tarzan	8.4 e	8.2 bc	1.0 f	279.6 d
Satsuki	9.2 c	7.9 c	1.2 d	365.2 b
Momiji 3	9.0 cd	8.1 bc	1.1 e	331.9 c
Shippoama 70	10.2 a	8.3 ab	1.2 c	436.5 a
OL	9.6 b	6.6 e	1.5 a	337.3 c

[z] Each value represents means of 5 observations in complete randomized block design for each characteristic.
[y] Mean separation within column by Duncan's multiple range test, 5%.

Table 3. Comparison of the principal morphological features of eight recognized cultivars of *Allium cepa* evaluated during 2000.

Variety	Attribute[z]			
	Diameter (cm)	Height (cm)	Diameter / Height Ratio	Weight (g)
Shippowase 7	9.3 a	7.6 b	1.22 b	345.7 b
Answer	8.7 b	7.2 cd	1.22 b	300.5 c
Advance	9.5 a	8.2 a	1.16 c	395.0 a
Tarzan	7.8 d	7.0 d	1.10 d	216.8 e
Satsuki	8.8 b	7.6 b	1.18 bc	308.8 c
Momiji 3	8.3 c	7.5 b	1.10 d	262.2 d
Shippoama 70	8.4 c	7.4 bc	1.14 cd	260.2 d
OL	8.5 bc	6.3 e	1.36 a	238.2 de

[z]Each value represents means of 5 observations in complete randomized block design for each characteristic.
[y]Mean separation within column by Duncan's multiple range test, 5%.

five varieties possessed weights inferior to 300 g. In the F_1 varieties beginning with the Advance at 470 g, and with the exception of Momiji, the remaining seven varieties registered weight values superior to 300 g. These results showed a consistent tendency that F_1 hybrids are heavier than the local varieties. This implies that if they are sown at similar planting densities, the former will result in a higher yield.

Results of experiment 2 where the varieties Apollo and Momiji were not considered, but with the inclusion of Shippo-ama, are summarized in Table 2. Eight F_1 hybrids were used in this experiment.

Results of the experiment conducted from 1999-2000 with the same varieties are shown in Table 3. With the exception of Answer, a discernible decrease in fresh-weight was noted for all varieties. This decrease could be due to the lack of complementary fertilization during the year. Unsuitable weather conditions prevailing during the winter months prevented its application.

This work is consistent with the findings of Kashi and Frodi[5], who reported that nitrogen exerts an effect on bulb yield, quality and the storability. Sing and Mohanty[6] also documented that the total nitrogen as well as the nitrogen : potassium ratio has a strong influence on plant stature and bulb size. The probable cause of the decreased yield during the third year may be ascribed to an insufficiency of nitrogen content and other nutrients included in the fertilizer.

Results of the combined analysis evidence a significant variety x years interaction for all variables, indicating that these varieties did not respond similarly over the years. Generally, greater variability was found in 2000 than in 1999 or 1998. Climatic conditions can be discounted as responsible for year variations because the climate did not present large fluctuations. The difference in years resulted primarily from modifications in fertilization amount applied in the third year. Evidence of the impact of a reduction in

