

Comparison of Seasonal Growth and Yield Performances of Japanese Cabbage Varieties in Nagano, Japan

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Summary

Three cabbage varieties, “Ajioh”, “Shutoku SP” and “Shinshu 868” were investigated at the AFC field, Faculty of Agriculture, Shinshu University during 2014. The experiment was established in a simple Randomized Complete Block Design, where these three cabbage varieties were transplanted and harvested at five different seasons. There were some significant differences among the varieties in head weight, head width and head height, as well as the number of leaves and their weight. For seasonal difference, the highest growth and yield performances were observed in Phase 3 (harvested in October) among the varieties. The results obtained indicated that “Shinshu 868” produced the highest head weight (1.64 kg) and the highest head width (19.1 cm); while “Ajioh” produced the highest head height (14.4 cm/head). The phase 5 had no head formation due to change in weather condition from October to December.

Key words : *Brassica oleracea* L., Cabbage, Varietal difference, Seasonal difference

Introduction

Cabbage (*Brassica oleracea* var. *capitata* L.) belongs to the Brassicaceae Family and is one of the most important leafy vegetable crops grown under temperate to tropical climate conditions around the world (Singh et al., 2010). According to world estimates, there are more than two million hectares under production, with an average yield of 27.8 tons per hectare (FAOSTAT, 2010). Cabbage is a crop plant that is easily grown on a wide variety of soil types and can be adaptable to many different climatic conditions (Smith, 1995).

Cabbage has been ranked by the Food and Agriculture Organization among the ten top twenty vegetable crops grown annually, establishing it as an important food source globally (FAO, 1988). It has high water content, fiber, protein, calcium and iron. Additionally, cabbage is a rich source of vitamin A and Vitamin C (Adeniji et al., 2010; Meena et al., 2010). It can be prepared and eaten as food such as fresh salads or cooked with other foods.

There is much variation among cabbage types, with colors ranging from green to purple, and leaves from smooth to crinkly. The head shape also has wide variation such as flat, round and pointed. Maturity ranges from early to late in the growing season between 60 to 90 days depending on the variety. Cabbage varieties have been bred to produce good yielding mature heads very early in the season. For farmers growing cabbage in both tropical and temperate climates, early varieties are more advantageous for meeting early market demands (Adeniji *et al.*, 2010).

The objective of this research was to compare the growth and yield performances of three Japanese cabbage varieties during the various seasons of the year in Nagano Prefecture, Japan, to determine varietal differences in yield and identify the best varieties suited for the growing seasons.

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Materials

Three cabbage varieties, namely “Ajiroh”, “Shutoku SP” and “Shinshu 868”, were used in this experiment. “Ajiroh” is an ‘All-Season Variety’ produced by Tohoku Seed Company. It is known for cultivation from spring to autumn annually. This variety has an irregular-shape of head with green crinkly-like leaves. “Shutoku SP” is a summer type with heat tolerance produced by Takaii Seed Company and has a round head with light-green leaves. “Shinshu 868” is a ‘spring and summer type’ also produced by Tohoku Company. It has a flat-head with dark-green leaves. The seeds were purchased from the JA Company and Green Farm Incorporated in Ina City, Japan. The date to maturity of these varieties ranged approximately from 85-90 days from nursery to harvest.

Methods

The field experiment activities commenced from May 9 to December 12, 2014, during the annual vegetable production seasons. The two-factor experiment was established in a Randomized Complete Block Design (RCBD), using three cabbage varieties during five phases of investigation (Fig. 1). Nursery activities started in May in a glass greenhouse, and were repeated on the same date of subsequent months of the seasons until September (Fig. 3 A). The seedlings at 4-5 true leaves after 25 days of proper management, were transplanted to ridge covered by black vinyl mulch in the field on the 4th of each month of the investigation, starting June to October, 2014 (Fig. 3 B). After transplanting, each block of the seedlings was grown under low tunnels condition covered by cheesecloths (Fig. 3 C).

