

The sugarcane variety Co 0238 – a reward to farmers and elixir to India's sugar sector

Bakshi Ram and G. Hemaprabha

The early maturing sugarcane variety Co 0238 (Karan 4) developed by ICAR-Sugarcane Breeding Institute, Regional Centre, Karnal, Haryana has revolutionized sugar production in India. The variety gives high average yield (>81 t/ha) with a sugar recovery of more than 12%. The widespread cultivation of this variety has generated a cumulative gross value of ₹ 120,770 thousand crores during 2014–15 to 2017–18, accounting for ₹ 30,192 crores per year. The total additional benefit from sugar and by-products during the period was ₹ 28,795 crores or ₹ 7199 crores per year, bringing livelihood security and prosperity to lakhs of farmers and cheer to the sugar industry in the subtropical states, especially Uttar Pradesh, Punjab, Haryana, Bihar and Uttarakhand.

Sugarcane is the second most important commercial crop in India. It is grown in about 5 m ha area and sustains the sugar industry, which is the second largest agro-industry in the country. At present, the crop engages about 123.4 lakh farmers and farm workers. The average sugarcane productivity and sugar recovery have, however, hovered around 59.6–71.7 t/ha and 10.03–10.55% respectively, in the country as a whole during 2001–02 to 2013–14, whereas cane productivity and sugar recovery in the subtropical parts of India (including Uttar Pradesh, Punjab, Haryana, Bihar and Uttarakhand) were lower than the national average and varied from 52.3 to 60.3 t/ha and 8.98% to 9.21% respectively, during the same period. The release of sugarcane variety Co 0238 (Karan 4) evolved from the cross CoLk 8102 × Co 775 and developed by ICAR-Sugarcane Breeding Institute (SBI), Regional Centre, Karnal, Haryana for commercial cultivation in the North West Zone (Punjab, Haryana, Rajasthan, Uttarakhand, Central and Western Uttar Pradesh) has brought substantial improvement and revolutionized sugarcane cultivation in the subtropical parts of India.

Co 0238 has high average cane yield of 81 t/ha, against 68 t/ha of the zonal check variety CoJ 64. Its high-yield potential has been demonstrated to be 329.6 t/ha, as reported in the farmer's field in Uttar Pradesh during 2017–18. This variety has 18% sucrose in juice at 300 days crop age that steadily increases to more than 20% during March–April, as against 17.9% sucrose in the check variety. On peak maturity Co 0238 has given average recovery of 12.0% and as high as 14.01% sugar recovery has been

realized in Uttar Pradesh in 2019. The variety is moderately resistant to red rot and smut diseases. It is also tolerant to water deficit, waterlogging and saline conditions, making it widely adaptable to all prevailing situations and suitable for all planting seasons, viz. autumn, spring and summer of the subtropical region. Good ratooning ability and tolerance to low temperature further make it durable for raising a second ratoon crop, a practice which was not in vogue in the Zone mainly for want of suitable varieties with multiratooning potential. The thick canes to match the tallness of the crop have favoured Co 0238 for wider row planting, which is a pre-requisite for mechanical harvesting. The rare combination of increased yield with resilience to harsh climatic conditions favours its growth all through the year. Thus, Co 0238 is perfect for sugarcane-based cropping system of the subtropical region.

Spread of Co 0238 in subtropical India

Co 0238 with its remarkably impressive field stand and agronomic performance, including superior cane yield and juice quality, spread at an exceptionally faster rate in the subtropical region of the country (Table 1). After its release and notification during 2009, the North Indian states started reporting data on area occupied by Co 0238 in successive years and these figures are uniformly available since the 2014–15 season. Accordingly, the area under this variety increased from 2.70 lakh ha (2014–15) to 25.88 lakh ha (2019–2020) in the subtropical region, which is the highest ever area (79.15%)

