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Research Article

Effects of Sowing Date on the Quality of Curciferae Vegetables in Autumn

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Abstract: In this study, the effects of low temperature on the quality of 11 kinds of curciferae vegetables cultivated in autumn with different sowing date in Niigata of Japan was studied by evaluating the ascorbic acid, nitrate nitrogen and sugar content. The results showed that vegetables sown at Oct. 28 tended to higher sugar concentration, higher ascorbic acid content and lower nitrate nitrogen content in their leaves than that sown at the date of Sep. 7 and 28. It is indicated that changing the sowing date can improve the quality of vegetable by the low air temperature. The results also showed that it is possible to cultivated vegetables in autumn in Niigata prefecture of Japan, especially for chingensai and serihon.

Keywords: Ascorbic acid, low temperature, nitrate nitrogen, sugar content, vegetable of cruciferae

INTRODUCTION

The Niigata is located in hokuriku area in Japan sea side and it is characterized by low temperature, low radiation and snow cover during winter. Although it is thought that the environmental condition is disadvantageous for vegetables production comparing with other warm area, it is possible to produce some leafy vegetables under the non-heating condition during winter, if they have high resistance to low temperature (Yamaguchi, 1984). Recently, it has reported that some fresh vegetable and fruits have cancer-preventing functions (Shinohara, 1997). More and more people become to be interested in the food safety, taste and the nutrition of vegetables. They are also worrying about the higher nitrate concentrations in some vegetables, which are harmful components for human health (Shinohara, 1997). High quality of vegetables means higher ascorbic acids content, higher sugar content and lower contents of nitrate nitrogen. Although there is a significant differences in the ascorbic acid content among vegetables, even within the same species, which is depended on fertilizations, weather conditions and the cultivating seasons (Inoue *et al*., 1998). It is important to improve the quality of vegetables in order to meet the requirement of consumers.

It is reported that when spinach was cultivated in lower sunlight condition in winter, the content of vitamin and sugar were lower than that in normal condition (Oyama *et al*., 1999). However, it has been reported that sugar content and vitamin content of Komatsuna (*Brassica campestris L*.) were increased significantly when it was planted in non-heating greenhouse and exposed with cold air by opening the door of the greenhouse in winter (Ozawa, 1997). Furthermore, it has been reported that when Komatsuna was grown at low temperature condition during winter in Akita of Japan, the sugar content and ascorbic acid content were higher than which were grown in worm condition (Tamura, 1999). The weather in winter of Niigata Prefecture is much warmer than it in Morioka Prefecture. It seems possible to plant vegetables in autumn and early winter. On the other hand, the low temperatures in ripening period maybe are helpful to improve the quality of vegetables by increasing the content of sugar and ascorbic acids. The research was focused on the possibility of planting Tsukena vegetables from autumn to early winter and planting in overwinter in open-field in Niigata. In this study, effects of sowing date on growth, contents of sugar, ascorbic acids, as well as the content of nitrate nitrogen of Tsukena vegetables were evaluated.

MATERIALS AND METHODS

Plant materials: The experiment was designed by three sowing date, which was sowed at September 7, 28 and October 19. Twelve kinds of vegetables in Cruciferae were used for this experiment in field trial in Shindori Farm of Niigata University, which was komatsuna (*Brassica campestris L*.), leafradish (*Raphanus sativus*), chingesai (*Brassica chinensis*), Saishin (*Brassica peachiness*), autumn poem (*Brassica chinensis*), kousaitai (*Brassica chinensis*), kale (*Brassica oleracea*), serihon (*Brassica napiformis*), serihon (*Brassica napiformmis*), vitamina (*Brassica narinosa*), taisai (*Brassica chinensis*), ha-karashina (*Brassica cernua*), takana (*Brassica juncea*). Chemical fertilizer (8 Kg/10a, N: PO_2: K_2O = 8:8:8).

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Sapling time and determining items: To determine the resistance for vegetables to low temperature, the experiment was designed by three sowing date. The vegetables of komatuna, leaf radish and chingensai sown at Sep. 7 were harvested at Oct. 12 and others were harvested at Oct. 20. Vegetables which sown at Sep. 28 were harvested at Nov. 16 for komatsuna, leaf radish and chingensai and others were harvested at Oct. 20. Vegetables which sown at Oct. 19 were harvested at Dec. 24, the growth characteristics such as fresh weight, leaf number and plant height were measured once a week or two weeks for once during growing period. In their vegetable, five plants were sampled before harvesting. After roots were removed, the plant height, leaf numbers and fresh weight were measured. Then these plant materials were dried at 70°C for 48 h in a chamber for measuring the dry weight (Lutfor Rahman *et al*., 1999).