The total experimental plot of 12.5 meters by 7.5 meters was layout into five blocks for the five phases of field experiment. For the land preparation, 1.5 Kg of NPK 15-15-12 was evenly broadcast over each block and covered with plastic mulch to avoid nutrients leaching. The three varieties of cabbage were randomized on each block of 12.5 meters x 0.7 meter with 1 meter between blocks. Each block consisted of three plots of double rows with twenty plants per variety ; and a plant-to-plant spacing of 30 cm and 30cm between rows.

In the process of field maintenance, the integrated crop and pest management (ICPM) system was applied. Transparent nets or row covers were used over each block after transplanting to control environmental hazards of pests/insects and diseases. Limited pesticide was used on the crops and regular weeding was conducted. We observed head weight, head width, head height, number of leaves and their weight, for the three varieties at maturity. For appropriate data collection, eight marketable cabbage heads per variety were randomly harvested and weighed separately during four phases. Besides leaves, head parameters for phase 5 were excluded for lack of head formation based on weather condition (Fig. 1). There were variations in rainfall and temperature conditions of the seasons during all five phases of field experiment, according to the Annual Weather Report from the Japan Meteorological Agency,

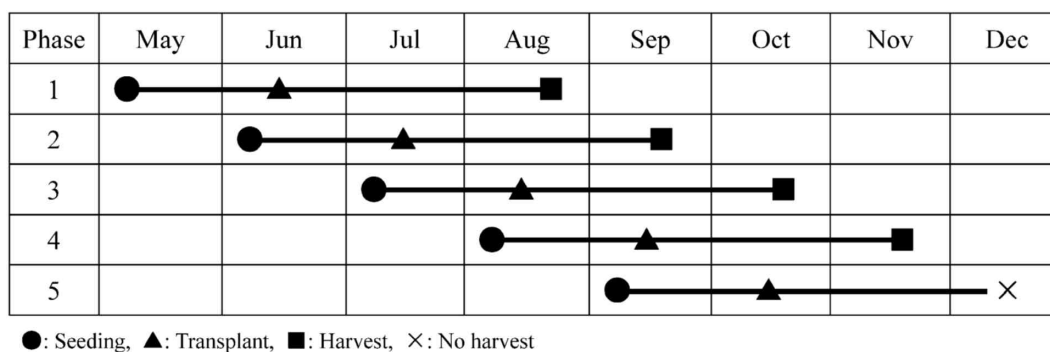


Fig. 1 Monthly activities schedule of field cabbage experiment during 5 phases in 2014.

Nagano WMO Station : ID 47610 for 2014 (Fig. 2).

Results

All data collected in this experiment were summarized in Table 1. Considering the differences in climatic conditions, plant varieties, uniform management practices and harvest dates, each variety

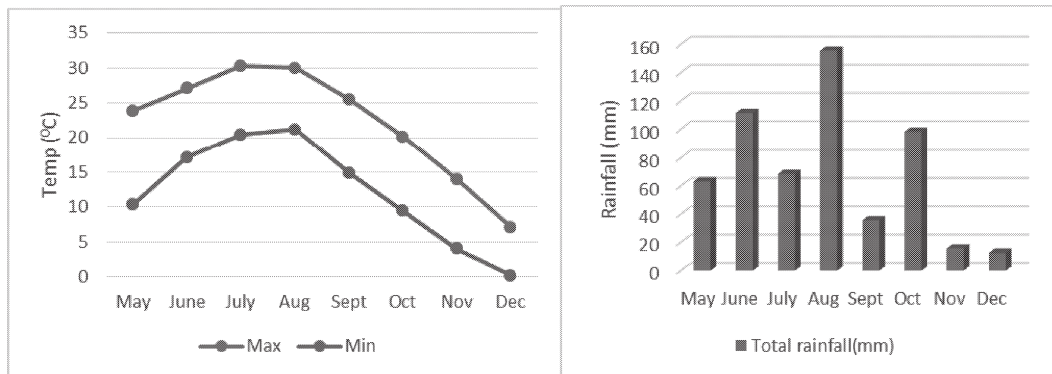


Fig. 2 Total monthly mean temperature and rainfall at Ina city, Nagano Prefecture in 2014.

