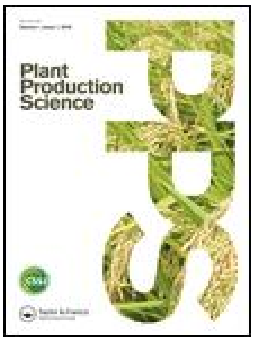

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Relationships between nutrients and sucrose concentrations in sugarcane juice and use of juice analysis for nutrient diagnosis in Japan

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ABSTRACT
Sugarcane is an important economic crop in southwest Japan, but its production is decreasing. To increase sugar production, both sugarcane yield and quality should be improved. Fertilizer management is one of the factors that influence sugarcane quality. We accordingly focused on nutrients present in sugarcane juice and attempted to identify the key factors affecting sugarcane quality. We collected sugarcane samples from 2013 to 2015 from all of the sugar mills in Japan and examined the relationships between juice nutrients and sucrose concentration. Juice analysis over 3 year showed that potassium (K^+) and chloride (Cl^-) were the most abundant cation and anion in the juice and that both negatively correlated with the sucrose concentration. K^+ and Cl^- concentrations significantly varied depending on production areas and those with higher K^+ and Cl^- concentrations had a low sucrose concentration. This finding suggests that sugarcane in those areas may have been supplied with these two ions in excess. Electrical conductivity (EC) in the juice always positively correlated with K^+ and Cl^- concentrations. EC may thus be a reliable indicator of K^+ and Cl^- concentrations and could be used for nutrient diagnosis because of its ease of measurement. For improving sugarcane quality, we recommend that potassium chloride, which supplies both K^+ and Cl^- and is a commonly used potassium fertilizer for sugarcane production in Japan, should be used in lower quantities in a year following one in which the EC of sugarcane juice at harvest is found to be high.

Abbreviations: ANOVA, analysis of variance; Ca^{2+}, calcium ion; Cl-, chloride ion; EC, electrical conductivity; Mg^{2+}, magnesium ion; PO_4^{3-}, phosphate ion; K, potassium; K^+, potassium ion; KCl, potassium chloride; K_2SO_4, potassium sulfate; Na^+, sodium ion; SO_4^{2-}, sulfate ion

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Chloride; electrical conductivity; fertilizer management practice; nutrient diagnosis; potassium; sucrose concentration

Introduction

In Japan, sugarcane is mainly grown in Nansei Islands, which are composed of many small islands and located at 24–31° N latitude and 123–131° E longitude. Sugarcane is one of the most important agricultural products in this region, with an economic impact greater than that of any other crop (Iesaka, 2001) because of its relatively strong resistance to typhoons and drought. Despite its essential role in the economy, its production remains sluggish mainly due to the decreasing harvested area and the number of growers (Inoue, 2006; Kikuchi, 2009; Matsuoka, 2006). Considering that sugarcane price is determined by cane weight and sucrose concentration in juice, increasing production and producer profit will require improving both cane yield and quality.

Fertilizer management practice is one of the factors that influence sugarcane quality (Meyer & Wood, 2001), but the application of suitable fertilizer management practices requires the knowledge of the nutritional status of each sugarcane field. Foliar diagnosis is a common practice in agriculture to manage the mineral nutrition of plants (Oliveira et al., 2010) and used to identify deficiency, sufficiency or excess of nutrients, optimize crop production, and evaluate fertilizer requirements. The method is well established (Samuels et al., 1955) and is widely used as a diagnostic tool in sugarcane production (Anderson et al., 1995; Bokhtiar, 2004; Kumar & Verma, 1997). However, foliar diagnosis can be a complex exercise because of the dynamic nature of foliar composition, which is strongly influenced by aging processes as well as interactions

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affecting nutrient uptake and distribution (Walworth & Sumner, 1987). The method also requires considerable time and skill. Nutrient diagnosis should be as easy and precise as possible for anyone needing to know the nutritional status of sugarcane. We accordingly investigated a new method for sugarcane nutrient diagnosis on the basis of the sugarcane juice obtained at harvest. The advantages of using this method are as follows:

- Nutrients in the juice more precisely represent the nutritional status of the whole plant, given that it reveals the total amount of nutrients absorbed and stored into stem parts during cultivation, while leaf analysis evaluates temporary leaf nutritional status.
- Juice quality depends on the amount and type of nutrients present in the juice (Gomathi & Thandapani, 2005) as sucrose is also accumulated into the stems.
- It is not necessary to take samples for diagnosis, given that the stem is an economic part of the sugarcane.
- Sample preparation is easier because juice samples are liquid.

