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Sweetpotato Research Front

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Contents

Smart Food Chain Systems

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One of the features of agriculture in the Kyushu-Okinawa region is the cooperation with the food industry. In this region, the share of the food industry shipment value to all manufacturing industries is approximately two times higher than the national average. Therefore, the food manufacturing industry plays a vital role in the regional economy. On the basis of this current situation, the NARO Kyushu Okinawa Agricultural Research Center has developed numerous varieties and technologies in collaboration with the local food industry. It is important to continue revitalizing the regional economy via the research and development accomplished through collaboration between the agricultural and food manufacturing industries.

On the other hand, recent developments in information and communication technologies of the Internet of things (IoT) and artificial intelligence (AI) have been remarkable because of the potential solutions to problems, such as a decreasing number of farmers and increasing abandoned farmland areas. For instance, automatic driving was implemented in the farming fields. Moreover, the high yield and high quality produced in horticulture facilities are achieved using advanced environmental control technologies. In addition, it is expected that the growth of crops can be predicted using weather forecasting and AI analysis with large data involving information detected in the field; in this way, precision cultivation management can be implemented efficiently with low costs. These agricultural production systems are called "smart agriculture."

Regarding cooperation between the agricultural and food manufacturing industries, we are going to construct a "smart food chain system" to connect breeding, production, processing, storage, distribution, export, and sale by using the information and communication technologies providing a high added value to foods from the Kyushu-Okinawa region. For the main agricultural product in the Kyushu-Okinawa region, the sweet potato, we should also build a "smart food chain system" in accordance with the domestic and foreign market needs, such as scheduled and quantitative supply with smart agriculture systems, novel processing and storage methods, construction of information systems from production to sale, and so on. The NARO Kyushu Okinawa Research Center will conduct the research and development of diverse varieties and innovative technologies in this value chain system, which will contribute to revitalizing the local economy, via the collaboration among industries, universities, prefectural research institutes, and administrative agencies.

Research Paper

Discovery of a New Race of Southern Root-knot Nematode

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The southern root-knot nematode (SRKN) *Meloidogyne incognita* is an intractable pest and causes severe damage to the yield and quality of sweetpotato. The use of resistant sweetpotato cultivars is a low-cost and effective method to control SRKN damage. Sano and Iwahori (2005) examined 129 SRKN isolates and detected nine races (SP1 to SP9) that were identified on the basis of their distinctive responses to five differential sweetpotato cultivars: 'Norin-1', 'Norin-2', 'Tanegashimamurasaki-7', 'Elegant Summer', and 'J-Red'[1)]. Therefore, it is important to elucidate which are the primary SRKN races in a certain region and which SRKN races the sweetpotato cultivars produced in that region are resistant to. As for the former, Sano and Iwahori revealed that SP1 was predominant in the prefectures of Saga, Nagasaki, and Kumamoto, while SP2 was predominant in Miyazaki and Kagoshima, and SP4 and SP6 were predominant in Okinawa[1)]. Regarding the latter, we have been testing various sweetpotato cultivars for resistance to SRKN races.

During the resistance tests, two SP6 SRKN isolates (Okiishi-12 and Ishigaki-2) showed the same response to each of the five differential cultivars; however, three sweetpotato cultivars ('Murasakimasari', 'Suzukogane', and 'Chienoha') were resistant to the Okiishi-12 isolate and susceptible to the Ishigaki-2 isolate[2)]. These results indicated that the Okiishi-12 and Ishigaki-2 isolates were distinct and that SP6 included at least two races. We designated the Okiishi-12 and Ishigaki-2 isolates as SP6-1 and SP6-2, respectively; we also chose 'Murasakimasari' as the sixth differential cultivar. Then, we proposed a modified method for identifying six SRKN races (Table 1).

Five isolates of SP6 collected from a sweetpotato field in the Chiba Prefecture were examined using this modified method, and all of them were identified as SP6-1. Such corroborating research of the SRKN races in other sweetpotato fields where SP6 was detected could improve the control of SRKN by using resistant sweetpotato cultivars.

REFERENCES

1) Sano and Iwahori, Jpn. J. Nematol. 35, 1-12 (2005).
2) Tabuchi *et al.*, Nematol. Res. 47, 29-33 (2017).

Table 1. SRKN race identification based on the pattern of susceptibility (+) and resistance (-) to infection of six differential sweetpotato cultivars.

