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Sweetpotato Research Front

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Contents

Strategic Research Plans for Sweetpotato to Achieve Food Security in Japan: Perspective of Next Decade

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The Kyushu-Okinawa district accounts for nearly 50% of the sweetpotato production in Japan. However, the sweetpotato can be grown nearly anywhere in agricultural production areas with sufficient warm temperature. The sweetpotato is grown on a wide range of soil types with texture ranging from sandy loams to heavy clays, and can provide considerable yields in marginally fertile soils. These are the major reasons why sweetpotatoes were able to support Japan's large population in the postwar years. Such high adaptability of sweetpotato to diverse environments could benefit us as a food source when supplies of food deteriorate. Therefore, the sweetpotato should be researched as a strategic crop for national food security. From this stand point, we should develop a national research vision of the sweetpotato. The root yield potential should be improved further, particularly in unfavorable environments including both abiotic and biotic stresses. Leaf and root vegetables of the sweetpotato have been developed, but to be not yet protein-rich sweetpotatoes. The sweetpotato can be used for feeding livestock but has not been manipulated sufficiently for a biomass energy source.

Genetic manipulation could play an important role in improving root yield potential and nutritional values of the sweetpotato and diversifying utilization as both a food source and an energy source.

I suggest here the following sweetpotato research plans.

1. Breakthrough in root yield potential

A breakthrough could possibly be facilitated by introducing novel genes from wild relatives or different species using advanced technology in molecular science. However, it is very essential to begin by determining the limiting factors or genes for carbon fixation and allocation.

2. Improvement of nutritional values

If a food crisis should occur, supplies of both carbohydrates and proteins would be essential for human beings to maintain their health. Sweetpotatoes are good sources of carbohydrates but not proteins. Since sweetpotatoes contain 3 to 4% proteins in general, doubling or tripling the protein concentration in the harvested roots could partly supplement protein supply from animal meats or protein-rich legume grains.

3. Improvement as power-energy source

The recent worldwide energy crisis caused extraordinary increases of food prices in many nations. Stabilizing the supply of energy has become a critical global issue and is closely related to food security among many nations. We believe that the sweetpotato would be a promising species to make a balance between food and energy because it is able to produce large amounts of biomass and Japan has an advanced fermentation technology using sweetpotatoes.

KONARC is a central breeding system of sweetpotatoes in Japan and must take the initiative in strategic research on the sweetpotato.

Tokimasari: New Sweetpotato Cultivar for Sweetpotato *Shochu* (Spirits)

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Introduction

"Tokimasari" is a newly released cultivar for sweetpotato *shochu* (spirits); developed by the National Agricultural Research Center for Kyushu Okinawa Region. It was evaluated in the prefectural agricultural experiment stations as breeding line Kyushu No. 135, and officially registered as "Sweetpotato Norin No. 63" by the Ministry of Agriculture, Forestry and Fisheries in 2008.

Origin

Tokimasari is a progeny from a cross between Starch Queen and Konahomare conducted at the Ibusuki branch of the station in 1995. Two hundred seven seeds were sown in the nursery of the Sweetpotato Breeding Laboratory and selected based on the field performance and starch content. Both parents have a high starch content and high yield.

Description

Tokimasari, a slightly prostrate plant type, has slightly better sprouting ability. The top leaves are light green. The mature leaves are green and cordate. The vines are slightly thin with a somewhat short internode length. Pigmentation of anthocyanin is absent in the veins and very pale in the vine nodes. The storage roots are short and fusiform with light pink skin color and light yellowish-white flesh color. Its steamed root is not palatable.

Performance

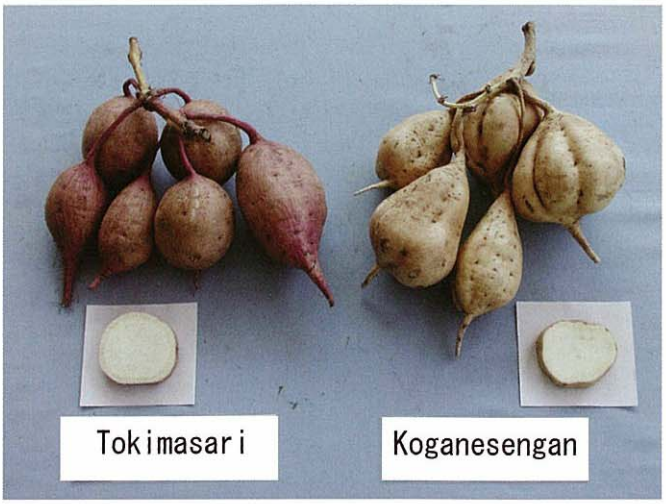
The yield of Tokimasari is comparable to that of Koganesengan. The dry matter content and starch content of Tokimasari are 1 to 4% higher than those of Koganesengan. The starch yield of Tokimasari is higher than that of Koganesengan. The alcohol yield of Tokimasari is higher than that of Koganesengan in brewing of *shochu*. *Shochu* made from Tokimasari has good body and sweetness, and is characterized by a rich aroma of steamed sweetpotato roots.