In this study, we first investigated the relationships between nutrients and sucrose concentration and identified the key factors affecting sugarcane quality, and then investigated the application of this method to sugarcane nutrient diagnosis.

Materials and methods

This study was performed over three harvest seasons, from February to March in 2013, 2014, and 2015. Each sample was composed of a 3- to 4-kg bundle of clean cane stalks, and 10 samples differing in sampling sites, cropping types, and varieties were randomly chosen and sent from the 17 sugar mills currently operating in Japan (Table 1) to the University of the Ryukyus (26°25′N, 127°77′E; 125 m a.s.l.) in each of the harvest seasons. The samples were shredded with a cutter grinder (CG03; Jeffco) and 550 g of carefully mixed subsample was pressed to obtain juice. Approximately 100 ml of the press juice was used for determining sucrose concentration and 15 ml of the remainder was stored at −20 °C for ion analysis and measurement of electrical conductivity (EC). To the 100 ml of juice, 1.5 g of lead (II) acetate trihydrate (Wako Pure Chemical Industries) was added, and the mixture was stirred for 2 min and passed through a filter paper (No. 2; Advantec). Sufficient filtrate was collected to rinse and fill the polariscope tube, and sucrose concentration was then measured by the combined data of a modular circular polarimeter (MCP 500; Anton-Paar) and a refractometer (Abbemat WR; Anton Paar).

Table 1. List of 17 sugar mills under operation in Japan.

No.	Name	Location
1	Shinko Togyo Co., Ltd.	30°51′N, 130°96′E
2	Fukoku Seito Co., Ltd.	28°45′N, 129°68′E
3	Showa Togyo Co., Ltd.	28°33′N, 129°95′E
4	Nansei Togyo Co., Ltd., Tokuwase Factory	27°76′N, 129°02′E
5	Nansei Togyo Co., Ltd., Isen Factory	27°68′N, 128°92′E
6	Nanei Togyo Co., Ltd.	27°37′N, 128°64′E
7	Yoronjima Seito Co., Ltd.	27°04′N, 128°41′E
8	Okinawa Agricultural Coop. Assoc., Izena Branch	26°93′N, 127°94′E
9	Kyuyo Sugar Mfg. Co., Ltd.	26°34′N, 127°86′E
10	Kumejima Sugar Mfg. Co., Ltd.	26°33′N, 126°77′E
11	Shonan Sugar Mfg. Co., Ltd.	26°19′N, 127°70′E
12	Kita-Daito Sugar Mfg. Co., Ltd.	25°95′N, 131°30′E
13	Daito Sugar Mfg. Co., Ltd.	25°83′N, 131°20′E
14	Miyako Sugar Mfg. Co., Ltd., Irabu Factory	24°81′N, 125°27′E
15	Okinawa Sugar Mfg. Co., Ltd.	24°75′N, 125°29′E
16	Miyako Sugar Mfg. Co., Ltd., Gusukube Factory	24°73′N, 125°35′E
17	Ishigakijima Sugar Mfg. Co., Ltd.	24°39′N, 124°16′E

After complete thawing, juice samples for ion analysis were diluted 100 times with extra-pure water and filtered with a membrane filter (diameter, 13 mm; pore size, 0.45 μm; Advantec). Ion chromatographs (ICS-1,600; Thermo Fisher Scientific) were used to determine the concentrations of major ions present in sugarcane juice (sodium (Na^+), potassium (K^+), magnesium (Mg^{2+}), calcium (Ca^{2+}), chloride (Cl^-), phosphate (PO_4^{3-}), and sulfate (SO_4^{2-}) ions). The columns and eluents used were Ion Pac CS12 and 20 mM methane sulfonic acid solution for cation analysis and Ion Pac AS22 and a solution of 4.5 mM sodium carbonate and 1 mM sodium hydrogen carbonate for anion analysis. EC of juice samples was measured with an EC meter (WM-32EP; Toa). In 2013, 40 of 170 data on EC were missing, but this loss had little effect on the results because the sample number was sufficient enough to understand the general tendency. The samples were also categorized by harvest year, production area, cropping type, and variety for detailed analyses.

Mean and standard deviations of the samples were calculated and statistical analysis was performed with R (R Core Team, 2014). Data were subjected to one-way analysis of variance (ANOVA) to test differences among sugar mills. Significance was accepted based on a P value <.05.

