



# Sweetpotato Research Front

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## First Step in Developing a Market for the New Sweetpotato "AYAMURASAKI," a Purple Sweetpotato Variety Making its Mark in Sweetpotato Production.

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The sweetpotato is a major crop that feeds millions of people in tropical and subtropical areas. Sweetpotato cultivation first reached Japan via Okinawa from China and spread to mainland Japan starting in Tanegashima and Kagoshima. Since it can easily adapt to poorer soil, its planting area increased radically throughout Japan. The various names for sweetpotato indicate its route of expansion, such as Um (sweetpotato) in Okinawa, Karaimo (sweetpotato from China) in Tanegashima and Kagoshima of mainland Japan, and Satsumaimo (sweetpotato from Satsuma, now called Kagoshima) in other areas of mainland Japan. Sweetpotato has been a primary source of starch, a key ingredient in Shochu liquor (distilled liquor) and a popular food item in Japan for many decades. Thus, it has long been one of the most important food crops in Japan.

Various reasons have been advanced for the decrease in sweetpotato usage, including changes in Japanese dietary habits and a low demand for sweetpotato as a source of starch. In contrast, sweetpotato cultivation for Shochu liquor has increased significantly, and as the domestic supply and demand for Shochu liquor production stabilizes, sweetpotato will become a more competitive crop in the future.

This movement seems to have begun in 1996, when a purple sweetpotato variety with a high anthocyanin content and an orange sweetpotato variety high in  $\beta$ -carotene were released. Recently, anthocyanin and  $\beta$ -carotene have been reported to have beneficial health effects. Various kinds of

foods have been produced from these sweetpotatoes, such as juice, vinegar, miso, ice cream, beer and wine. They were well received by a large number of consumers, including the younger generation. Both the sweetpotato and food markets are enjoying a new surge of growth from innovative uses for sweetpotato, and an increased demand for Shochu liquor in recent years has accelerated market expansion.

We now face the prospects of serious problems, such as the enhanced greenhouse effect and food and energy shortages, which could cause disasters in the future. To solve these problems, the potential uses of sweetpotato should be evaluated. By nature, sweetpotato is highly adaptable to low fertility soil. Additionally, symbiotic colonization with *Acetobacter*, i.e. nitrogen fixing bacteria, has been recognized in recent years. Sugarcane is also widely cultivated in tropical and subtropical areas, including the southwest island of Japan. Similar to sweetpotato, new types of sugarcane, such as an autumn harvest variety and high biomass lines for biofuel use are now being bred, and it is well known that sweetpotato-sugarcane rotation is suitable for maintaining continuous crop production. Feeding both sugarcane and sweet potato to livestock is a well-established practice. Research scientists, therefore, should be encouraged to develop improved practices based on innovative cultivation and the sweetpotato-sugarcane rotation described above together with crop-livestock combinations for sustainable farming systems under adverse conditions.

## Caffeoylsophorose in Red Vinegar Produced through Fermentation with Purple Sweetpotato

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Vinegars are widely used for seasonings and drinks all over the world and are made from apples, rice, and other fruits and grains. They are also considered to be nutritionally healthy with beneficial effects for health care and disease prevention. For example, one black vinegar (Kurozu), traditionally manufactured in Kagoshima Prefecture, Japan, is made from rice by brewing it for a long time, and is known to promote improved blood fluidity.

Miyazaki JA Food Research & Development Inc. has recently developed a new red vinegar. The red vinegar (RV) is produced through acetic fermentation with the steamed and crushed storage roots of purple-fleshed sweetpotato (PS), which is a newly released cultivar, "Ayamuraski," with a high anthocyanin content, developed by KONARC. RV has been used as an ingredient in health drinks, red dressing, and other food products.