Determination of sugar content, ascorbic acids content and nitrate nitrogen content: Three plants were sampled for determining the quality of vegetables. One gram of leaf blade was homogenized with 9 mL distilled water and filtrated with filter paper (No. 5), then the filtrate was used for determining the sugar content by hand refract meter (ATAGO), ascorbic acid content by refract meter (RQ flex 2, Merch, Germany) and nitrate nitrogen content (Miyajima, 1994; Watanabe, 1996).

RESULTS AND DISCUSSION

Effects of sowing date on the growth of vegetables: Table 1 showed the increase of length, leaf number, fresh weight and dry weight during the 3-5 weeks after sowing. The plants sown at Sep. 7 showed rather higher growth rate. The growth rate of plants sown at Sep. 28 was remarkably smaller due to the cold condition; the growth rate of plants sown at Oct. 19 was the smallest. Because the temperature is the main factor for determining growth rate, the delay of sowing date means lower air temperature in the growing period. Table 1 also showed the growth rate varies with sowing date. The plants sown at Sep. 7 grew greatly during the third to the fifth week after sowing. The plants sown at Sep. 28 grew speedily during the third to seventh week after sowing and there was little increase of leaf length and leaf numbers during the seventh to the ninth weeks, their growth were obviously slower comparing with the plants sown at Sep. 7, with two or three weeks extension of growing period. The plants sown on Oct. 19 had a little increase of leaf number, but most of them had not grown to 10 cm at harvest, all of them have not grown to marketable size because of the cold environment during growing period. The fresh weight and dry weight increased greatly in the plants sown at Sep. 7 during the fourth to 6th week. Although the

Table 1: Increase rate of leaf length, leaf number, fresh weight and dry weight of three kinds of cruciferae vegetables during growth

Material	Sowing date	Leaf length (cm/day)	Leaf numbers (numbers/day)	Fresh weight (g/day)	Dry weight (g/day)
Komatsuna	Sep. 07	1.3	0.29	3.5	-
	Sep. 28	0.5	0.18	1.1	0.13
	Oct. 19	0.2	0.12	0.1	0.02
Leaf radish	Sep. 07	0.9	0.67	4.1	-
	Sep. 28	0.7	0.37	1.9	0.23
	Oct. 19	0.3	0.17	0.3	0.03
Chingensai	Sep. 07	1.0	0.47	5.2	-
	Sep. 28	0.4	0.20	0.8	0.08
	Oct. 19	0.2	0.09	0.1	0.01

-: Not determined

Table 2: Fresh weight, dry weight and percentage of dry matter of six kinds of cruciferae vegetables at harvest

Materials	Sowing date	W.R.H (weeks)	Fresh weight (g/plant)	Dry weight (g/plant)	Dry matter (%)
Kale	Sep. 07	6	163.0	13.5	8.3
	Sep. 28	9	117.5	16.7	14.2
	Oct. 19	9	3.4	0.5	14.7
Serihon	Sep. 07	6	138.1	11.0	8.0
	Sep. 28	9	240.9	26.3	10.9
	Oct. 19	9	4.6	0.6	13.0
Vitamin-na	Sep. 07	6	261.6	18.5	7.1
	Sep. 28	9	182.7	19.1	10.4
	Oct. 19	9	4.9	0.6	12.2
Taisai	Sep. 07	6	379.1	19.0	5.0
	Sep. 28	9	353.9	28.3	8.0
	Oct. 19	9	7.5	0.9	12.0
Ha-karashina	Sep. 07	6	203.1	17.2	8.4
	Sep. 28	9	244.2	30.6	12.5
	Oct. 19	9	4.3	0.7	16.3
Takana	Sep. 07	6	186.2	12.7	6.8
	Sep. 28	9	148.5	18.4	12.4
	Oct. 19	9	3.5	0.5	14.3

fresh weight and dry weight increased remarkable in the plants sown on Sep. 28 during the 5th to 9th week, their growth rate were much lower than the plants sown at Sep. 7 in each materials used. The fresh weight and dry weight of the plants sown at Oct. 19 increased little under low temperature. All of vegetables had a similar increasing pattern of fresh weight and dry weight.