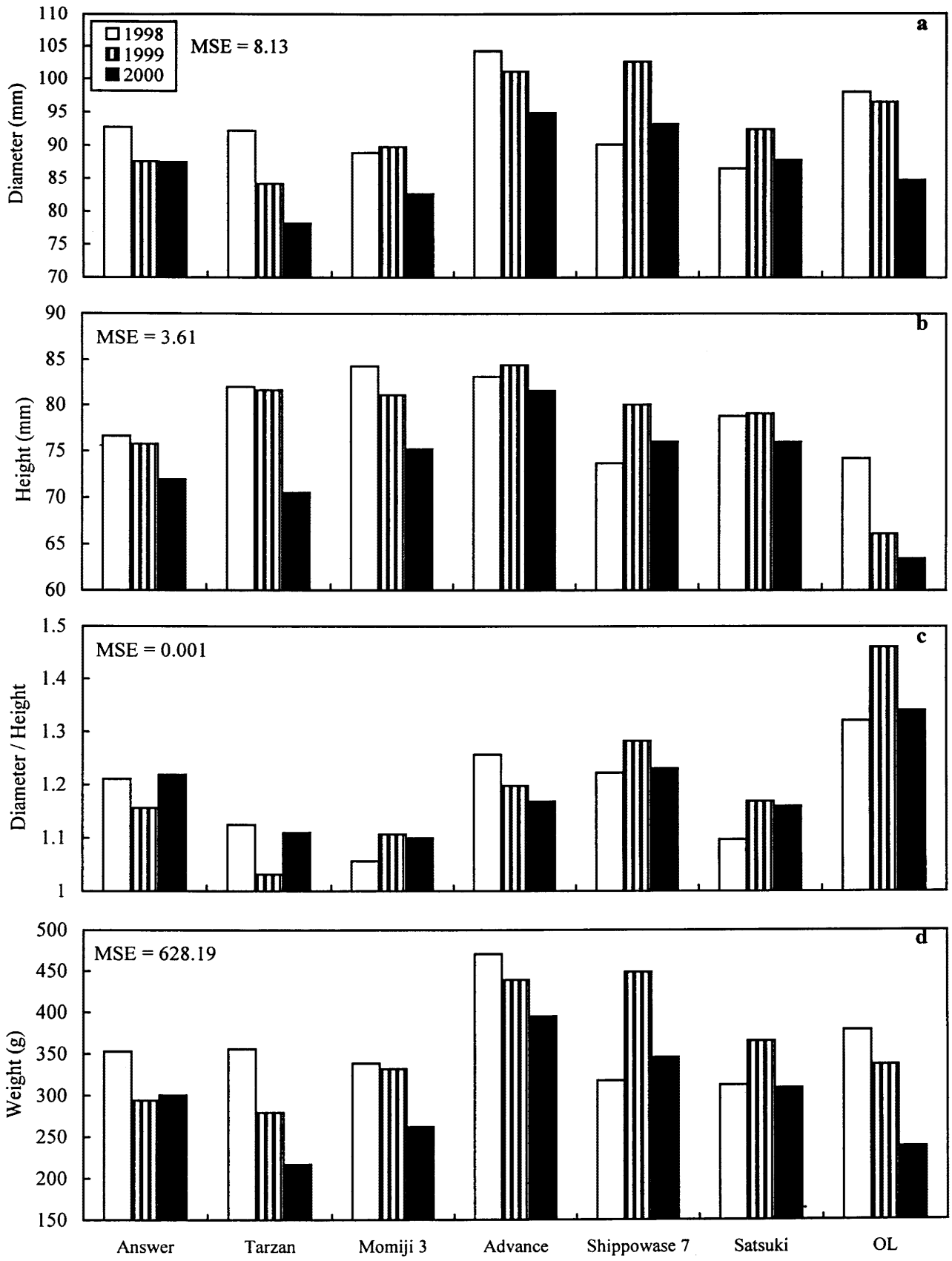

Figure 1. Comparison of (a) diameter, (b) height, (c) diameter / height ratio and (d) fresh weight of seven cultivars evaluated over 1998-2000.

fertilization was reflected in smaller bulb size, weight, and shape. A further implication of the above mentioned differences among cultivars is that traditional varieties cultivated by its recognized shape (e.g. OL) can result in a change in form, flavor and other characteristics for the growing conditions in which they were grown[7].

With regards to bulb fresh-weight, the influence of environmental conditions during cultivation is well documented, particularly during the swelling period, where the amount of rainfall is a key factor[8].

The results of this study provide evidence that additional fertilization plays a key role in the production of onions. Although analysis for the detection of dimethyl sulfides levels, which is the compound responsible for flavor intensity and quality were not done, it goes unquestioned that changes in its composition occurred. In Southwestern Japan seedling planting commences in November and harvesting occurs in May - June, implying that the season for bulb development is from March to April, coinciding with the rainy season ; thus the potential problem of humidity insufficiency is probable relatively scarce. Requirements for the application of the additional fertilization should take place in February to early March prior to bulb development, which commences in March. When not performed, there are undoubted repercussions, resulting in the decreased yield.