Tokimasari is slightly resistant to root-knot nematode, moderately resistant to root-lesion nematode, and slightly susceptible to black rot. The storage ability of Tokimasari is superior to that of Koganesengan.

Yield and other traits of Tokimasari in yield trial
(1999-2001 and 2003-2006, standard harvesting)

Traits	Tokimasari	Koganesengan	Daichinoyume
Root yield (t/ha)	27.8	27.9	29.5
Dry matter content (%)	39.3	35.1	38.6
Starch content (%)	25.5	24.0	26.6
Starch yield (t/ha)	7.1	6.7	7.8
Root size (g)	206	217	202
Alcohol yield (L/t of root)	231	214	213
Root-knot nematode resistance [1)]	SR	SS	R
Root-lesion nematode resistance [1)]	I	I-SS	R
Storage ability of root in winter [2)]	SH	SL	SH

1) R: Resistant. SR: Slightly Resistant. I: Intermediate. SS: Slightly Susceptible. S: Susceptible.
2) SH: Slightly High. I: Intermediate. SL: Slightly Low.



Reproduction of *Pratylenchus coffeae* on Sweetpotato Cultivars

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Pratylenchus coffeae is a nematode pest of the sweetpotato in southern Japan, causing lesions on storage roots and yield loss. Resistance to nematodes has been one of the sweetpotato breeding objectives. Resistant cultivars effectively prevent nematode damage and suppress the nematode population. Some studies demonstrated the effectiveness of resistant cultivars used in rotation with a susceptible crop.

When we use a sweetpotato cultivar to suppress population of *P. coffeae*, it is essential to understand that cultivar's host suitability for the species. Most current cultivars were examined for their level of resistance to *P. coffeae* by the breeders (Table 1). However, this level of resistance was not determined based on the level of nematode reproduction, i.e. host suitability, but on level of nematode damage on storage roots. The level of resistance similarly determined for *Meloidogyne incognita* does not correspond to their host suitability in some cultivars. Therefore, we examined the reproduction of *P. coffeae* on 25 sweetpotato cultivars with different levels of resistance in pot and field microplot experiments.

Pratylenchus coffeae reproduced on 21 cultivars in the pot experiments, and the soil nematode density was increased on all cultivars in the field microplot experiments (Table 1). The reproduction rate was high even on the cultivars determined as "resistant" or "slightly resistant" by the breeders. Consequently, the level of resistance had little correspondence with host suitability of cultivars. This result has an important implication in cultivar selection for rotation. Some cultivars, such as Elegant Summer, were relatively poor hosts for *P. coffeae*. However, even these cultivars supported multiplication of the nematode in the field and may not be desirable for rotation with highly susceptible crops such as taro.

Table 1. Reproduction rate (Pf/Pi) of *Pratylenchus coffeae* on 25 sweetpotato cultivars

Cultivar	Level of Resistance	Pf/ Pi		Cultivar	Level of Resistance	Pf/ Pi	
		Pot	Microplot			Pot	Microplot
Norin 2	S	26.9	25.6	Quick Sweet	—	2.8	14.7
Bise	—	13.1	24.1	Murasakimasari	R	3.0	10.0
Miyano 36	—	11.2	13.3	Tamayutaka	R	2.9	22.3
Norin 1	R	7.7	6.9	Okikogane	R-	2.1	23.6
J-Red	R-	7.9	27.1	Shiroyutaka	R-	1.2	6.6
Benimasari	I	5.2	9.3	Hamakomachi	I	1.3	9.1
Kokei 14	R- to I	5.9	16.8	Purple Sweet Lord	—	1.0	3.3
Koganesengan	S+	4.7	28.7	Minamiyutaka	R	1.2	9.7
Tanegashimamurasaki 7	—	4.3	10.5	Sunny Red	I	1.2	3.5
Akemurasaki	R	3.8	54.8	Daichinoyume	R-	0.8	10.9
Tamaotome	I	3.9	26.2	Beniazuma	S+	0.9	7.1
Ayakomachi	R-	3.6	16.4	Elegant Summer	—	0.5	1.7
Beniotome	I	3.0	6.4				

Data on level of resistance were taken from the breeding reports. R, resistant; R-, slightly resistant; I, intermediate; S+, slightly susceptible; S, susceptible; -, data on resistance unavailable.
In pot experiments, rooted cuttings were inoculated with 500 nematodes and grown for three months in a greenhouse. In field microplot experiments, cultivar were planted in microplot of initial nematode density 1.8-9.5 nematodes/ 20g soil and grown for four months. Pf/Pi= Final nematode density / Initial nematode density.