RV exhibited higher antioxidative activity than white and black vinegars. Indeed, in addition to anthocyanins and polyphenolics, like the caffeoylquinic acids characteristic of PS, new UV-absorbing constituents (UCs) have been detected in RV. These were probably derived from the original PS

substances during fermentation. A major component in the UCs was isolated by using successive column chromatographies followed by a preparative high-performance liquid chromatography. The chemical structure was determined to be 6-*O*-(*E*)-caffeoyl-2-*O*- $\beta$ -D-glucopyranosyl-D-glucopyranoside (caffeoylsophorose: CS) by chemical and instrument analyses such as MS and NMR (Fig.1). The CS was found to be produced from YGM-5b, a major anthocyanin of PS during RV fermentation and storage. Since CS has caffeoyl residue in its molecular chain, it demonstrated high antioxidative activity (DPPH radical-scavenging activity) comparable to or greater than caffeic acid, as displayed in Fig. 2, and also resulted in  $\alpha$ -glucosidase inhibitory action *in vivo* due to its anti-hyperglycemic function. Thus, CS has an important functional role for RV as well as anthocyanins and other components, and other newly generated UCs are also likely to have functional roles. The structural determination of other UCs is now in progress. RV is expected to exhibit the additive or synergistic physiological effects of CS and other functional components.

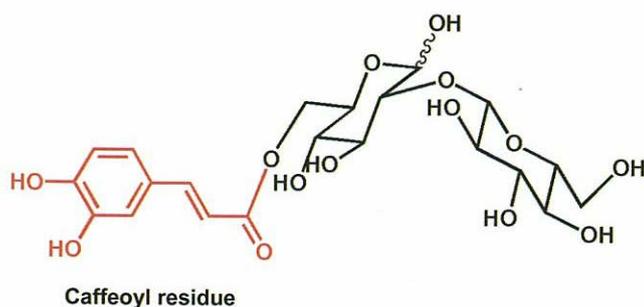


Fig.1. Chemical structure of caffeoylsophorose from a red vinegar

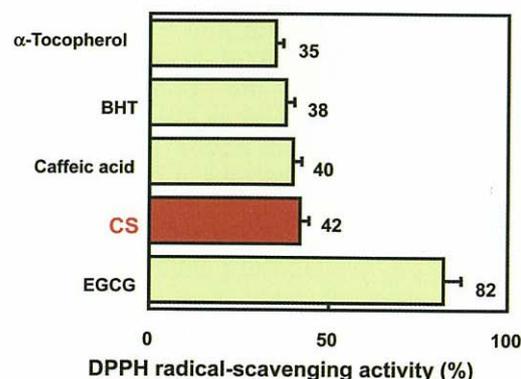


Fig.2. DPPH radical-scavenging activity of caffeoylsophorose

## Relationships between acrylamide formed during heating and components of sweetpotato roots

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### INTRODUCTION

In 2002, the presence of acrylamide, which is classified as “probably carcinogenic to humans,” was reported in foods cooked at high temperatures.<sup>1,2</sup> It was further determined that acrylamide formation occurs during Maillard browning due to the interaction of reducing sugars and the amino acid asparagine at high temperatures.<sup>3</sup> Many investigations also determined the acrylamide content in a number of heated foods. Acrylamide formation, particularly during heating of potato tubers, has been examined in detail in many countries. In Japan, sweetpotato (*Ipomoea batatas* L.) roots are generally heated for table consumption, and many companies use heating processes, including frying, to produce products from sweetpotato roots. However, there have been no reports on acrylamide formation during heating of raw sweetpotato roots. This paper describes the relationships between the acrylamide level in sweetpotato roots after frying and the amount of chemical components such as free asparagine and reducing sugars in raw roots.

### RESULTS AND DISCUSSION

The roots from 15 sweetpotato varieties harvested in 2004 were used. The root slices (5mm thick) were divided into two groups. One was fried in 3L of preheated soybean oil for 4min at 197°C. The other raw group was used to prepare samples for determining chemical components. Figure 1 presents the relationships between free asparagine and glucose content in raw roots and the acrylamide level in fried slices. A high correlation was obtained between free asparagine and the acrylamide level (Fig.1A:  $R^2 = 0.803$ ,  $P < 0.001$ ,  $n = 75$ ). However, there was no significant correlation between the content of reducing sugar (glucose) and acrylamide (Fig.1B:  $R^2 = 0.002$ ,  $P > 0.05$ ,  $n = 75$ ). The same was true for the fructose content ( $R^2 = 0.0004$ ,  $P > 0.05$ ,  $n = 75$ , data not shown).