Results

In all the 3 yr, K^+ was the most abundant ion present in sugarcane juice, with the mean concentration ranging from 58.1 to 65.7 mM (Table 2). The second most abundant was Cl^- (35.2 to 39.7 mM), whose mean was highest among the three anions. These two ions were thought to be dominant, as their sum accounted for more than 70% of total ion concentrations. SO_4^{2-} was the third most abundant with a mean from 13.8 to 16.1 mM. The mean concentrations of the other ions were lower than 10 mM. EC means were approximately 700 mS m^{-1}.

The correlation coefficients between sucrose concentration and the ion concentrations in sugarcane juice for the 3 yr are given in Table 3. In 2013, the concentrations of Na^+, K^+, and Cl^- and EC negatively correlated with sucrose concentration and the correlations were significant at the 1% level. These factors significantly negatively correlated with sucrose concentration in 2014 as well. Negative correlations of K^+, Cl^-, and EC, but not Na^+, were also observed in 2015. The other ions showed mostly positive correlations with sucrose concentration. That of PO_4^{3-} in 2013 was significant at the 5% level and those of Mg^{2+} in 2014 and 2015, Ca^{2+} in 2015, PO_4^{3-} in 2015, and SO_4^{2-} in 2015 were significant at the 1% level. Cl^- showed the strongest correlation with sucrose concentration in 2013, whereas EC had the closest relations in 2014 and 2015.

Because the concentrations of K^+ and Cl^- were the most abundant among the cations and the anions, respectively, and the correlations of these ions and EC with sucrose

Table 2. Means of ion concentrations and EC in sugarcane juice.

	Na^+	NH_4^+	K+	Mg2+	Ca2+	Cl^-	NO_2^-	NO_3^-	PO_4^{3-}	SO_4^{2-}
2013	3.5 ± 2.6	1.3 ± 1.7	65.7 ± 18.6	8.4 ± 2.5	4.7 ± 1.9	39.7 ± 11.7	0.0 ± 0.0	0.1 ± 0.2	5.5 ± 3.6	16.1 ± 4.7
2014	2.1 ± 1.2	1.3 ± 1.7	58.1 ± 18.8	9.4 ± 2.9	5.9 ± 2.1	35.2 ± 10.8	0.1 ± 0.5	0.1 ± 0.1	4.1 ± 2.5	15.5 ± 4.2
2015	3.3 ± 2.2	5.5 ± 10.6	63.9 ± 19.0	7.7 ± 2.6	4.5 ± 1.6	38.0 ± 11.5	0.0 ± 0.1	0.1 ± 0.2	4.7 ± 2.5	13.8 ± 3.5
Average	3.0 ± 2.2	2.7 ± 6.5	62.1 ± 19.3	8.5 ± 2.8	5.0 ± 1.9	37.5 ± 11.7	0.0 ± 0.3	0.1 ± 0.2	4.8 ± 3.0	15.1 ± 4.3

Table 3. Correlation coefficients of ion concentrations and EC with sucrose concentration in sugarcane juice.

	Na^+	NH_4^+	K+	Mg2+	Ca2+	Cl^-	NO_2^-	NO_3^-	PO_4^{3-}	SO_4^{2-}
2013	−.54**	.05	−.34**	.07	−.01	−.67**	.04	−.37 **	.18*	.09
2014	−.20**	−.06	−.47**	.21**	.13	−.56**	−.05	−.22**	.15	.05
2015	.01	.01	−.38**	.23**	0.29**	−.44**	−.06	−.47**	.30 **	.20**