Sweetpotato differential cultivars	SRKN races[a]					
	SP1	SP2	SP3	SP4	SP6-1	SP6-2
Norin-1	+	+	+	+	+	+
Norin-2	-	+	-	+	-	-
Tanegashimamurasaki-7	-	-	+	+	+	+
Elegant Summer	-	-	-	+	+	+
J-Red	-	-	-	-	-	-
Murasakimasari	-	+	-	-	-	+

a) The races were identified on the basis of the egg mass number per root system of each differential sweetpotato cultivar inoculated with 500 second-stage juveniles of SRKN. Minus sign (-): egg mass number < 10; plus sign (+): egg mass number ≥ 10. The resistance tests of 'Murasakimasari' to SP5, SP7, SP8, and SP9 were not performed because these races were not kept in our laboratories.

Suppressive Effects of Nematode Population Density by Cropping Newly Bred Sweetpotato Cultivars ('Daichinoyume' and 'Konamizuki') Resistant to the Southern Root-knot Nematode

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The southern root-knot nematode (*Meloidogyne incognita*) is widely distributed in warm upland farming areas in Japan. It causes severe damage to the external appearance (e.g., cracks and constrictions) of sweetpotato tuberous roots. The nematode has ten known races, SP1 to SP9 (including SP6-1 and SP6-2), which are identified on the basis of their differential pathogenicity to various sweetpotato cultivars. SP2 is a dominant race in the Miyazaki and Kagoshima Prefectures (southern area of Kyushu). Nowadays, some new cultivars (e.g., 'Satsumamasari', 'Koganemasari', 'Daichinoyume' and 'Konamizuki') have been found to exhibit a strong resistance to SP2. Crop rotation with resistant and susceptible cultivars may suppress the nematode population. Therefore, in a SP2 infested field, the following characteristics were investigated by cropping newly bred sweetpotato cultivars resistant to SP2: nematode damage, nematode population density after cropping, and nematode damage to the succeeding crop.

Two nematode-resistant cultivars ('Daichinoyume' and 'Konamizuki') and one nematode-susceptible cultivar ('Koganesengan') were cultivated in 2011; the tuberous roots of the former were scarcely damaged, whereas those of the latter were highly damaged (Fig. 1). In the spring of 2012, the nematode density in the plow layer soil was lower after cropping 'Daichinoyume' and 'Konamizuki' than after cropping 'Koganesengan' (Fig. 2). The tendency of nematode density in the subsoil was similar to that in the plow layer soil, although the overall nematode density was considerably higher in the subsoil than in the plow layer soil. Additionally, nematode damage to tuberous roots of 'Koganesengan' in the 2012 cultivation after cropping of 'Daichinoyume' and 'Konamizuki' were slightly suppressed compared to the cropping of 'Koganesengan'(Fig. 3).

'Daichinoyume' and 'Konamizuki' are relatively new sweetpotato cultivars bred for starch production. Cropping these cultivars would be an effective method for reducing the nematode damage to sweetpotato without applying soil fumigants and other nematicides, which are commonly used in upland farming in Japan.

Fig. 1. Root-knot nematode damage to 'Daichinoyume,' 'Konamizuki,' and 'Koganesengan'. The numbers indicate the percentage of tuberous roots yielded without damage.

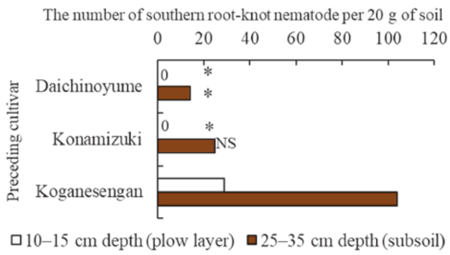

Fig. 2. Influence of preceding sweetpotato cultivars after harvest on the southern root-knot nematode population density at 10–15 and 25–35 cm of soil depths. Asterisk (*): significant difference from the result with the preceding cropping of 'Koganesengan' ($P < 0.05$); NS: not significant.

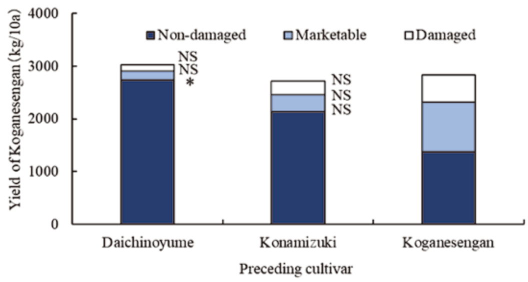

Fig. 3. Influence of preceding cultivars on root-knot nematode damage to 'Koganesengan'. Asterisk (*): significant difference from the result with the preceding cropping of 'Koganesengan' ($P < 0.05$); NS: not significant.

Research Paper

Improved Laboratory Evaluation Method for Soil Rot Resistance in Sweetpotato via Vine Cutting

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Soil rot of sweetpotato is caused by a soil-borne pathogen, *Streptomyces ipomoeae* (Person and Martin) Waksman and Henrici, and it is prevalent in most sweetpotato production areas in Japan. The disease may markedly reduce the yield and their market quality. A method that satisfactorily control the disease is yet to be established, except for fumigation with chemicals. Therefore, soil rot resistant varieties of sweetpotato are urgently needed. Currently, breeding lines are being evaluated in the fields for resistance to the disease, but results vary depending on the year. Therefore, we developed a laboratory method for stable evaluation of the resistance by improving a method previously reported.