The diameter of the base plate in experiment 1 ranged from 1.12 ± 0.02 cm in the Shizuoka-wase variety to 1.85 ±0.04 cm in the Awaji-chukodaka variety. The local varieties and the F_1 hybrid cultivars presented almost the same values in the base plate diameter without any difference. The same trend was also noted for the early and later strains, exhibiting comparable values in this parameter. In addition, a marked fluctuation in the diameter was found in variety Momiji 3 from 1998 and 2000 with values ranging from 1.50 ± 0.02 cm and 2.07 ± 0.31 cm respectively.

One of the breeding goals in onion breeding programs is centered in the reduction of non-edible onion parts as the scale thickness and the base plate. However, our data did not reveal any correlation between the sizes of base plates and cultivars, indicating that the regulation of base plate size was neglected by onion breeding programmers.

Breeding onions for improved yield, storability and physiological characters has been reported as the focus in recent breeding programs. Similarly, advances are also being reported with respect to disease tolerance and nutrients absorption capacity. Reduction in the base plate could difficult rooting, but in the contrary case this base plate can be fissured and become prone to rot. Therefore, it will be necessary to consider a reduction in the base plate for future directions in onion breeding programs.

Literature Cited

1. Augusti, K. T. : Therapeutic and medicinal values of onions and garlic. *In* : H. Rabinovitch and J. Brewster (eds.), Alliums and allied crops. pp. 93-108. CRC Press, Boca Raton, Fla. (1990).
2. Block, E. : The organosulfur chemistry of the genus *Allium* - Implications for the organic chemistry of sulfur. *Angewante Chemien.*, 31, 1135-1178 (1992).
3. Havey, M. J. : Seed yield, floral morphology, and lack of male-fertility restor ation of male-sterile onion (*Allium cepa*) populations possessing the cytoplasm of *Allium galanthum*. *J. Amer. Soc. Hort. Sci.*, 124, 626-629 (1999).
4. Japanese Science Meteorological Data. National Astronomical Observatory (ed.). Maruzen, Tokyo (1999). (In Japanese).
5. Kashi, A. and Frodi, B. R. : Effects of nitrogen on the yield, quality and stor ability of edible onion cultivars (*Allium cepa L.*). *Iranian J. Agric. Sci.*, 29, 589-597 (1998).
6. Randle, W. M. : Increasing nitrogen concentration in hydroponic solutions affects onion flavor and bulb quality. *J. Amer. Soc. Hort. Sci.*, 125, 254-259 (2000).
7. Sing, S. P. and Mohanty, C. R. : A note on the effect of nitrogen and potassium on the growth and yield of onion. *Orissa J. Hort.*, 26, 70-71 (1998).
8. Vavrina, C. S. and Smittle, D. A. : Evaluating sweet onion cultivars for sugar concentrations and pungency. *HortScience*, 28, 804-806 (1993).

(Received September 29, 2000)

タマネギ品種における鱗茎の形状と重量比較

長谷川暉・薮木広幸・鍋浦高弘・福井宏至・岩田豊志

要　　約

1997－2000年の三作にわたり，タマネギの品種における鱗茎の形状と球重について調査した。鱗茎の形状（球径／球高）は在来品種では早生種の‘貝塚早生’（1.8±0.04）や‘静岡早生’（1.8±0.03）が扁平球であったが，晩生種の‘大阪丸’や‘山口甲高’では1.1±0.02とほぼ正球に近かった。一方，F_1品種では‘アポロ’や‘アドバンス’‘OL’が1.3±0.05と高く，‘モミジ’では1.0±001と低く，全体的には在来種に比べ扁平率が低くなった。

球重は在来品種では‘淡路中甲高’の363.8gや‘泉州中生’の356.9gが大きく，他の５品種は300g以下であった。一方，F_1品種では‘アドバンス’の470gをはじめ，‘モミジ’を除いた他の７品種はいずれも300g以上であった。

球重は栽培年によって差が認められた。較差の大きい品種は‘OL’140.7g，‘ターザン’138.96gおよび‘七宝早生７号’130.77gであり，小さい品種は‘アンサー’58.59gと‘さつき’62.4gであった。その主要因は追肥量によるものと考えられた。