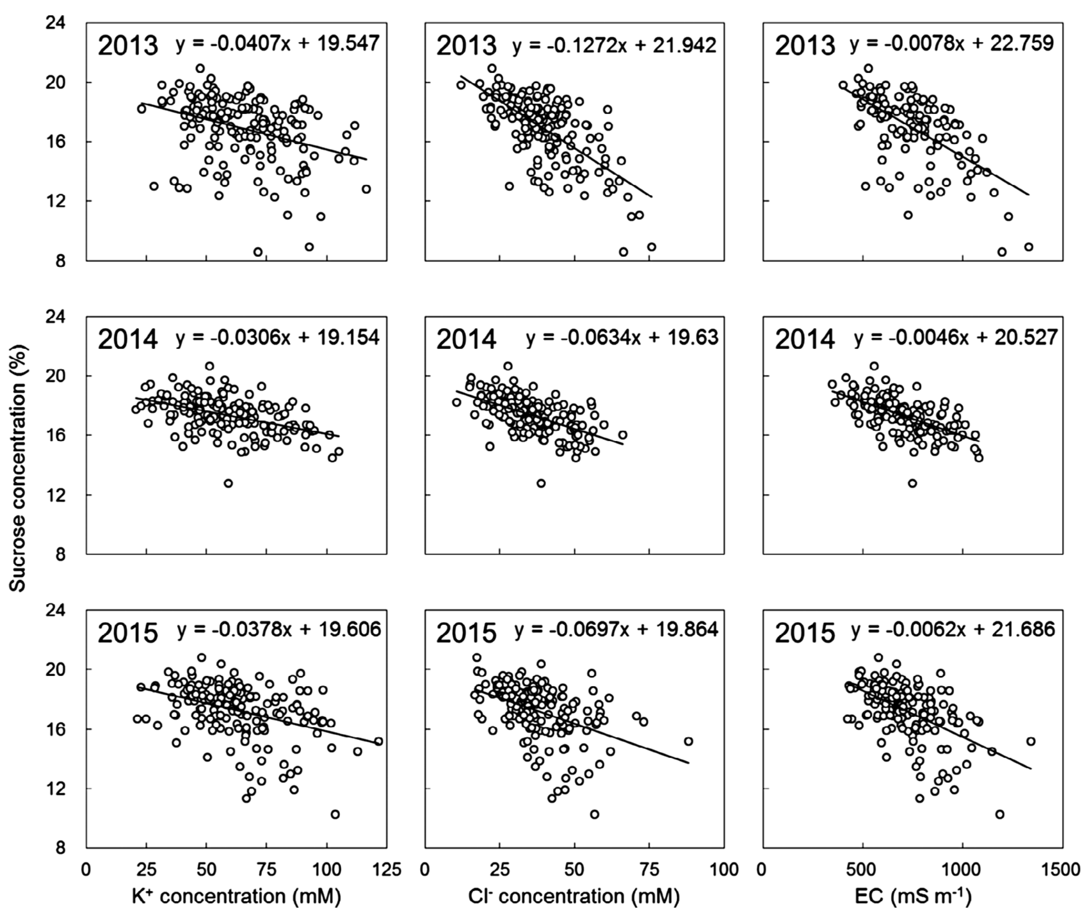

Figure 1. Relationships of K^+ and Cl^- concentrations and EC with sucrose concentration in sugarcane juice.