The improved method was performed as follows: the vines of sweetpotatoes cultivated in pots were cut to a length of approximately 25 cm, the lower leaves were excised leaving three fully expanded leaves, and then, the vines were planted in 50-mL polypropylene centrifuge tubes containing sterile vermiculite. The soil rot pathogen cultured in yeast extract glucose broth was centrifuged and then the pellet was washed with sterile distilled water (SDW) and resuspended in nine times the SDW weight. A 100-fold dilution of the suspension was used as inoculum (10 mL/a tube). The vines planted in the tubes were immersed in a 30°C water bath (Fig. 1) and grown uniformly by applying liquid fertilizer or distilled water when some of the tubes were light enough to float on the water bath. Two weeks after inoculation, the disease severity for each plant was calculated by adding up each disease index score (DIS) of the vines and feeder roots in the underground. The DIS for vines or feeder roots was determined on the basis of the black and decayed area percentage (0, no symptoms; 1, less than 20%; 2, less than 40%; 3, less than 60%; 4, less than 80%; and 5, up to 100%) and of the yellowing or death of the stem tip (which gave 6 of DIS to feeder roots).

Five varieties, ‘Purple sweet lord’, ‘Koukei No. 14’, ‘Benikomachi’, ‘Beniazuma’, and ‘90IDN-47’, which were assessed in field evaluations as susceptible, susceptible, moderately susceptible, moderately resistant, and resistant to soil rot, respectively, were used in the laboratory evaluation method. Statistically significant differences in the disease severities were detected between the susceptible varieties and the moderately resistant or the resistant variety (Fig. 2). These results suggest that the method developed in this study can be incorporated in the screening for resistance in sweetpotato varieties to soil rot.

Fig. 1. Cultivation of sweetpotato vines in a water bath.

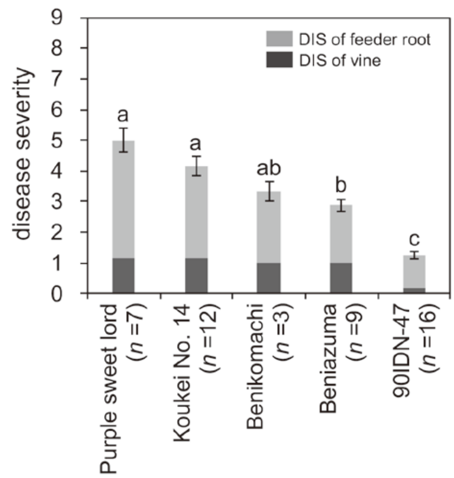

Fig. 2. Evaluation of soil rot-resistance of five varieties in the laboratory evaluation method. The different letters indicate statistically significant differences according to Tukey’s HSD test ($P < 0.05$).

Research Paper

Anthocyanin Contents in Purple-fleshed Sweetpotatoes under Different Cropping Patterns in the Okinawa Region

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Purple-fleshed sweetpotatoes (also called “beni-imo”) containing the anthocyanin pigment have been accustomed in the Okinawa region, which is in southern Japan, since the latter part of the Edo period. In Japan, sweetpotatoes are mostly planted in the spring and harvested in the fall. Furthermore, only in the Okinawa region, they can be planted in the fall and harvested in the spring. Therefore, sweetpotatoes are harvested twice a year in this region. However, there is little information available about the anthocyanin content of purple-fleshed sweetpotato tubers under these two different cropping patterns.

In this study, three purple-fleshed sweetpotato cultivars (Bise, Okiyumemurasaki, and Churakoibeni) were either planted in April and harvested in September (spring planting) or planted in September and harvested in April (fall planting). They were cultivated between 2014 and 2017 in farmlands of Itoman City and Yaese Town in the Okinawa Island. After harvest, the tubers were peeled and lyophilized, and their anthocyanin contents were determined using high-performance liquid chromatography. The anthocyanin content was calculated by the sum of two, six, and six species of non-acylated, mono-acylated, and di-acylated anthocyanins, respectively.

The box-and-whisker plot (Fig. 1) showed the anthocyanin content in tubers under the different cropping patterns. A statistical comparison was performed using the average anthocyanin content in tubers harvested at the two areas (Itoman City and Yaese Town), although only when the Bise cultivar was planted in the fall, the anthocyanin content in tubers cultivated at Itoman City was significantly higher ($P < 0.01$) than that in those cultivated at Yaese Town. It was confirmed that within each cultivar, the anthocyanin content was significantly higher in sweetpotato tubers planted in the fall than the anthocyanin content in those planted in the spring. This could be attributed to lower soil temperature during the cultivation period for sweetpotatoes planted in the fall than for those planted in the spring. In addition, the anthocyanin content within each cropping pattern increased in the following order: Bise < Okiyumemurasaki < Churakoibeni.