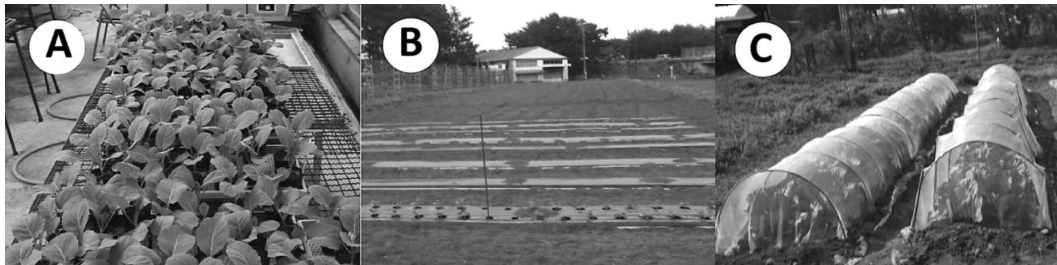


Fig. 3 The experiment activities in green house and field in this study.

A : Cabbage seedling nursery in green house.

B : The seedlings were transplanted to ridge covered by black vinyl mulch.

C : Low tunnels by cheesecloth were covered in each of the ridges.

Table 1 Head and outer leaves characters of three cabbage varieties for five harvest seasons.

Part	Character	variety	Harvest season ¹⁾				
			Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Head	Weight (kg)	Ajioh	1.67 ±0.14a, <i>xy¹⁾, ²⁾, ³⁾</i>	1.30 ±0.18a, <i>x</i>	1.51 ±0.14a, <i>x</i>	1.24 ±0.07b, <i>x</i>	no head
		Shutoku SP	1.27 ±0.09a, <i>x</i>	1.31 ±0.04a, <i>x</i>	1.71 ±0.20a, <i>x</i>	1.36 ±0.08a, <i>x</i>	
		Shinshu 868	1.75 ±0.18a, <i>y</i>	1.64 ±0.07a, <i>x</i>	1.86 ±0.10a, <i>x</i>	1.31 ±0.05a, <i>x</i>	
	Height (cm)	Ajioh	12.8 ±0.38a, <i>x</i>	15.2 ±0.41b, <i>x</i>	14.1 ±1.13ab, <i>x</i>	15.8 ±0.27b, <i>x</i>	no head
		Shutoku SP	11.6 ±0.53a, <i>x</i>	14.4 ±0.26bc, <i>x</i>	16.2 ±0.30b, <i>y</i>	14.1 ±0.57c, <i>y</i>	
		Shinshu 868	12.8 ±0.55a, <i>x</i>	13.8 ±0.33a, <i>x</i>	13.2 ±0.28a, <i>x</i>	12.1 ±0.11a, <i>z</i>	
	Width (cm)	Ajioh	16.1 ±0.62a, <i>x</i>	17.3 ±0.27ab, <i>x</i>	18.8 ±0.82b, <i>x</i>	16.0 ±0.43a, <i>x</i>	no head
		Shutoku SP	13.9 ±0.39a, <i>y</i>	16.0 ±0.37b, <i>x</i>	19.9 ±0.37c, <i>x</i>	17.8 ±0.32d, <i>y</i>	
		Shinshu 868	16.4 ±0.56a, <i>x</i>	18.9 ±0.42b, <i>y</i>	21.6 ±0.32c, <i>y</i>	19.4 ±0.18b, <i>z</i>	
	Height/width ratio	Ajioh	0.80 ±0.01a, <i>x</i>	0.88 ±0.03b, <i>x</i>	0.75 ±0.03ad, <i>x</i>	0.99 ±0.01c, <i>x</i>	no head
		Shutoku SP	0.84 ±0.02ab, <i>x</i>	0.90 ±0.03a, <i>x</i>	0.81 ±0.02b, <i>x</i>	0.79 ±0.02b, <i>y</i>	
		Shinshu 868	0.78 ±0.02a, <i>x</i>	0.73 ±0.03a, <i>y</i>	0.61 ±0.01b, <i>y</i>	0.62 ±0.01b, <i>z</i>	
Number of Outer leaves	Total weight (g)	Ajioh	931 ±37a, <i>x</i>	718 ±27b, <i>x</i>	797 ±25ab, <i>xy</i>	733 ±31b, <i>x</i>	409 ±31c, <i>xy</i>
		Shutoku SP	809 ±49ab, <i>xy</i>	729 ±24b, <i>x</i>	923 ±43a, <i>x</i>	895 ±79a, <i>y</i>	357 ±22c, <i>x</i>
		Shinshu 868	793 ±41a, <i>y</i>	781 ±37a, <i>x</i>	743 ±32a, <i>y</i>	741 ±31a, <i>x</i>	498 ±22b, <i>y</i>
	Number of Outer leaves	Ajioh	12.3 ±0.56ac, <i>x</i>	9.9 ±0.26bd, <i>x</i>	11.0 ±0.61ad, <i>x</i>	8.6 ±0.53b, <i>x</i>	14.1 ±0.45c, <i>x</i>
		Shutoku SP	14.5 ±0.55ab, <i>y</i>	14.1 ±0.23a, <i>y</i>	14.5 ±0.33ab, <i>y</i>	12.9 ±1.07a, <i>y</i>	16.4 ±0.42b, <i>y</i>
		Shinshu 868	12.5 ±0.38ab, <i>x</i>	14.3 ±0.60b, <i>y</i>	12.8 ±0.30ab, <i>xy</i>	11.5 ±0.41a, <i>y</i>	17.5 ±0.60c, <i>y</i>