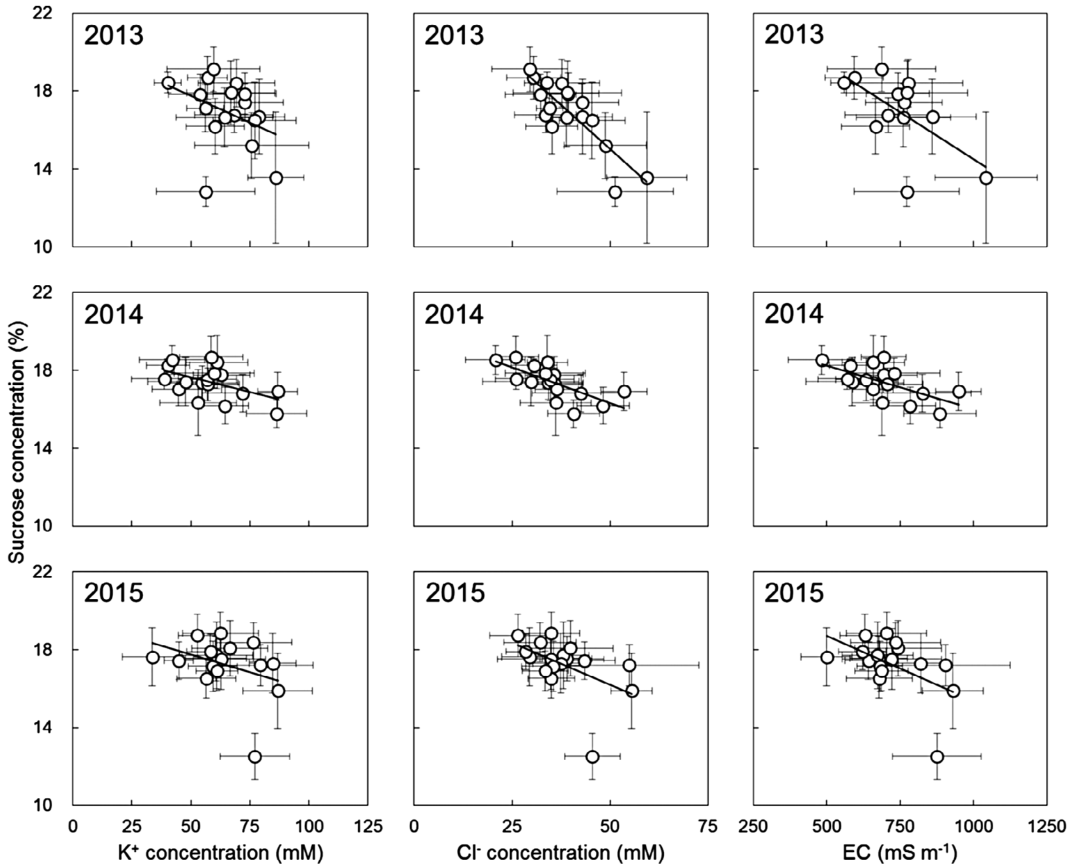

Figure 2. Relationships of the mean K⁺ and Cl⁻ concentrations and EC with the mean sucrose concentration in sugarcane juice. Each circle represents the mean of each sugar mill. Horizontal bars indicate SD of K⁺ and Cl⁻ concentrations and EC and vertical bars indicate SD of sucrose concentration. Each circle represents the mean of each sugar mill. Horizontal bars indicate SD of K⁺ and Cl⁻ concentrations and EC and vertical bars indicate SD of sucrose concentration.

concentration were significantly negative at the 1% level in all three harvest seasons, we concluded that they are the factors to be concerned for improving sugarcane quality and accordingly focused on these two ions and EC. The correlations between these factors and sucrose concentration are illustrated in Figure 1. Sucrose concentration ranged widely from 8 to 21% in 2013, 13 to 21% in 2014, and 10 to 21% in 2015. K^+, Cl^-, and EC scattered in a wide range as well, namely K^+ from 23 to 117, 21 to 105, and 21 to 121 mM; Cl^- from 12 to 76, 11 to 66, 18 to 88 mM; and EC from 400 to 1328, 343 to 1079, and 420 to 1341 mS m^{-1} in 2013, 2014, and 2015, respectively. As previously stated, K^+, Cl^-, and EC negatively correlated with sucrose concentration in all 3 yr. The slopes of the regression lines varied depending on the years and those in 2013 were slightly steeper.

We also plotted the mean values of the three factors and sucrose concentration when samples were categorized by sugar mill, resulting in 17 circles in a plot (Figure 2). The means varied greatly and, similar to the tendency in Figure 1, those three factors were negatively associated with sucrose concentration, so that cane from areas with high K^+, Cl^-, or EC generally had a low sucrose concentration.

From Figure 2, it was suggested that there were differences in K^+ and Cl^- concentrations and EC between sugar mills. Then, the means of each mill over three harvest seasons were given in Table 4. As a result of ANOVA, the means significantly differed depending on sugar mills in all 3 yr. Although each of the means greatly varied depending on the years, some sugar mills constantly had higher values than the means, namely higher K^+ concentrations were observed in Shinko Togyo Co., Ltd, Shonan Sugar Mfg. Co., Ltd, Kita-Daito Sugar Mfg. Co., Ltd, and Ishigakijima Sugar Mfg. Co., Ltd, Cl^- in Nanei Togyo Co., Ltd, and EC in Nanei Togyo Co., Ltd, Kita-Daito Sugar Mfg. Co., Ltd., and Ishigakijima Sugar Mfg. Co., Ltd.

To obtain more information, we categorized the juice samples by cropping type and variety (Table 5). The total numbers were not necessarily 170 because information about some samples was missing or minor varieties were not included in the table. There are three cropping types for sugarcane cultivation in Japan: spring planting, summer

Table 4. Means of K^+ and Cl^- concentrations and EC in sugarcane juice of each sugar mill.