Effects of sowing date on size of the vegetables: Usually, leaf vegetables are harvested at the time when plants are still in the vegetative stage, so it is necessary to let vegetables to reach marketable size at harvest. Table 2 and 3 showed the fresh weight, dry weight and percentage of dry matter at harvest. From the Table 2 and 3, it can be seen that effects of sowing date on fresh weight at harvest were different. Significant difference can be found between plants sown at Sep. 7 and 28 in all of the percentage of dry matters and the dry weight. The dry weight of each plant sown at Sep. 28 increased particularly, although its fresh weight per plant did not increased, some of them even decreased markedly. Percentage of dry matter was the highest in plants sown at Oct. 19, even if those plants have not grown to marketable size as they grown under low temperature conditions. The lower the temperature was the more dry matters were stored in the plants. This result suggested that low temperature in growing period would help dry matters in growing period would help dry matters accumulation in the plants.

Effects of sowing date on yield of the vegetables: As a rosette plant, leaf vegetables are harvested at the

Table 3: Fresh weight, dry weight and percentage of dry matter of five kinds of cruciferae vegetables sown at harvest

Materials	Sowing date	W.R.H (weeks)	Fresh weight (g/plant)	Dry weight (g/plant)	Dry matter (%)
Kale	Sep. 07	6	163.0	13.5	8.3
	Sep. 28	9	117.5	16.7	14.2
	Oct. 19	9	3.4	0.5	14.7
Serihon	Sep. 07	6	138.1	11.0	8.0
	Sep. 28	9	240.9	26.3	10.9
	Oct. 19	9	4.6	0.6	13.0
Vitamin-na	Sep. 07	6	261.6	18.5	7.1
	Sep. 28	9	182.7	19.1	10.4
	Oct. 19	9	4.9	0.6	12.2
Taisai	Sep. 07	6	379.1	19.0	5.0
	Sep. 28	9	353.9	28.3	8.0
	Oct. 19	9	7.5	0.9	12.0
Ha-karashina	Sep. 07	6	203.1	17.2	8.4
	Sep. 28	9	244.2	30.6	12.5
	Oct. 19	9	4.3	0.7	16.3
Takana	Sep. 07	6	186.2	12.7	6.8
	Sep. 28	9	148.5	18.4	12.4
	Oct. 19	9	3.5	0.5	14.3

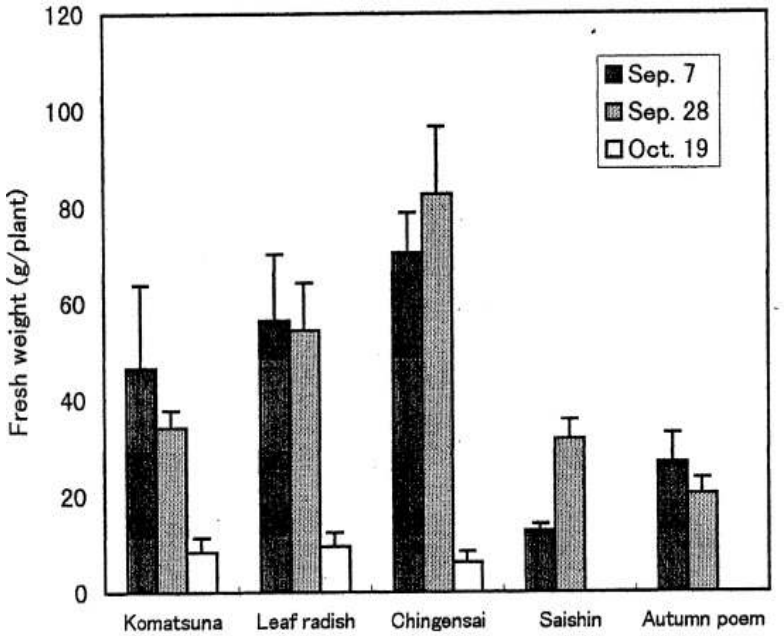

Fig. 1: Comparison of fresh weight at harvest in vegetables of komatsuna, leaf radish, chingesai, saishin, autumn poem which were sown at Sep. 7, Sep. 28 and Oct. 19 respectively