Many studies have indicated a high correlation between the acrylamide level after heating and the content of reducing sugars (fructose and glucose) in raw potato tubers, and a very low correlation between the acrylamide level and the free asparagine content.<sup>4,5,6</sup> The data from sweetpotato roots in this study did not coincide with previous findings on potato tubers. The content of free asparagine was lower, and those of reducing sugars were higher in sweetpotato roots in this study, compared to those previously reported in potato tubers. The much lower ratio of asparagine to reducing sugars in sweetpotato roots was deduced to be the reason for the good correlation of acrylamide formation with asparagine content, but not with the content of reducing sugars. As depicted in Fig.1, the acrylamide level of some roots reached approximately 3,000  $\mu\text{g}/\text{kg}$ . This value appears to be high; however, the heating temperature of 197°C was higher than that for usual cooking and processing. Many studies reported that a lower temperature reduced

the acrylamide level. Indeed, the acrylamide level in one variety of sweetpotato roots fried at 180°C was approximately 18% of those heated at 197°C (data not shown).

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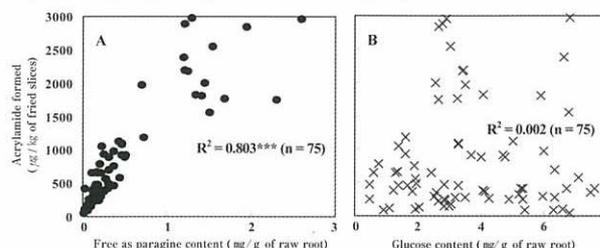


Fig.1. Correlation between free asparagine (A) and glucose (B) in raw roots and acrylamide in fried root slices of 15 varieties of sweetpotato.

Five roots of each variety were tested. Acrylamide content was determined by gas chromatography-mass spectrometry after bromination, and glucose content by high-performance liquid chromatography. Free asparagine was analyzed by Japan Food Research Laboratories. The asterisks\*\*\* designate significance  $p < 0.001$ .

## Anthocyanins in Purple-fleshed Sweetpotato Improve Whole Blood Fluidity

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Decreased blood fluidity induces lifestyle related circulatory diseases, and it is assumed that improving blood fluidity will prevent them. Foods and beverages made from purple-fleshed sweetpotatoes (PSP) have come into the spotlight for this purpose because the anthocyanins in PSP possess multiple physiological functions such as radical-scavenging (antioxidative), antimutagenic, hepato-protective, and antihypertensive activities. In particular, evidence of the direct absorption of PSP anthocyanins in rats and humans suggests that the physiological functions of anthocyanins operate on the circulatory system. This research paper reports the effect of PSP anthocyanins on the fluidity of whole blood in rats through a capillary-model microchannel array.

Blood (500 $\mu$ L) was drawn from a tail vein of a Wistar rat (male, over ten weeks old) and mixed with a 25 $\mu$ L heparin solution and a 25 $\mu$ L solution of 8% (w/v) trisodium citrate aqueous. The mixed whole blood was measured by a microchannel array flow analyzer (MC-FAN KH-3, Hitachi Haramachi Electronics Co., Ltd., Ibaraki, Japan). The whole blood fluidity was evaluated by the passage time of the mixed blood (100 $\mu$ L) through the microchannel array (type; Bloody 6-5). Only rats with a passage time above 60sec were used in the experiment. After one

week, the selected rats were subjected to a restraint stress. The restraint stress significantly lengthened the passage time ( $p < 0.01$ , Student- $t$  test,  $n = 11$ ), as presented in Fig.1. This indicates that stress caused the blood to change from smooth-flowing to restricted-flow. Typical smooth- and restricted-flow blood samples from the MC-FAN evaluations are illustrated in Fig.2. One week after the first restraint, the rats were randomly divided into two groups and subjected to a second restraint stress. The protocol was the same as that for the first restraint; however, the PSP anthocyanins or deionized water were administered orally to the rats by direct stomach intubation 1hr before the end of the restraint. The dosage was set at 84mg of YGM-5b (peonidin 3-caffeoylsphoroside-5-glucoside) equivalent per kg of body weight. After 1hr administration, the passage time of the PSP anthocyanins group ( $n = 6$ ) decreased significantly ( $p < 0.01$ , Student- $t$  test), compared to that of the deionized water group ( $n = 5$ ) (see Fig.1). This indicates that the anthocyanins in PSP improved whole blood fluidity. The use of nutritional foods to improve blood circulation is very popular in Japan, so the effects of PSP anthocyanins on a human being are now being investigated.