	K+(mM)			Cl−(mM)			EC (mS m^{-1})		
No.	2013	2014	2015	2013	2014	2015	2013	2014	2015
1	68 ± 17	86 ± 13	77 ± 15	34 ± 8	41 ± 7	46 ± 7	710 ± 147	886 ± 123	876 ± 151
2	57 ± 8	61 ± 13	61 ± 13	30 ± 7	34 ± 5	39 ± 6	595 ± 99	658 ± 106	678 ± 98
3	40 ± 6	40 ± 9	45 ± 6	34 ± 4	31 ± 6	43 ± 8	559 ± 44	581 ± 73	642 ± 81
4	73 ± 13	63 ± 12	61 ± 16	39 ± 8	36 ± 7	38 ± 7	743 ± 107	693 ± 115	673 ± 120
5	73 ± 16	55 ± 15	57 ± 12	43 ± 9	34 ± 9	35 ± 6	763 ± 130	658 ± 105	679 ± 112
6	86 ± 12	57 ± 13	87 ± 15	59 ± 10	36 ± 7	56 ± 5	1042 ± 173	707 ± 120	930 ± 104
7	56 ± 21	45 ± 11	34 ± 13	51 ± 15	36 ± 6	30 ± 7	773 ± 180	659 ± 69	500 ± 87
8	79 ± 11	57 ± 12	63 ± 16	43 ± 8	35 ± 6	35 ± 7	860 ± 149	634 ± 102	705 ± 136
9	76 ± 24	48 ± 16	63 ± 19	49 ± 11	30 ± 12	35 ± 14	–	587 ± 156	722 ± 168
10	64 ± 21	42 ± 14	59 ± 10	39 ± 8	21 ± 8	36 ± 8	761 ± 160	483 ± 114	681 ± 77
11	77 ± 18	59 ± 13	85 ± 10	45 ± 8	26 ± 6	37 ± 7	–	695 ± 75	820 ± 100
12	69 ± 16	60 ± 17	80 ± 22	38 ± 10	34 ± 10	55 ± 18	778 ± 186	730 ± 156	905 ± 221
13	60 ± 20	87 ± 8	67 ± 16	30 ± 10	54 ± 6	40 ± 11	688 ± 185	950 ± 77	743 ± 147
14	56 ± 8	65 ± 10	58 ± 10	35 ± 3	48 ± 7	28 ± 5	–	784 ± 88	622 ± 80
15	54 ± 14	39 ± 14	53 ± 8	32 ± 9	26 ± 5	26 ± 7	–	570 ± 99	631 ± 86
16	60 ± 12	53 ± 16	61 ± 9	35 ± 7	36 ± 9	33 ± 6	667 ± 116	688 ± 101	687 ± 90
17	67 ± 19	72 ± 17	77 ± 16	39 ± 14	43 ± 12	32 ± 9	774 ± 207	826 ± 167	735 ± 154

Table 5. Number of each cropping type and variety.

		2013	2014	2015
	Spring planting	47	46	37
	Summer planting	53	47	57
	Ratooning	70	77	61
	NiF8	34	38	43
Cropping type	Ni21	9	14	12
Variety	Ni22	21	22	20
	Ni23	14	16	15
	Ni27	16	21	30

Table 6. Correlation coefficients of K^+ and Cl^- concentrations and EC with sucrose concentration in sugarcane juice sorted by cropping type and variety.

		K+			Cl−			EC		
		2013	2014	2015	2013	2014	2015	2013	2014	2015
Cropping type	Spring planting	−.25	−.61 **	−.66 **	−.67**	−.59**	−.73**	−.43**	−.67**	−.81**
	Summer planting	−.08	−.36 *	−.20	−.37**	−.52**	−.35**	−.31	−.57**	−.34*
	Ratooning	−.50**	−.46 **	−.34**	−.78**	−.58**	−.37**	−.83**	−.58**	−.50**
	NiF8	−.05	−.57 **	−.36*	−.48**	−.53**	−.48 **	−.36	−.71**	−.56**
	Ni21	−.10	−.60 *	−.02	−.19	−.81**	−.66 *	.00	−.80**	−.39
Variety	Ni22	−.52*	−.69 **	−.51*	−.83**	−.58**	−.36	−.89**	−.76**	−.63**
	Ni23	−.10	−.24	−.63*	−.77**	−.61*	−.52*	−.68**	−.50	−.73**
	Ni27	−.43	−.18	−.39*	−.19	−.18	−.68**	−.60	−.23	−.53**

planting, and ratooning. Spring- and summer-planted canes are newly planted, whereas ratooned canes have been continuously grown after harvest for two or more years. In this investigation, the number of varieties cropped by ratooning was highest among these three types. More than 30 varieties were analyzed and NiF8, Ni21, Ni22, Ni23, and Ni27 were five dominant varieties. The correlation coefficients of juice K^+, Cl^-, and EC with sucrose content, when the samples were categorized by cropping type or variety, are shown in Table 6. All of the correlations were negative and most were significant. In particular, the correlations between Cl^- and sucrose concentrations were significant at the 1% level for all cropping types in all 3 yr. Except for summer cropping in 2013 and 2015, EC showed significant correlations with sucrose concentration.