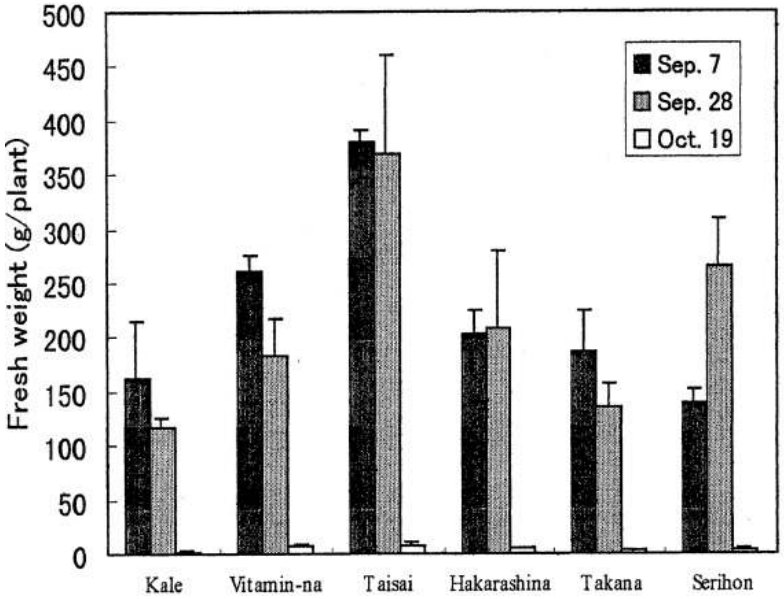

Fig. 2: Comparison of fresh weight of vegetables of kale, vitamin-na, taisai, ha-kanashina takana and serihon which were sown at Sep. 7, Sep. 28 and Oct. 19 respectively

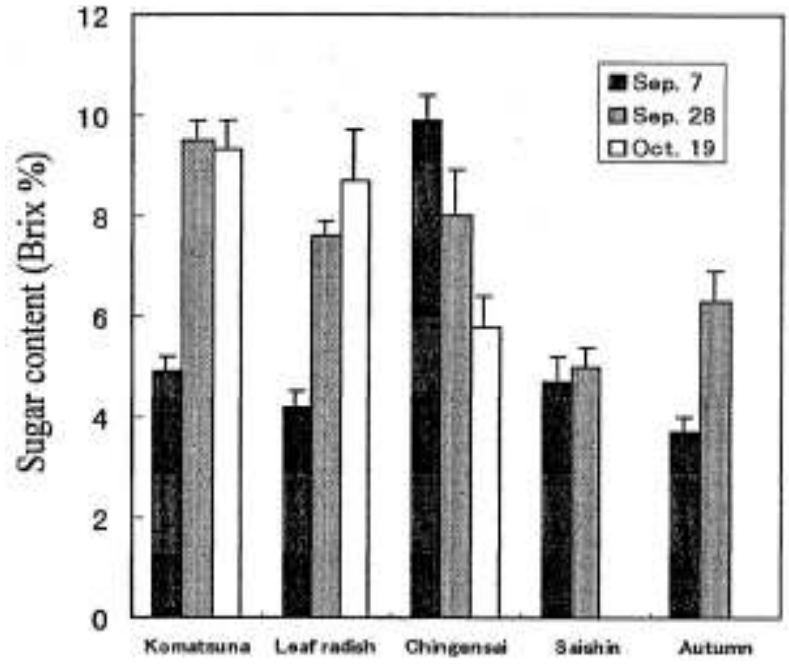

Fig. 3: Comparison of sugar content of in the leaves of vegetables of komatsuna, leaf radish, chingesai, saishin, autumn poem which were sown at Sep. 7, Sep. 28 and Oct. 19 respectively

vegetative stage. Stem vegetables, such as saishin and autumn poem, are different from leaf vegetables. As the edible part is its elongated stem, there was not any harvest because of no bolting in kousaitai in the experiment. Figure 1 and 2 showed the effects of sowing date on fresh weight at the harvest. It can be seen that the effects were different from various vegetables. Some of them were very sensitive to the changes of air temperature for example komatsuna, kale, vitamin-na and takana, their fresh weight increased with the extension of growing period. Leaf radish, taisai and ha-kanashina were not evidently affected by the low temperature during growing period.

