HOKKAIDO UNIVERSITY

Title	Studies on the year-round production and quality improvement of baby-leaf vegetables [an abstract of entire text]
Author(s)	髙濱, 雅幹
Description	この博士論文全文の閲覧方法については、以下のサイトをご参照ください。 https://www.lib.hokudai.ac.jp/dissertations/copy-guides/
Degree Grantor	北海道大学
Degree Name	博士(環境科学)
Dissertation Number	甲第13747号
Issue Date	2019-09-25
Doc URL	https://hdl.handle.net/2115/76259
Type	doctoral thesis
File Information	Masayoshi_TAKAHAMA_summary.pdf

Hokkaido University Collection of Scholarly and Academic Papers : HUSCAP

Studies on the year-round production and

quality improvement of baby-leaf vegetables

Masayoshi Takahama

Division of Biosphere Science, Graduate School of Environmental Science,

Hokkaido University

Summary

1. General Information

‘Baby-leaf vegetables’ (BLV) is a new category in leafy vegetables and they are used as the mixture of juvenile stage of different kinds of leafy vegetables. They include Brassicaceae, Asteraceae, Amaranthaceae, and other vegetable leaves. These crops show wide ranges of leaf shapes, colors, textures and flavors. Baby-leaf vegetables production began in early 1980s, mainly in Europe and the USA, as kinds of ready-to-eat salad mixtures, and has increased gradually also in Japan.

Ready-to-eat salad mixtures such as BLV are expected to be available in stable qualities all year-round. However, BLV contains many kinds of crops (baby leaf crops; BLC) and their characteristics on production and quality are different among BLC. Furthermore, the characteristics in each crop vary among growing season. Kyushu, the south Japan, and Kanto, around Tokyo, were the main BLV production regions and BLV are produced from autumn to spring in these regions. However, it is too hot to produce BLV in summer in Kyushu or Kanto region. Therefore, BLV production in Hokkaido, which is located in the northern subarctic region of Japan, has been expected as a new production region. However, winter temperature often depressed below freezing point even inside plastic house in Hokkaido. Therefore, heated

cultivation is necessary for the winter crop production and takes vast fuel costs in general. For this reason, winter production in Hokkaido will be at an economic disadvantage. Therefore, the following studies were examined for the establishment of year-round production of BLV with higher quality.

2. Research on demand and supply of commercial baby-leaf vegetables

In general, the compositions and numbers of crops in BLV depends on producers thinking leaf shapes, colors, textures and flavors in account. If BLC are selected by reflecting consumer demands of BLV, their marketability will rise. Therefore, a questionnaire survey was carried out to two hundred forty-three general consumers. More than half of consumers had “tasty” and “healthy” image for BLV more strongly, and “colorful” and “fashionable” impressions were next to them. Based on the result of survey, the measurement of ascorbic acid and nitrate content as most interesting internal qualities and SPAD value as external appearance was checked.

On the other hand, there are no definite criteria of leaf sizes of BLC, and producers harvest BLC by their decision. Furthermore, criteria might be different among BLC. Therefore, commercial BLV packed by plastic bags or punnets were collected from eight production groups and were investigated the kinds of commercial BLV and the leaf size of each crop. Commercial BLV from each production group contained 4 to 10 crops including green-colored crops and red one. Leaf length and leaf area in most of BLC in commercial BLV products are around 80 mm and 1,000 - 1,500 mm^2 except for spatulate incised leaf blade crop (Mizuna etc., leaf length is below 120 mm) and some leaf lettuce (leaf area is below 2,000 mm^2). Based on the survey results, harvest criteria were established as to BLC.

3. Classification based on productivity, external appearance and internal quality

To understand the characteristics of BLC, 22 BLC including Brassicaceae, Asteraceae, and Amaranthaceae crops were grown in unheated plastic house in the Donan Agricultural Experiment

Station, Hokkaido, Japan. BLC were sown into the soil directly in spring 2010 and 2011, which is suitable season for growth evaluation considering the leafy vegetable production, and were investigated the emergence periods, growing periods, total cultivation periods, from sowing to harvest, as well as the yields, SPAD values, ascorbic acid and nitrate contents, and leaf characteristics. A principal component analysis, based on the total cultivation periods, the yields, the SPAD values, the ascorbic acid and nitrate contents, showed three main groups: 1) Brassicaceae crops, which had short total cultivation periods and high ascorbic acid contents; 2) Asteraceae crops (except for 'Italian Red' chicory), which had long total cultivation periods and low ascorbic acid contents; 3) Amaranthaceae crops, which had a comparatively large yields and low nitrate contents. 'Italian Red' chicory did not fall into any of these three groups. From the correlation with leaf characteristics of each crop, the yield had very limited effects on the grouping. The larger-yield crops tended to have more leaves and less dry matter ratios, and the crops with higher SPAD values tended to have thicker leaves.