Research Paper

Report of the 23rd Annual Meeting on Root-Crop Research

Masaru Yoshinaga

Team Leader of Sweetpotato Breeding Research

The 23rd annual meeting on Root-Crop Research was held December 3-4, 2009, in Beppu City, Oita Prefecture, Kyushu, the leading hot-spring resort of Japan. The meeting also became hot and intensive in the sense that about 70 participants freely exchanged the latest sweetpotato research information. In recent years, Oita Prefecture has received much attention after introducing a new sweetpotato variety named "Beniharuka." On the second day of the annual meeting, a special lecture by Mr. Sato from the Oita Prefectural Agriculture Research Center provided us important information on how Beniharuka was produced and marketed. It also taught us that Beniharuka has been processed into *shochu* alcohol and many kinds of confectionery in Oita Prefecture (Fig. 1). The participants interested in introducing new varieties were greatly stimulated by the lecture. On another sweetpotato research topic, Mr. Fujita from the Kagoshima Prefectural Institute for Agricultural Development presented the current status of producing an orange-fleshed local sweetpotato variety called "Anno-Imo" on Tanegashima Island in Kagoshima Prefecture. Anno-Imo is booming now in Japan, and its sweet taste and soft texture when baked are highly appreciated by consumers and processors. He insisted on ensuring a regional trademark for Anno-Imo in order to promote the production of the local variety on Tanegashima Island. Anno-Imo produced outside Tanegashima could not be sold as Anno-Imo if a regional trademark could be acquired. This means that Anno-Imo is recognized as a brand and is a specialty product only when grown on Tanegashima Island in Kagoshima Prefecture. Dr. Ishiguro (KONARC) made a presentation on utilizing sweetpotato peptides prepared from starch waste in a starch factory. The peptides exhibited physiological functions that reduced blood pressure of model rats (SHR) and are expected to be used in functional health foods in the near future. Dr. Kumagai, the leader of the Sweetpotato Breeding sub-team in NICS, introduced characteristics of a new variety for table use called "Himeayaka". Interestingly, Himeayaka produces many small storage roots that have deep-yellow flesh and excellent taste. The 24th annual meeting on Root-Crop Research is planned to be held in Karatsu City, Saga Prefecture, on December 2-3, 2010.

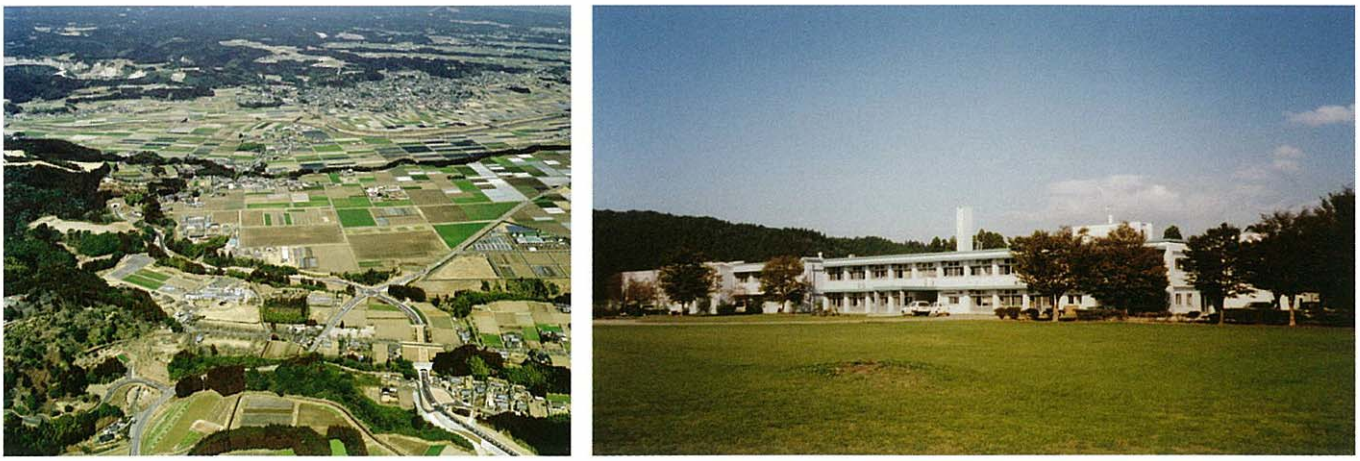
Fig. 1. Fried breads, caramels and a cake made from Beniharuka sold in a shop.