Effects of sowing date on quality of the vegetables: The sugar content of sugar content in leaves at harvest was shown in Fig. 3 and 4. The sugar content in komatsuna, leaf radish, autumn poem, kale, saishin and

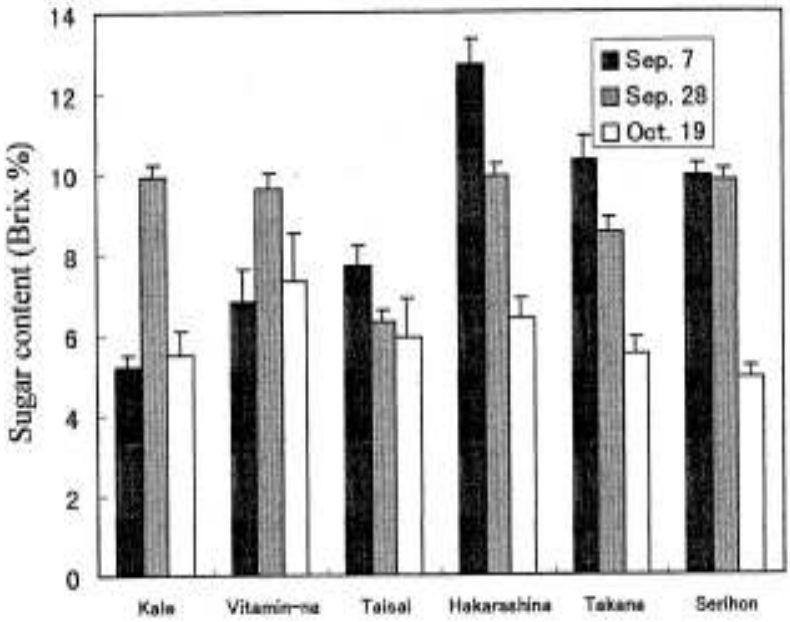

Fig. 4: Comparison of sugar content in leaves of vegetables of kale, vitamin-na, taisai, ha-kanashina takana and serihon which were sown at Sep. 7, Sep. 28 and Oct. 19 respectively

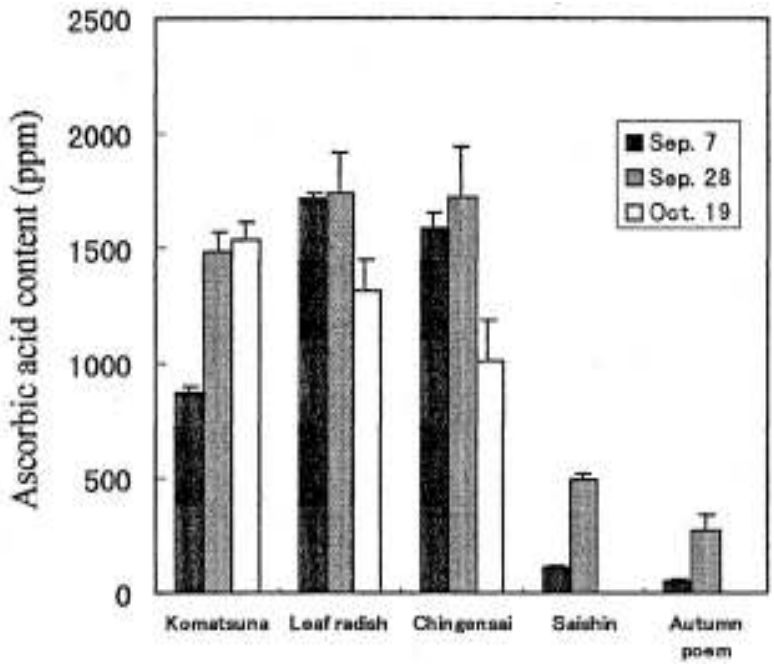

Fig. 5: Comparison of sugar content of in the leaves of vegetables of komatsuna, leaf radish, chingesai, saishin, autumn poem which were sown at Sep. 7, Sep. 28 and Oct. 19 respectively

vitamin-na increased greatly as sowing date was delay, the sugar content in serihon kept almost same level. The sugar content in chingensai, taisai, ha-karashina and takana decreased with the reducing of air temperature. Some vegetables might resist the low temperature stress by the sugar accumulation in plant.