4. Seasonal variation of productivities and qualities from spring to autumn

Crop yields varied depending on the season. Furthermore, qualities such as ascorbic acid and nitrate contents could be changed by air temperature in some leafy vegetables. Therefore, 22 BLC were grown in an unheated plastic house in the Donan Agricultural Experiment Station for eight times between spring 2009 and autumn 2011. The total cultivation periods, the yields, the SPAD values, the ascorbic acid and nitrate contents and the leaf characteristics of BLC were investigated to clarify the relation between these characteristics and air temperature, one of the important environmental factors.

Most of BLC had longer total cultivation period, larger yield, higher ascorbic acid and lower nitrate contents in May and showed shorter total cultivation period, smaller yield, lower ascorbic acid and higher nitrate contents in August. The lower daily mean air temperature during total cultivation period is, the longer total cultivation period, the larger yield, and lower nitrate

contents most of BLC had. The leaf weight and leaf thicknesses increased by low temperatures in some BLC. The ascorbic acid contents were affected more strongly by daily minimum temperature immediately before harvest in some Brassicaceae and Asteraceae crops. There were less relations between SPAD value and air temperature in most of BLC. These results will be a useful information for planning of sowing and harvest date as well as improvement of internal qualities for stable marketing supply of the BLV.

5. Productivity and internal quality in winter

It has been said that the production of vegetables is economically difficult in cold and snowy winter in Hokkaido and a big problem to overcome for establishment of the year-round BLV production. On the other hand, previous report showed that it was possible to produce cold-tolerant crops during winter by using heat insulation structures such as high tunnels in severe cold regions. Furthermore, another report revealed the increases of sugars and vitamin C contents in some leafy vegetables under cold condition. Therefore, 22 BLC were sown in the unheated plastic house in late autumn 2013, 2014, and 2015 to investigate yields, ascorbic acid and nitrate contents, Brix, and leaf characteristics between December and February.

All BLC could survive when the minimum air temperature decreased to about -10^{o}C inside the plastic house and could be harvested from December to February, though the adjustment of intact harvest were required. The yields, ascorbic acid contents, and Brix increased and the nitrate contents decreased from December throughout February in almost all BLC. The dry matter ratios increased in January and February, unlike any other seasons from spring to autumn. The increase of Brix and the decrease of nitrate content showed the strong relations with the increase of dry matter ratio caused by low air temperature. These phenomena could cause by the inhibition of water and nitrate absorption from root by lower temperature. Consequently, the possibility of high-quality BLV production in severe cold condition such as winter in Hokkaido was shown.

6. Effect of internal quality by salinity application in hot season

Seasonal variations in BLV yields and qualities were observed. The depressions of yields and ascorbic acid contents in summer could be commercial weak points from the view point of a stable production. On the other hand, it has known that the rises of the functional substances such as antioxidants and the reductions of nitrate in the plants can be obtained by exposing plants to stress, such as salinity stress. However, the reactions of the plants in terms of yield and of components to the salinity exposure is different depending on vegetables. Twenty-two BLC were grown in hydroponic soilless culture system and salinity treatments were carried out ranged EC 2.5 (Control) to 7.5 $dS \cdot m^{-1}$ of hydroponic solutions by adding NaCl for one to two weeks before the harvest in the Experimental Center of the Department of Agricultural, Forest and Food Science, University of Turin, Italy. The influences of salinity treatments on the yield, ascorbic acid, total phenolics, and nitrate contents were evaluated. Furthermore, the mineral factors affecting the improvement of yields and qualities soilless culture production were clarified.

There were no significant differences in the yields among EC 2.5 and 7.5 $dS \cdot m^{-1}$ salinity treatment in any crops. However, the yield in 'Detroit' table beet was likely to increase due to rise of water content in leaves by the salinity treatment. The ascorbic acid contents of spinach crops increased according to increase of the Na^+ absorption. The total phenolics contents increased in 'Green Romaine' lettuce and rucola when sum of Na^+, K^+, and Ca^{2+} contents in leaves increased by salinity treatments. The nitrate contents decreased according to the increasing Na^+ absorption, especially in Asteraceae crops. Therefore, table beet, spinach, romaine lettuce, rucola, and so on crops may be suitable crop for salinity treatment and will be used for the improvement of the productivity or internal quality in hot season.

7. General discussion

Based on the studies so far, year-round BLV production system in Hokkaido was established in which BLV can be harvested from May to February by cultivating 8 times in an

unheated plastic house. Furthermore, BLC were screened suitable for spring, summer, and winter production. Above all, BLV produced in Hokkaido in winter are the unique salad mixtures. These results on the studies will contribute to the enhancement of BLV production in Hokkaido and the improved publicity of BLV produced in Hokkaido.

On the other hand, soilless cultivation systems will be introduced increasingly in Hokkaido and global warming will make winter production easy and summer production difficult in the future. Hereafter, the differences between soil culture system and soilless one in BLV characteristics and seasonal variations should be investigated.