occupied by a single variety in the country in a short span of five years. The share of Co 0238 in the total sugarcane area in the country is 53.18%. Apart from the five subtropical states, the variety has occupied a sizable area in Gujarat, Madhya Pradesh and Odisha. This area increase of Co 0238 has made the subtropical region the major sugarcane-producing area in the country. Before the introduction of Co 0238 in 2012–13, the share of the subtropical region in sugarcane area and production of the country was 55.8% and 49.4% respectively, and with Co 0238 occupying a sizable area during 2017–18, the figures increased to 59.6% and 57.9% respectively. The very fact that no other sugarcane variety developed so far has spread rapidly over large areas in the country is a clear testimony of the merit in terms of farmers' acceptability and reliance of sugar factories on Co 0238.

Impact on cane yield and sugar recovery

Subtropical region

The impact of Co 0238 on cane yield and sugar recovery percentage in the subtropical states was assessed during 2014–15 to 2017–18, with 2013–14 as the base year. Area under this variety increased from 9.84% (2.72 lakh ha) in 2014–15 to 50.4% (14.75 lakh ha) in 2017–18 (Table 1). The improvement in cane yield was maximum in Bihar. Improvement in cane yield varied from 10.1 t/ha in Punjab to 18.0 t/ha in Bihar (Table 2), whereas improvement in sugar recovery varied from 0.65 units in Punjab to 1.67 units in UP.

Table 1. Area (ha) under Co 0238 in subtropical India

State	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19	2019–2020
Punjab		26,683 (27.8)	52,075 (52.0)	60,018 (60)	62,184 (62.77)	87,000 (63.66)	87,000 (63.66)	78,306 (66.10)
Haryana	3,866 (3.7)*	13,831 (12.6)	22,503 (19.0)	36,459 (29.0)	58,004 (39.45)	93,772 (54.15)	95,825 (60.46)	83,937 (60.20)
Uttarakhand	612	1574 (1.4)	3617 (3.7)	8281 (8.9)	14,451 (17.01)	27,708 (32.20)	55,642 (59.87)	64,303 (75.71)
Uttar Pradesh		72,623 (3.1)	176,763 (8.3)	402,719 (19.6)	728,604 (35.47)	1,208,081 (52.55)	1,928,451 (69.02)	2,202,385 (82.21)
Bihar	1,795 (0.7)		17,170 (5.5)	19,279 (9.3)	35,592 (15.8)	57,961 (24.87)	136,847 (45.35)	159,198 (64.12)
Total area of Co 0238	6,273 (0.2)	114,716 (4.3)	272,128 (9.84)	526,756 (20.43)	896,834 (34.53)	1,474,522 (50.36)	2,303,765 (66.13)	2,588,129 (79.15)
Total area of sugarcane	2,996,734	2,676,008	2,764,547	2,578,278	2,626,030	2,928,001	3,483,904	3,269,933

*Figures in parenthesis indicate values in percentage.
Source: Offices of Cane Commissioners of the respective states.

Table 2. Impact of Co 0238 on cane yield (t/ha) and sugar recovery (%) in different subtropical states

State	Year of introduction	Character	Before introduction of Co 0238	2017–18	Improvement
Uttar Pradesh	2013–14	Cane yield (t/ha)	61.6	79.2	17.6
		Recovery (%)	9.18	10.85	1.67
Haryana	2012–13	Cane yield (t/ha)	73.3	84.5	11.2
		Recovery (%)	9.10	10.35	1.25
Punjab	2013–14	Cane yield (t/ha)	71.3	81.4	10.1
		Recovery (%)	9.13	9.78	0.65
Bihar	2014–15	Cane yield (t/ha)	49.9	67.9	18.0
		Recovery (%)	8.48	9.54	1.06
Uttarakhand	2014–15	Cane yield (t/ha)	57.1	69.3	12.2
		Recovery (%)	8.89	10.24	1.35

Source: Offices of Cane Commissioners of the respective states.

