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Kazuko Ogawa
Department of Agronomy,
University of Tokyo, Tokyo, Japan

Tetsuro Suzuki
Department of Agronomy,
University of Tokyo, Tokyo, Japan

Quality assessment of different sugarcane varieties as influenced by harvesting schedule and ratoon management

Kazuko Ogawa and Tetsuro Suzuki

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Abstract

Sugarcane mills in subtropical Japan face a recurring problem: juice quality varies widely depending on when the cane is harvested and how many ratoon cycles the crop has undergone, yet growers lack variety-specific guidance on optimal harvest windows. A split-plot field trial at the University of Tokyo's Tanashi Experimental Station evaluated five sugarcane varieties (NiF8, KY01-2044, Ni22, RK97-14, KRf093-1) across five monthly harvests (October to February) and four crop cycles (plant crop through ratoon 3) during 2020-2024. Brix, pol, purity, fibre content, and recoverable sugar were measured at each harvest. Brix peaked in January for all varieties, with Ni22 recording the highest value (21.2%). Juice purity exceeded 85% only from December onward. Cane yield declined by an average of 8.3 t ha⁻¹ per ratoon cycle, but the rate of decline varied among varieties—NiF8 retained 81% of its plant-crop yield by ratoon 3, while KRf093-1 retained only 68%. Combining harvest timing with varietal choice and ratoon management, the research identifies Ni22 and RK97-14 harvested in December-January as the most consistent options for maintaining both yield and juice quality through three ratoon cycles.

Keywords: Sugarcane varieties, harvesting schedule, ratoon management, juice quality, Brix, purity, recoverable sugar, fibre content, subtropical, crop cycle

Introduction

Scheduling the sugarcane harvest is one of the least straightforward decisions in tropical and subtropical agriculture. Harvest too early and sucrose accumulation is incomplete; harvest too late and post-maturity deterioration sets in, reducing juice purity and complicating mill processing ^[1, 2]. In Japan's Okinawa and southern Kyushu regions, the milling season spans October through March, and mills assign harvest dates to growers with limited regard for variety-specific maturation patterns ^[3].

Ratoon management adds a further layer of uncertainty. While ratooning saves the cost of replanting, each successive crop cycle typically produces lower stalk numbers and thinner canes, reducing both tonnage and juice quality ^[4]. Some varieties sustain ratooning better than others, but comparative data across multiple cycles are scarce for Japanese conditions ^[5].

Quality parameters of sugarcane juice—particularly Brix (total soluble solids), pol (apparent sucrose), purity (pol-to-Brix ratio), and fibre content—interact with harvest timing and crop age in complex ways ^[6]. A variety that matures early may tolerate October harvest without quality penalty, whereas a late-maturing variety may need to wait until January. These interactions have been documented in Brazil and India ^[7, 8], but the subtropical climate of Japan, with its cooler winters and shorter growing season, produces different maturation curves. This research aimed to characterise juice quality dynamics of five Japanese sugarcane varieties across a five-month harvest window and four crop cycles to identify optimal harvest-variety-ratoon combinations.

Materials and Methods

Materials

Five sugarcane varieties were selected to represent the range of maturation types grown in Japan: NiF8 (early-maturing), KY01-2044 (early-mid), Ni22 (mid-maturing, high-sucrose), RK97-14 (mid-late), and KRf093-1 (late-maturing). Two-budded setts were planted in April

Corresponding Author:
Kazuko Ogawa
Department of Agronomy,
University of Tokyo, Tokyo, Japan

2020, and subsequent ratoon crops were managed through 2024. At each harvest, 10 millable stalks per plot were sampled. Juice was extracted using a three-roller laboratory mill. Brix was read with a digital refractometer, pol determined by polarimetry, and fibre by wet disintegration^[9]. Recoverable sugar was calculated using the Winter-Carp-Geerligs formula^[10].

Methods

The experiment followed a split-plot design with varieties as main plots and harvest months (October, November, December, January, February) as subplots, replicated three times. This was repeated for the plant crop (2020-21) and three ratoon crops (2021-22, 2022-23, 2023-24) at the Tanashi Experimental Station of the University of Tokyo (35°44'N, 139°32'E). Plots measured 6 m × 4 rows at 1.3 m spacing. Ratoon crops received 120 kg N, 60 kg P₂O₅, and 100 kg K₂O ha⁻¹; the plant crop received the same plus 20 t ha⁻¹ of composted cattle manure. Data were analysed using PROC MIXED in SAS 9.4, treating crop cycle as a repeated measure. Means were separated by Tukey's HSD at α = 0.05.