Figure 5 and 6 showed the ascorbic acid content in leaves which changed by sowing date. Most vegetables had higher ascorbic acid content in komatsuna, saishin, autumn poem and taisai. The content of ascorbic acid increased significantly with the reducing of growing temperature. The ascorbic acid content kept almost same level in leaf radish, ha-karashina and takana. The results suggested that low temperature in growing period might increase the accumulation of ascorbic acid in plants.

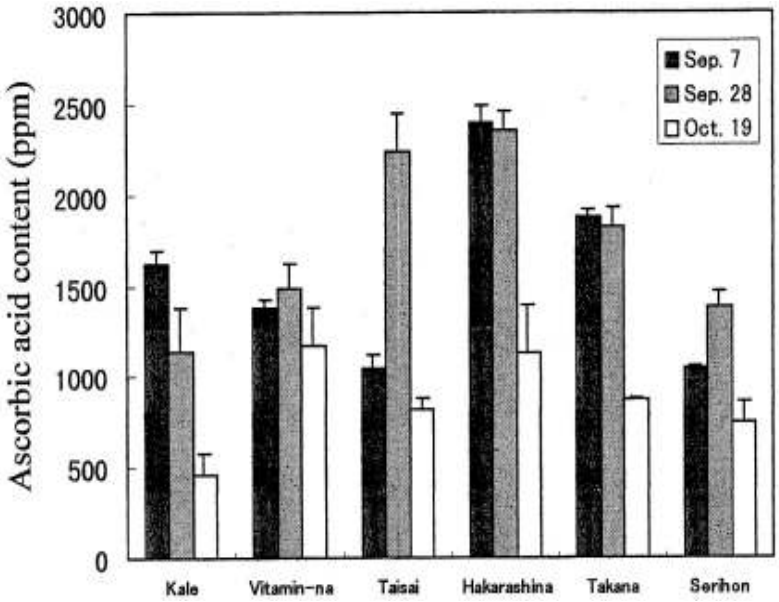

Fig. 6: Comparison of ascorbic acid content in leaves of vegetables of kale, vitamin-na, taisai, ha-kanashina takana and serihon which were sown at Sep. 7, Sep. 28 and Oct. 19 respectively

Table 4: Nitrate nitrogen content in leaves of nine kinds of cruciferae vegetables at harvest

	Nitrate nitrogen content (ppm)	
Materials	Sep. 28	Oct. 19
Komatsuna	118.5	504.0
Leaf radish	73.5	373.5
Chingensai	63.5	295.0
Saishin	72.5	-
Autumn poem	128.5	-
Kale	448.5	797.5
Vitamin-na	468.5	182.5
Taisai	459.0	1090.0
Serihon	48.5	648.5

-: Not determined

Table 4 showed the nitrate nitrogen content in leaves of tested vegetables at harvest. The plants sown at Sep. 28 had lower nitrate nitrogen content by comparing with the plant sown on Oct. 19.

CONCLUSION

In this study, the effect of sowing date on the quality of 11 kinds of curciferae vegetables cultivated in autumn was studied by evaluating the ascorbic acid, nitrate nitrogen and sugar content. The plants sown at Sep. 28 tended to have a slower growth under lower growing temperature by comparing with plants sown at Sep. 7 and their growing period was delayed about two or three weeks. The fresh weight of plants at harvest was different from various vegetables. In some vegetables, their fresh weight decreased with reducing of growing temperature, but the fresh weight increased with the extension of growing period in chingensai and serihon. The dry weight increased significantly with the reducing of air temperature. Their dry matters percentage increased at the same time. The yield of vegetables was different from the resistance of plants to the low temperatures. In some vegetables, even if the growing temperature fell, their yield did not decrease. It was found that ascorbic acid content in leaves was increased greatly with low growing temperature. On the quality of vegetables, plants sown at Sep. 28 tended to a higher sugar concentration and ascorbic acid content accompany with a lower content of nitrate nitrogen in their leaves. So it is possible to improve the vegetable quality by changing the sowing date and let it grow up under low temperature conditions. For the quality of plants, it is showed that Sep. 28 is the optimum sowing date for tsukena vegetables production in autumn.

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