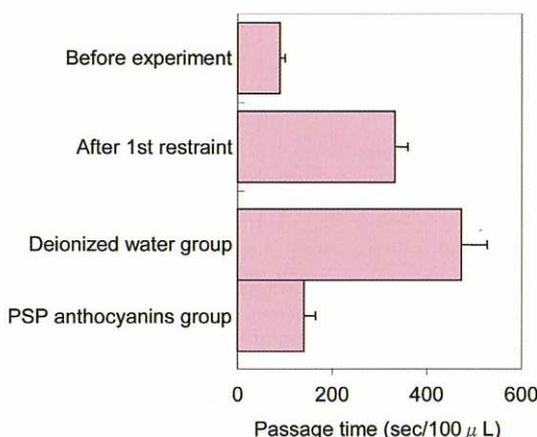


Fig.1. Effect of PSP anthocyanin administration on whole blood fluidity in rats

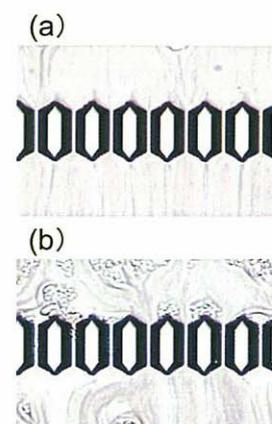


Fig.2. Typical blood samples with smooth- (a) and restricted-flow (b)

## Lutein Content of Sweetpotato Leaves II.

### Cultivar Differences, Distribution in Leaves at Different Positions, and Changes during Storage

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#### INTRODUCTION

Lutein is a member of the xanthophylls family of carotenoids and is believed to be beneficial for eye diseases such as age-related macular degeneration (AMD) and cataracts. Today, lutein can be obtained from supplements as well as from vegetables and fruits containing high levels of lutein. It was previously reported that sweetpotato leaves have a much greater lutein content than any other commercial vegetable (1). In order to obtain further information about the lutein content in sweetpotato leaves, this report examines cultivar differences, the lutein distribution in leaves at different positions along the stem and changes during storage after harvesting.

#### RESULTS & DISCUSSION

The lutein content of 579 genotypes preserved in the KONARC gene bank was analyzed. The genotypes differed widely in lutein content (Fig.1), which ranged from 29.7mg/100g DW to 165mg/100g DW, with a mean value of 93.2mg/100g. This result could be useful for a breeding program to further improve lutein content.

The distribution of lutein in leaves at different positions along the stem was investigated in "Suioh," a representative cultivar for the utilization of tops. The leaves were grouped into five-leaf intervals from the apex to the 20<sup>th</sup> leaf along the stem. Lutein content did not differ significantly in any position (data not shown). The protein content was higher in the upper leaf positions and lower in the lower positions, while the content of oxalate, an anti-

nutritional factor, was lower in the upper positions and higher in the lower positions (2). In the case of lutein, the content in the main region for utilization was comparable.

Changes in lutein content of harvested leaves during storage were analyzed. Harvested "Suioh" tops were stored at 15°C and 25°C under weak light conditions and at >90% relative humidity, and the lutein content in leaves was measured every day from 0 to 4 days in storage after harvesting. The content in storage at 25°C significantly increased (about 1.4 times higher) after 3 days in storage and decreased after 4 days in storage to the level of the first day (Fig.2). There was no significant change in content during storage at 15°C (Fig.2). This result indicates that the lutein content in leaves can be maintained or increased depending on temperature during storage after harvesting.

Two successive reports have now demonstrated that lutein content in sweetpotato leaves, which is higher than in other vegetables, varies among cultivars and at different positions along the stem and is affected by changes in harvesting time and storage. Consumers and users should consider these factors when selecting the tops for lutein intake. Lutein's stability during cooking and its bioavailability will be the next research topics.