The correlations between K^+, Cl^-, and EC were also investigated. Because the results were similar in the 3 yr, only that in 2015 is shown in Figure 3. Both K^+ and Cl^- concentrations positively correlated with EC and each mM increase in K^+ and Cl^- increased EC by 7.85 and 11.49 mS m^{-1}, respectively. K^+ and Cl^- were closely associated as well. The correlations were all significantly positive at the 1% level.

Discussion

In this study, we tried to identify factors affecting sugarcane quality and, following juice analysis for 3 yr, found that K^+ and Cl^- were the most abundant cation and anion in sugarcane juice (Table 2) and that the concentrations of

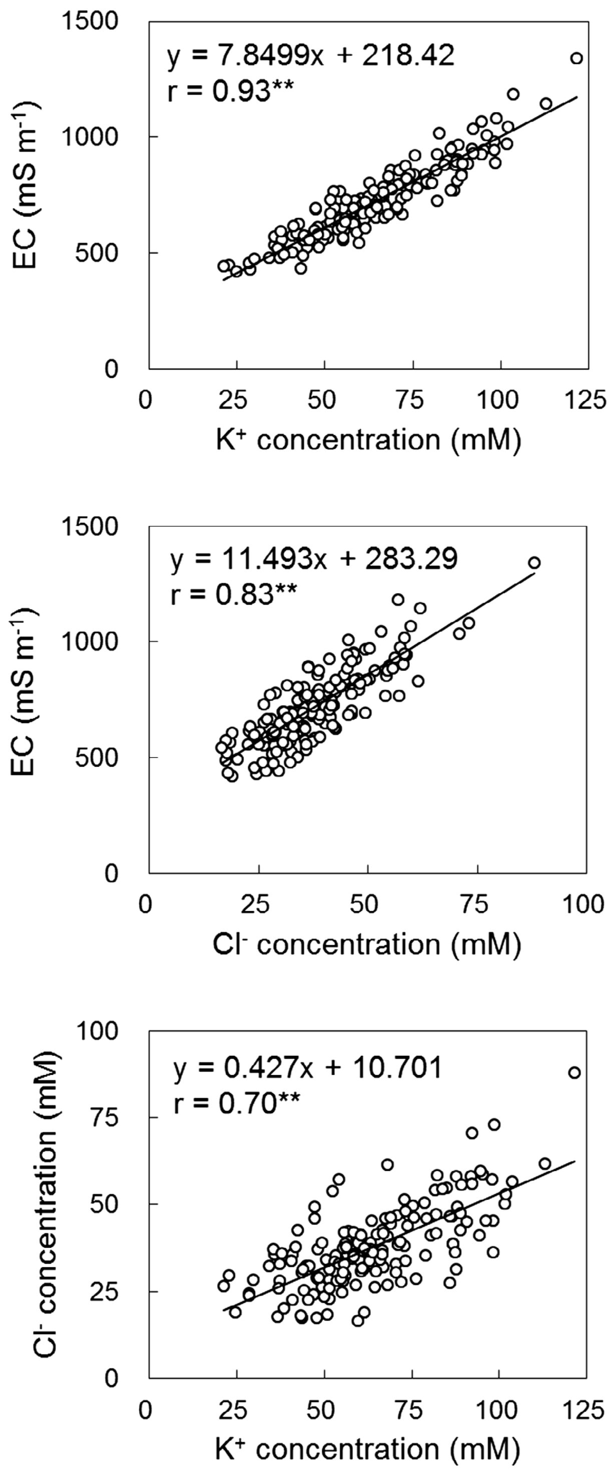

Figure 3. Relationships between K^+ and Cl^- concentrations and EC in sugarcane juice in 2015. The expressions of the linear lines are described in the figures. **means the relationships are significant at the 1% level.

these two ions negatively correlated with sucrose concentration (Table 3). It is noteworthy that we observed similar results for all 3 yr, although the sugarcane samples differed in cropping type and variety and were derived from different fields every year. Watanabe et al. (2015) conducted pot experiments using potassium chloride (KCl) and potassium sulfate (K_2SO_4) and reported that sucrose concentration was reduced by increasing KCl levels but not by K_2SO_4 levels, indicating that the combination of excessive potassium (K^+) and chloride (Cl^-) ions causes sucrose reduction. From these, we conclude that K^+ and Cl^- are influential ions and exert adverse effects on sugarcane quality.