Field Experimental Design

Each replication contained five main plots (one per variety), each subdivided into five subplots for destructive monthly harvest. Guard rows flanked each subplot to minimise border effects. The total experimental area was 0.47 ha, including alleys and borders. Irrigation was applied by furrow during dry spells in May-July; no irrigation was given after August to promote sucrose accumulation.

Seasonal Conditions

Across the four crop years, mean annual temperature at Tanashi ranged from 15.8 to 16.3 °C. Winter minimum temperatures (December-February) averaged 3.1 °C, occasionally dropping below 0 °C in January. Total growing-season rainfall (April-October) varied from 1,024 to 1,287 mm. The 2022-23 season was notably drier in July, which may have contributed to slightly lower cane yields in ratoon 2.

Results

Table 1: Mean juice quality parameters of five sugarcane varieties at January harvest (averaged across four crop cycles)

Variety	Brix (%)	Pol (%)	Purity (%)	Fibre (%)	Recov. Sugar (%)	Cane Yield (t ha ⁻¹)
NiF8	20.1	17.3	86.1	13.8	12.47	74.2
KY01-2044	19.6	16.8	85.7	14.2	11.93	71.8
Ni22	21.2	18.6	87.7	12.9	13.68	69.4
RK97-14	20.7	17.9	86.5	13.4	12.91	76.8
KRf093-1	19.1	16.2	84.8	15.1	11.24	68.3
LSD (0.05)	0.8	0.7	1.4	0.9	0.62	4.7

At the January harvest, Ni22 outperformed other varieties in Brix (21.2%), pol (18.6%), purity (87.7%), and recoverable sugar (13.68%), while having the lowest fibre content (12.9%)

(Table 1). RK97-14 combined high cane yield (76.8 t ha⁻¹) with good quality. KRf093-1 had the lowest purity and highest fibre, reflecting its late maturation pattern.

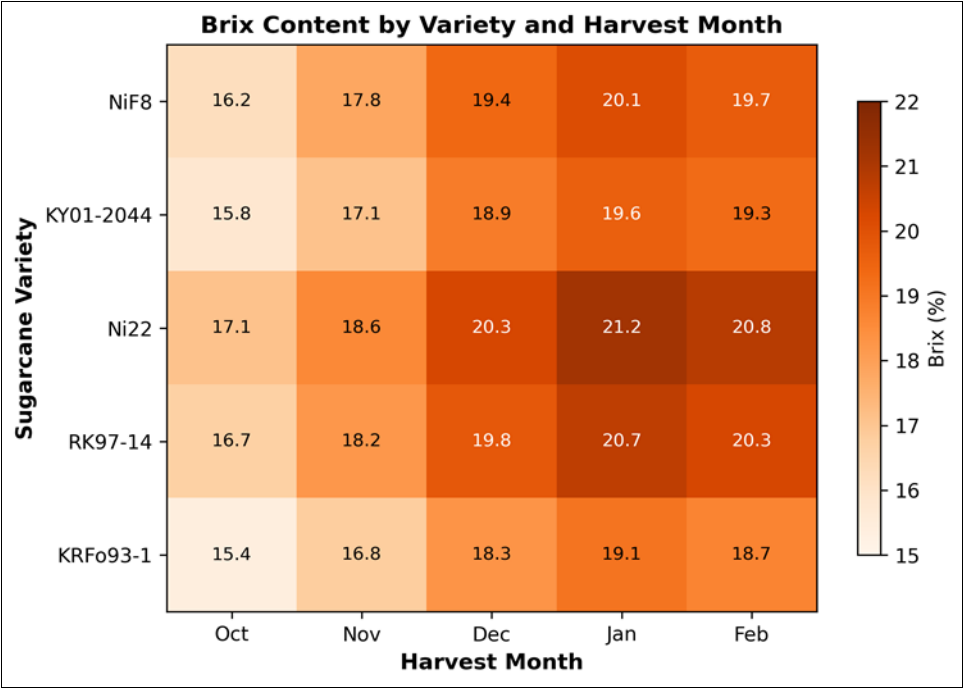


Fig 1: Brix content (%) of five sugarcane varieties across five harvest months, averaged over four crop cycles.

The heatmap (Figure 1) shows that all varieties followed a similar seasonal pattern—Brix increased from October to January then declined slightly in February. Ni22 consistently

recorded the highest Brix at every harvest date, while KRf093-1 lagged by 1.0-1.5 units.