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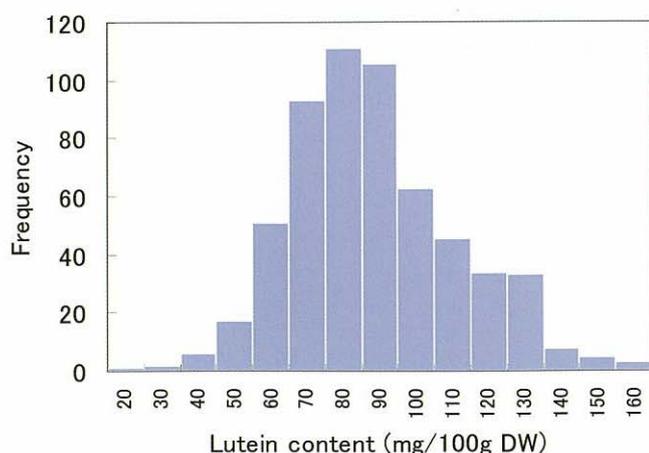


Fig. 1. Frequency distribution of lutein content in sweetpotato leaves of 579 genotypes.

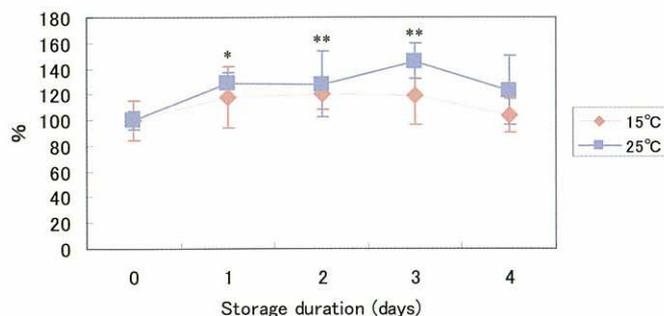


Fig.2. Changes in lutein content of sweetpotato leaves during storage at 15°C and 25°C. Values represent the mean  $\pm$  SD of six vines. Values with an asterisk indicate significant difference (\*  $p < 0.05$ , \*\*  $p < 0.01$ ) compared to the value before storage (day 0 of storage) at indicated temperatures.

# Research Paper

## Phenolic Composition of Sweetpotato Tops Harvested at Different Times

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Our group reported six caffeoylquinic acid derivatives, caffeic, chlorogenic (5-*O*-caffeoylquinic), 3-*O*,4-*O*-dicaffeoylquinic (3,4-diCQA), 3-*O*,5-*O*-dicaffeoylquinic (3,5-diCQA), 4-*O*,5-*O*-dicaffeoylquinic (4,5-diCQA) and 3-*O*,4-*O*,5-*O*-dicaffeoylquinic (3,4,5-triCQA) acids, in sweetpotato leaves (*Ipomoea batatas* (L.) Lam)<sup>11</sup>. These phenolics have many physiological functions including antioxidative, antimutagenic, and anti-HIV (human immunodeficiency virus) activities. A new sweetpotato cultivar, Suioh, was recently developed for use as an edible green vegetable in KONARC.<sup>2</sup> The green tops of Suioh also contain caffeoylquinic acid derivatives. Our group is examining the phenolic composition of the tops of many sweetpotato varieties. This paper describes these derivatives, found in the tops of fifteen sweetpotato varieties including Suioh.

The table lists the varieties we tested, and the content of 3,4,5-triCQA in the tops harvested in 2002, which is the most physiologically active of the six derivatives previously mentioned. When we considered the average content for the six harvests, eleven varieties contained more 3,4,5-triCQA than Suioh, as

shown in the Table. Among the six derivatives, 3,5-diCQA was the most abundant in all varieties during every harvest. For example, the average content of 3,5-diCQA among the six harvests was 1216mg/100g for KT98214-4 and 1074mg/100g (dry weight) for KT98214-6 (data not shown). Caffeic acid and 3,4,5-triCQA were lower than the other derivatives in all varieties. These tendencies were the same as the results obtained in other years. One important goal of our study is the development of sweetpotato cultivars with a higher content of 3,4,5-triCQA for table use and supplements.

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Table Content of 3,4,5-triCQA in sweetpotato tops harvested in 2002.