1) See Fig. 2

2) Mean ± standard error

3) Different letter (a, b, c, d) differ significantly at 5 by Tukey's test within each variety in each character.

4) Different letter (x, y, z) differ significantly at 5 by Tukey's test within each harvest season in each character.

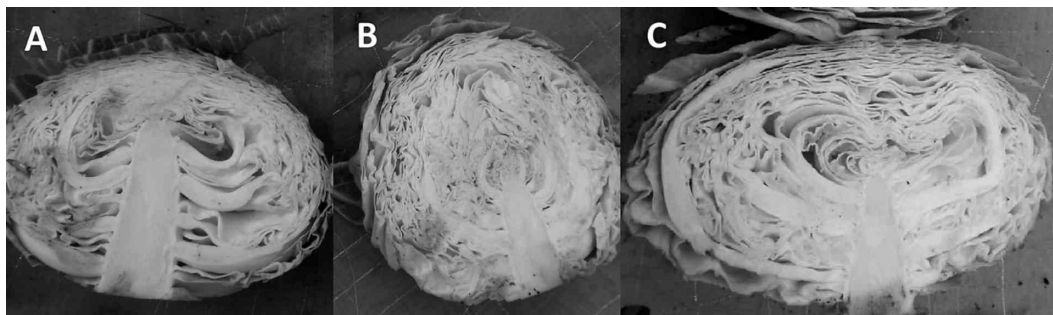


Fig. 4 The cross section of three cabbage varieties. A : Ajiroh, B : Shutoku SP, C : Shinshu 868

performed according to its natural characteristics.

In head weight, the heaviest weight was observed in Phase 3 in all three varieties. There were some significant differences among the three varieties during the four seasons of observation. Varietal difference appeared in phase 4 between “Ajiroh” and the other two varieties “Shutoku SP” and “Shinshu 868” at 5% level. Seasonal difference was observed in phase 1 between “Shutoku SP” and “Shinshu 868”. The head weight of “Shinshu 868” seems slightly better than the other two through the seasons.