Table 1 indicates the color space values (L*, a*, and b*) of lyophilized powders made from purple-fleshed sweetpotato tubers. The L* and b* values were lower for the tubers planted in the fall than for those planted in the spring, while the a* values were higher for the tubers planted in the fall than for those planted in the spring within each cultivar. These results indicated that the flesh color of tubers planted in the fall is darker, redder, and bluer (because of the high anthocyanin content) than that of those planted in the spring. The color differences ($\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$) between the spring and fall planting were 4.0, 6.2, and 8.6 for Bise, Okiyumemurasaki, and Churakoibeni, respectively. The color difference for Bise was judged to be ‘appreciable’, although ΔE^* was smaller for Bise than for the other cultivars.

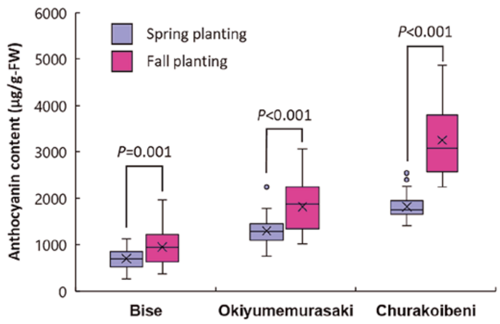

Fig. 1. Anthocyanin content in Bise, Okiyumemurasaki, and Churakoibeni tubers under different cropping patterns (spring and fall planting).
Eighteen tubers of each cultivar for spring and fall planting were harvested at both Itoman City and Yaese Town.

Table 1. Color values (L*, a*, and b*) of lyophilized powders made from Bise, Okiyumemurasaki, and Churakoibeni tubers under different cropping patterns (spring and fall planting).

Cultivar	Planting season	L*	a*	b*
Bise	Spring	65.5±3.1	7.4±4.7	-7.4±2.0
	Fall	62.7±4.5	9.2±4.6	-9.6±2.8
Okiyumemurasaki	Spring	58.3±2.4	10.8±4.5	-11.0±1.6
	Fall	52.9±2.9	13.1±3.4	-13.1±1.1
Churakoibeni	Spring	55.9±1.9	14.1±4.3	-11.3±1.6
	Fall	49.4±2.3	19.1±2.9	-13.7±1.0

Research News

Report of the 8th International Sweetpotato Symposium

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Background

The 8th International Sweetpotato Symposium was held at Jeonju City, Korea, from September 5-8, 2018. It was the first international sweetpotato symposium since the 7th Trilateral Sweetpotato Workshop at Shandong, China, in 2016. The slogan of the symposium was "Promoting High-value Added Industry of Sweetpotato for the 4th Industrial Innovation". Approximately 129 participants were gathered from China, Korea, Japan, Kazakhstan, Kentucky State University (USA), and the International Potato Center (China and India). Fifteen Japanese researchers from the Kazusa DNA Research Institute, Okayama University, Minami Kyushu University, Tokyo University, and NARO were attended to the symposium.

The symposium was carried out in 8 sessions: 1. Keynote Lectures. 2. General Session I: Genetic Resources, Breeding and Cultivation. 3. General Session II: Physiology and Biotechnology. 4. General Session III: Biochemistry and Processing. 5. Special Session I: Genomics. 6. Special Session II: Biomaterials. 7. Special Session III: Young Scientists. 8. Poster Session. At first, keynote speakers introduced the status of the sweetpotato demand, production and research activities of their respective countries or institutions. Throughout the workshop, recent research activities and the future direction of sweetpotato were shared and discussed by all participants to meet the 4th industrial innovation. Also, there was a business meeting about the Trilateral Research Association of Sweetpotato (TRAS) and its sweetpotato genome sequencing project.

General assembly and future announcement

There was a general assembly on the evening of September 7. Dr. Liu Qingchang from China was selected as the next president. The 9th workshop was announced to be held at Xuzhou City, China, in 2020. Ten people received awards for best presentation; those from Japan were: Dr. Shirasawa (Kazusa), Mr. Ohata (Okayama University) and Dr. Sakaigaichi (NARO).

Technical tour

On September 7-8, the participants visited RDA Institutes: National Institute of Crop Sciences (NICS), National Institute of Agricultural Sciences (NAS), and Korea Research Institute of Bioscience and Biotechnology (KRIBB).

I feel that the workshop not only strengthened the sweetpotato research of Japan-China-Korea, but also opened the doors for internationally bridging the sweetpotato research and industry.

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