Variety	Content (mg/100g, dry weight)						Average
	Harvesting time						
	1 (Apr 24)	2 May 29	3 Jul 2	4 Aug 7	5 Sep 11	6 Oct 30)	
KT98214-4	158	103	132	137	136	110	129
KT98214-6	101	112	91	152	61	117	106
KT98215-1	68	62	71	233	124	68	104
Tsurusengan	22	73	120	166	115	112	101
Simon No.171	113	124	125	68	45	91	
Kyushu No.119	31	52	85	161	93	71	82
Shiroyutaka70	67	99	96	94	44	78	
KT98213-1	63	65	107	117	70	46	78
KT98216-1	79	63	79	102	69	39	72
Kyukei No.58	63	74	81	76	65	64	71
KT98212-2	23	38	73	104	90	69	66
Suioh36	46	87	88	55	81	66	
K66Mu72-2 30	46	46	104	65	27	53	
Elegant	45	40	46	92	71	21	52
Summer							

We planted seed roots in a nursery on March 19 and harvested the whole top of each variety six times from April 24 to October 30. We then washed, oven-dried at 70 °C, and milled the materials. We treated the resulting powder samples with 80%(v/v) methanol and analyzed the extracts using high-performance liquid chromatography.

# Research Paper

## Effect of nematode-resistant sweetpotato on root-knot nematode density and succeeding crop yield

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In the upland farming area of Kyushu district, nematode injury is a major factor inhibiting continuous cropping. Soil fumigation is commonly applied every cropping to suppress nematode injury. Recently, a sweetpotato variety has been found to be antagonistic to dominant races of root-knot nematode (*Meloidogyne incognita*) in Kyushu. In this report, we describe the effect of the variety “J-red” with root-knot nematode resistance on nematode density and on carrot yield as the succeeding crop.

1. Root-knot nematode density in a “J-red” field was kept extremely low even three months after planting, when nematode density in a “Kokei 14” field increased remarkably (Fig. 1). The variety “Kokei 14” is sensitive to root-knot nematode.
2. Root-knot nematode density in a “Kokei 14” field increased with planting density and was detectable even at the soil depth of 30 to 40cm. However, root-knot nematode density was negligible at the soil depth of 30 to 40cm in a “J-red” field (Fig. 2).
3. Carrot following “Kokei 14” had almost the same yield as that following “J-red”, but the roots were more heavily injured by root-knot nematode than the carrot succeeding “J-red” or dwarf-type *Crotalaria*, which resulted in low commercial yield (Fig. 3).
4. When top of “Kokei 14” was applied to the field, chemical properties and carrot yield improved a little but the carrot root didn’t recover from nematode injury.

Sweetpotato variety “J-red” is thus useful as an antagonistic plant for reducing nematode injury without decreasing the commercial yield of succeeding carrot. However, “J-red” is not antagonistic to other nematode species, such as *Pratylenchus coffeae*, which also causes low commercial yield of the succeeding crop. A combined resistance to nematode is needed to establish wide adaptability in Kyushu district.