For the head width, there was no varietal difference among the varieties in phase 1, but “Ajiroh” was significantly different compared with the others in phase 2 and 3. While in phase 4, significant difference was observed among the three varieties at 5% level. The result of the study also indicated seasonal difference among the head width of varieties. “Shutoku SP” was different from the others in phase 1, “Shinshu 868” from the others in phases 2 and 3, and there was a significant difference among all the three varieties in phase 4 at 5% level.

The head height result further indicated no significant varietal difference among the three cabbage varieties in phase 1, but a significant difference was found between “Shinshu 868” and “Ajiroh” in phase 2. A difference was also realized between “Shinshu 868” and “Shutoku SP” in phase 3 and existed among the three varieties in phase 4 at 5% level. For seasonal difference in head weight, there was none observed in phases 1 and 2 among the varieties, but “Shinshu 868” was different from “Shutoku SP” in phase 3. Significant difference appeared among the varieties in phase 4 at 5% level. In terms of the head shape, the head height and /width ratio presented “Ajiroh” and “Shutoku SP” as having the same circular head shape from phases 1-3 and not phase 4 ; while “Shinshu 868” had a more flat-shape head compared to the others (Fig. 4 A, B and C).

The study further portrayed a varietal difference in the number of outer leaves indicating “Ajiroh” producing the least in all phases. Seasonal difference was observed similarly between “Ajiroh” and the other two varieties at 5% level. A high outer leaf production was achieved in phase 5 than other phases. Significant difference was observed in the outer leaves weight among the varieties with “Ajiroh” and “Shinshu 868” different from “Shutoku SP” in phase 1. “Shinshu 868” showed significant difference from others in phases 2 -5 respectively at 5% level. Likewise, seasonal difference was found among the varieties during phases 1, 3, 4, and 5, but not in phase 2. It was well noted that the outer leaves weight of all varieties decreased significantly during phase 5.

Discussion

The number of days to maturity or earliness in cabbage, is largely measured by variety ; and is a desirable characteristics when varieties that have short growth cycles are needed to meet marketable food security needs (Cervenski *et al.*, 2011). Differences in daylight hours and temperatures also affect the number of days to maturity and yield quality (Greenland *et al.*, 2000). In this investigation, the actual days to maturity from transplanting to harvestable cabbage heads were not uniformed due to change in weather

conditions. Hence, the results from this experiment highlighted that the cabbage varieties “Ajioh”, “Shutoku SP”, and “Shinshu 868”, have the potential to produce marketable head sizes within 60-75 days from transplanting date. According to Tanaka and Niikura (2000), early head formation in cabbage enables early harvesting in both tropical and temperate zones shortly after the season begins.

In this study, “Shinshu 868” presented the highest mean head weight of marketable heads of cabbage at 1.64 kg/head, and the highest mean head width at 19.109 cm/head when compared to the other two varieties. The head height was significant among the varieties with “Ajioh” having the highest mean at 14.44cm/head. Due to change in weather condition, the number of leaves produced in phase 5 was very high, but yielded decreased weight than other phases. The overall yields from the three improved varieties were impressive and matched with yields that are commonly produced from locally grown cabbages in Nagano prefecture.

The head weight and head width characteristics were consistent with Greenland et al., (2000), who observed that cabbages destined for fresh market must have high head densities, small to medium-sized heads and good appearance. From these results, it was observed that superior cabbage variety like “Shinshu 868”, with improved growing conditions and increased yield potentials, can enhance food security in any farming community.

Conclusion

The study can be concluded that the “Shinshu 868” Variety is preferable for the growing seasons in Nagano Prefecture more than the other two varieties. This determination was based on its superior head weight, head width and best growth potentials. Besides, the three cabbage varieties displayed good to excellent quality characteristics over the growing seasons, especially during phase 3, the best season of the study (August–October).

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