Cl^- is considered a micronutrient, but its actual concentration in plants is 10 to 100 times higher than that required for optimal plant growth, and its high concentrations in soil influence plant growth and quality (Chenet al., 2010). Cl^- is always highlighted as a problematic factor in terms of salt stress. It is well known that salinity in soils (Lingle & Wiegand, 1997; Saxena et al., 2010; Wiegand et al., 1996) and irrigation water (Golabiet al., 2009; Lingle et al., 2000; Thomaset al., 1981) containing a considerable amount of Cl^- is harmful to both cane yield and quality. In contrast, K^+ is recognized to be a key ion responsible for salt tolerance (Ashraf et al., 2010, 2012; Gandonou et al., 2011; Wahid, 2004). Watanabe et al. (2015) observed the increment of juice Cl^- concentration with increasing K_2SO_4 levels, although the plants were not given Cl^- by fertilization, probably following the principle of electrical neutrality by which a bulk solution always contains equal numbers of anions and cations (Assmann, 2010, Chapter 6). Similarly, in this study, K^+ and Cl^- concentrations highly and positively correlated (Figure 3). Close correlations between K^+ and Cl^- have been confirmed in many reports and Cl^- is considered to be the counterion of K^+ (Laties et al., 1964; Schnabl & Raschke, 1980; Stuart & Jones, 1978). All these findings taken together suggest that Cl^- had a strong effect on sugarcane quality and that K^+ indirectly influenced the quality by increasing juice Cl^- concentration. However, we could not conclude from our investigation whether Cl^- alone or both ions were involved in the reduction of sucrose concentration.

Depending on production area, the concentrations of K^+ and Cl^- varied greatly (Table 4) and areas with higher juice K^+ and Cl^- concentrations showed lower sucrose concentration (Figure 2). The concentrations of K^+ and Cl^- in soil or irrigation water highly correlated with concentrations of those in the juice (Lingle & Wiegand, 1997; Thomas et al., 1981), suggesting that K^+ and Cl^- had been supplied in excess in those areas, eventually leading to reduction in sucrose concentration. Ota et al. (2000) performed nutritional and soil diagnoses in some sugarcane-producing regions in Japan and found that levels of potassium (K) in sugarcane leaves and exchangeable K in soils were mostly sufficient or even overabundant. Kafkafi (2001) reported that negative effects of Cl^- are observed in coastal regions where airborne Cl^- is transported from the ocean. Sugarcane cultivation in Japan, as already mentioned, is limited to island areas. These partly support our results and indicate that some sugarcane production areas in Japan may contain large amounts of soil K^+ and Cl^-. One of the sources of K^+ and Cl^- is a common potassium fertilizer, KCl, which is widely used for sugarcane production in Japan. Recommended K dose is precisely decided depending upon soil, crop type, and variety, ranging from 50 to 250 kg ha^{-1} (Kagoshima Prefectural Government, Agriculture Department, 2015; Okinawa Prefectural Government, Department of Agriculture, Forestry and Fisheries, 2015), and sugarcane is generally fertilized with compound fertilizers including 6 to 15% of K by KCl (Japan Agriculture, Kagoshima Prefectural Economic Federation of Agricultural Co-operatives, 2015; Ryukyu Fertilizer Co., Ltd, 2015) in this region, so that use of fertilizers with lower K percentage could contribute to an increase in sucrose concentration in such areas. This measure would benefit not only the sugar industry but also cane growers and the environment because it is more cost-effective and environment-friendly. Negative correlations of K^+ and Cl^- concentrations with sucrose concentration were also confirmed when samples were categorized by cropping type or variety (Table 6). The proposed practice would thus be effective irrespective of cropping type or sugarcane variety.

Juice EC as well as K^+ and Cl^- had a highly negative correlation with sucrose concentration. Considering that EC is positively correlated with K^+ and Cl^- (Figure 3), increasing K^+ and Cl^- concentrations seemed to contribute to increased EC, suggesting that EC may be a reliable indicator of K^+ and Cl^- concentrations. It would be beneficial to measure EC of a juice sample in order to evaluate K^+ and Cl^- concentrations and use the data for fertilizer management, given that the measurement of juice EC is easy and rapid. Growers should consider reducing KCl application in a year following one in which the EC value of sugarcane juice is found to be high. Moreover, there is a possibility to apply portable EC meter to standing canes and use the data to determine the amount of additional K fertilizer. However, we still do not know how much of KCl can be applied, when it is necessary to reduce the amount and whether or not this method affects quantitative parameters. Further study to answer these questions and examine the effectiveness of the new practice is needed.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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