50th Anniversary of Miyakonojo Research Site, KONARC

Masaru Yoshinaga

Team Leader of Sweetpotato Breeding Research

The year 2010 marks the 50th anniversary of Miyakonojo Research Site, KONARC. It was established in 1960 as a department of upland farming of the Kyushu National Agricultural Experiment Station (KNAES). Originally, the department comprised laboratories for cropping systems and the management of soil and plant disease. Later, laboratories for mechanization, breeding of sweetpotato and corn were added in 1965 and 1988. In 1993, two more laboratories were opened in order to strengthen postharvest technology and utilization of genetic resources of the sweetpotato. In 2001, KNAES became an independent administrative institution and was reborn as the National Agricultural Research Center for Kyushu Okinawa Region. In 2006, a new internal research system based on a team unit was started, and the name of department was changed to Miyakonojo Research Site, KONARC, which comprises five research teams involved in sweetpotato breeding, cropping systems, biomass utilization, physiological functions, and corn. We have been consistently working to develop innovative technology for upland farming and the related food industry, with the great aid of many technicians and part-time workers. Major sweetpotato achievements in the last two decades include releasing 26 new varieties for table use, starch, and food processing. In addition, intensive work on physiological function and food processing technology using new varieties contributes to market expansion. It is particularly notable that purple-fleshed varieties such as Ayamurasaki and its processed products are helping to stabilize farmer's income and to stimulate the related food industries. The market for purple-fleshed sweetpotato and the processed products including natural pigments, juice, vinegar, and alcoholic beverages is estimated to be about $43 million a year. These research outcomes could be why Miyakonojo Research Site is said to be a Mecca for sweetpotato research in Japan. The memorial exhibition and ceremony of the 50th anniversary are planned on Nov. 20 in Miyakonojo Research Site. We are preparing to welcome many guests and the general public who are interested in upland crop research as well as those involved in Miyakonojo Research Site in the past.



Aerial photograph (left) and main buildings (right) of Miyakonojo Research Site.

Reader's Talk

Letter to the editor

More Than Sweetpotato: An Industrial Bioreactor on Marginal Land

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Who will support the world population of 9.2 billion people in 2050? The dramatic increase in population accompanied by rapid industrialization in developing countries has caused imbalances in the supply of food and energy. To cope with these global crises over food and energy supplies as well as environmental problems, it is urgently required to develop new, environmentally friendly industrial crop varieties to be grown on marginal land including desertification areas for sustainable development. The sweetpotato ranks seventh in annual production among food crops worldwide. It is also an alternative source of bio-energy and industrial materials such as natural antioxidants. Moreover, it does not require large amounts of fertilizer and pesticides and is rather tolerant to some environmental stresses. Its wide adaptability on marginal land ranging from tropical to temperate zones and rich nutritional content provide a high potential for preventing malnutrition and enhancing food security in the developing countries. Recently, the nonprofit Center for Science in the Public Interest (CSPI) (2007) designated the sweetpotato as one of ten super foods for better health, since it contains high levels of antioxidants, potassium, and fiber. The sweetpotato is very popular as the well-being food in developed countries. European people are also interested in the sweetpotato as a health food. The USDA (2008) reported that the sweetpotato can yield two to three times as much carbohydrate as field corn, approaching the amount that sugarcane can produce in Maryland and Alabama. It would be worthwhile to start pilot programs to study growing the sweetpotato for ethanol production, especially on marginal land. In this respect, the sweetpotato will be an attractive crop for solving the world food and environmental problems in the 21st century as an industrial bioreactor to produce various high value-added materials including bio-ethanol, functional feed, and antioxidants by molecular breeding. My research team focuses on molecular breeding of the sweetpotato with multiple functions on marginal land. For this purpose, we are developing the following platform technologies: a gene transformation system, functional genomics and proteomics, a gene expression system including intragenic vector using all genes derived from host plants and metabolic engineering for high yields of target materials in an environmentally friendly manner. We are developing new cultivars to combat desertification by increasing the local people's income in desertification areas in collaboration with the Xuzhou Institute of Sweet Potato, Chinese Academy of Agricultural Sciences (CAAS). In addition, I hope to develop the proper sweetpotato cultivars to contribute to solving the severe food problems of North Korea by molecular breeding of sweetpotatoes.

Editoer's note

Worldwide, abnormal weather continues. In this year, the drought of Russia caused the sudden rise of the price of wheat. Sweetpotato grows up even under such a bad weather condition. Excellent crop! (I.S.)

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