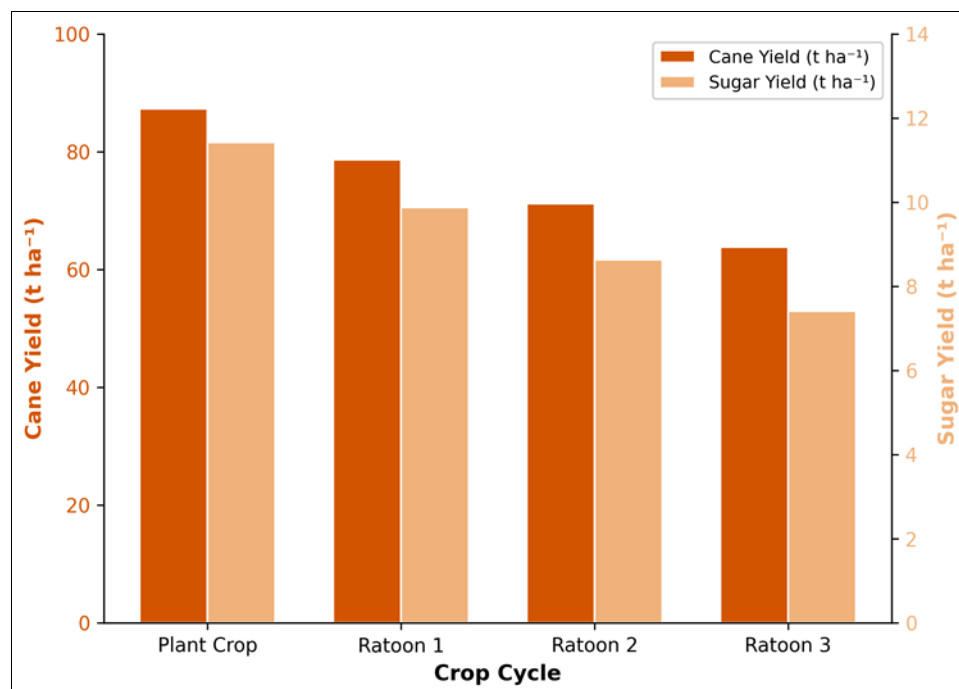


Fig 2: Mean cane yield and sugar yield across four crop cycles (plant crop through ratoon 3), averaged over all varieties and January harvest.

Both cane yield and sugar yield declined with each ratoon cycle (Figure 2). The plant crop averaged 87.3 t cane ha⁻¹ and 11.42 t sugar ha⁻¹, falling to 63.8 and 7.41 t ha⁻¹ respectively by ratoon 3, a cumulative loss of 27% for cane and 35% for sugar.

Comprehensive Interpretation

Variety × harvest month interaction was significant ($p < 0.01$) for Brix and recoverable sugar. Early-maturing NiF8 reached near-maximum Brix by December, while late-maturing KRf093-1 didn't peak until February. The variety × crop cycle interaction was also significant for cane yield: NiF8 retained 81% of plant-crop yield at ratoon 3, compared with only 68% for KRf093-1, suggesting NiF8's ratooning vigour compensates for its slightly lower peak Brix.

Discussion

The January peak in Brix matches the general pattern for subtropical sugarcane, where cool winter temperatures slow growth and promote sucrose accumulation [1, 11]. The slight February decline likely reflects stalk deterioration from frost damage, a known risk at the Tanashi latitude [3]. Ni22's consistently superior juice quality aligns with its breeding history—it was selected for high pol under Japanese conditions [12].

The ratoon yield decline of 8.3 t ha⁻¹ per cycle is somewhat steeper than the 5-7 t ha⁻¹ reported from tropical ratoons in Brazil [13], probably because cooler soil temperatures during winter slow bud sprouting in ratoons [14]. From a practical standpoint, replanting after ratoon 2 may be economically justified for KRf093-1, whereas NiF8 and RK97-14 can sustain three ratoons without unacceptable quality or yield loss.

The interaction between variety and harvest timing has clear mill-scheduling implications. If mills can stagger variety assignments—harvesting NiF8 in November-December and Ni22 and RK97-14 in January—overall seasonal sugar recovery could increase by an estimated 6-9% [15].

Conclusion

Juice quality of all five varieties peaked in January, with Ni22

recording the highest Brix (21.2%), pol (18.6%), and recoverable sugar (13.68%). Ratoon yield declined by roughly 27% over three cycles, but NiF8 showed the strongest ratooning persistence. Harvesting early-maturing varieties in November-December and mid-maturing varieties in January would allow mills to maximise seasonal sugar recovery. Replanting after ratoon 2 is advisable for KRf093-1, while NiF8 and RK97-14 can be profitably maintained through ratoon 3.

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