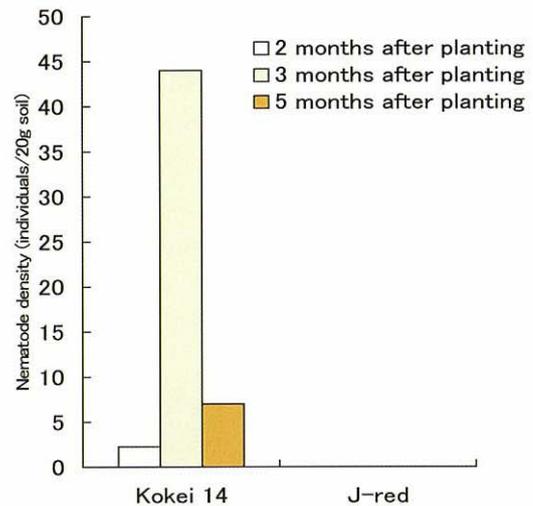


Fig.1. Nematode density of sweetpotato field

Nematode density before planting sweet potato is 192 individuals/20g soil

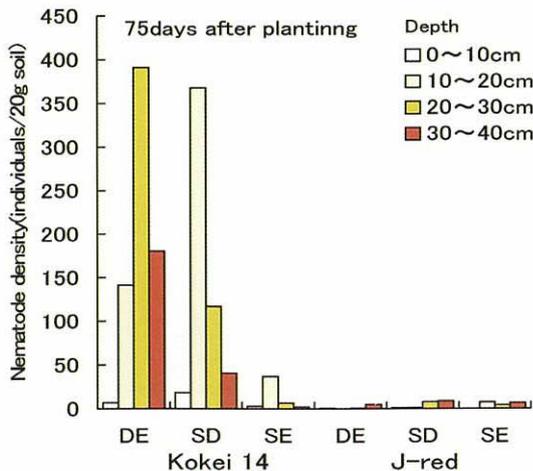


Fig.2. Nematode density in sweet potato field

DE;debse planting, SD;standart planting, SE;sparce planting

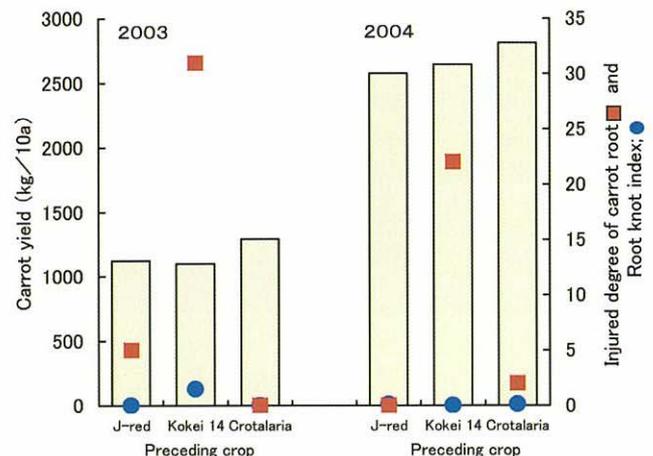


Fig.3. Effect of preceding crop on the nematode injury and carrot yield

Carrot yield, Injured degree, Root knot index

Carrot root are graded into five categories from 0; marketable to 4; unmarketable-galling symptoms

# Reader's Talk

## Letter to the editor

### Sweetpotato Scientists Meet Again!

*Swee Lian Tan, Ph.D*

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The 2<sup>nd</sup> International Symposium on Sweetpotato and Cassava (2ISSC) was held from 14-17 June 2005 in Kuala Lumpur, Malaysia. It followed from the 1<sup>st</sup> Symposium on Sweetpotato held in Lima, Peru in November 2001. With the venue in Asia, it was decided to include cassava, another root crop of importance to this part of the world. 2ISSC was organized jointly by the Malaysian Agricultural Research & Development Institute (MARDI) and the International Society for Horticultural Science (ISHS), and the proceedings containing selected papers were published in February this year. I feel honoured to be highly involved in the organization of this important symposium, and in the editing of the papers for the proceedings.

Realizing the need for competitiveness in today's scenario of globalization, we had chosen for the symposium the theme "Innovative Technologies for Commercialization". The scope of the symposium was defined by six sessions, *viz.*

- Session 1: Success stories in commercialization
- Session 2: New varieties for new markets
- Session 3: Combating biotic constraints
- Session 4: Innovative production systems
- Session 5: Value-adding for better health
- Session 6: Novel uses

There were 25 papers invited from prominent scientists and industry leaders on specific topics in the sessions. These eminent people gave

generously of their time and money to grace the symposium. I found of particular interest the papers in Session 1 touching on: "R&D collaboration with industry: The Japanese sweetpotato story" by K. Komaki and O. Yamakawa from the National Institute of Crop Science, Japan; "Sweetpotato products in a modern world: The New Zealand experience" by S. Lewthwaite from the New Zealand Institute for Crop & Food Research Ltd.; "The role of the Kawagoe Friends of Sweetpotato in popularizing the crop in Japan" by B. Duell from Tokyo International University; and "Linking small-scale cassava and sweetpotato farmers to growth markets: Experiences, lessons and challenges" by R. Best from the Global Forum on Agricultural Research of FAO, Italy. It is hoped that all of us were able to learn important lessons from these papers on how to achieve commercialization success.

Corresponding to the needs of old and new markets, as well as to those of producers and processors, were papers covering sweetpotato varieties improved by biofortification, and those having unique quality characteristics (altered starch structure and flavour); status of sweetpotato virus diseases; sweetpotato-based cropping systems; new drying technologies for root crops; nutritional food products from sweetpotato roots and leaves; and anthocyanin production from a sweetpotato cell line.(be continued)



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