Table 3. Cane yield, sugar recovery and rainfall in the tropical states

Year	Cane yield (t/ha)	Sugar recovery (%)	Rainfall (mm)
Gujarat			
2013–14	72.1	11.10	1006.5
2014–15	68.9	10.35	605.6
2015–16	70.8	10.39	677.6
2016–17	70.7	10.58	763.0
Karnataka			
2013–14	90.3	11.09	1235.6
2014–15	91.2	11.03	1238.5
2015–16	84.1	10.74	1024.6
2016–17	69.0	10.25	849.9
Maharashtra			
2013–14	82.1	11.57	1409.8
2014–15	82.2	11.28	1001.6
2015–16	74.7	11.33	875.7
2016–17	82.6	11.34	900.0
Tamil Nadu			
2013–14	103.7	8.32	740.9
2014–15	106.8	8.67	911.3
2015–16	101.2	8.74	1204.5
2016–17	87.1	9.05	530.0

National level

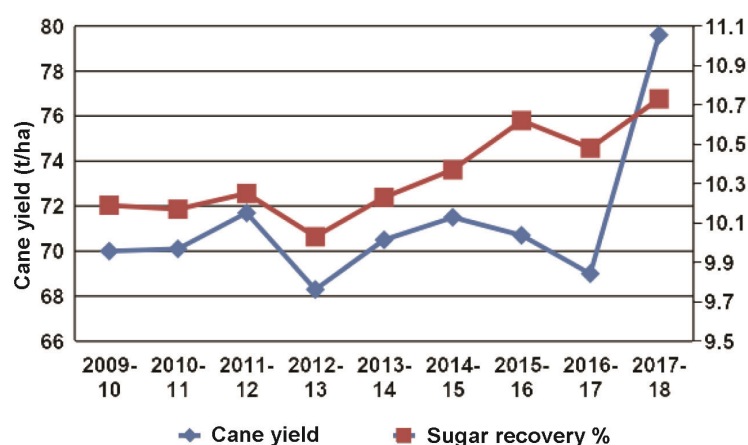
Impact of the increase in area of Co 0238 (from 2.70 lakh ha in 2014–15 to 14.75 lakh ha in 2017–18) was observed not only in individual states, but also at the national level. There was linear impact of increasing area under the variety on the national average sugar recovery (Figure 1). Slight reduction in sugar recovery was observed during 2016–17 in comparison with the previous year, which might be due to reduction in sugar recovery of the tropical states (Karnataka, Maharashtra and Gujarat) (Table 3). Similarly, cane productivity in the country also increased with increase in area of Co 0238 from 2012 to 2013 onwards, except the declining trend observed during 2015–16 and 2016–17. It is worth mentioning here that Maharashtra and Karnataka experienced unprecedented

Table 4. Quantity of cane and sugar produced and their values from 2014–15 to 2017–18

State	Cane produced (lakh tonnes)	Value of cane (₹ in crores)	Sugar produced (lakh tonnes)	Value of sugar (₹ in crores)
Uttar Pradesh	2,267.3	71,332	271.0	99,651
Punjab	200.9	6,021	19.6	6,987
Haryana	170.0	5,477	17.6	6,407
Bihar	77.4	2,298	7.3	2,653
Uttarakhand	35.0	1,109	3.5	1,284
Total	2,750.6	86,237	319.0	116,982

Table 5. Additional benefit to farmers and sugar mills (2014–15 to 2017–18)

State	Additional cane produced (lakh tonnes)	Additional benefit to farmers (₹ in crores)	Additional sugar produced (lakh tonnes)	Value of additional sugar and by-products (₹ in crores)	Yearly additional benefit (₹ in crore)
Uttar Pradesh	400.1	12,515	62.84	26,729.0	6,682.25
Punjab	16.8	509	1.30	610.3	152.58
Haryana	15.6	508	2.10	897.5	224.38
Bihar	13.5	412	0.75	381.7	95.43
Uttarakhand	4.1	132	0.39	176.2	44.05
Total	450.1	14,076	67.38	28,794.7	7,198.69

**Figure 1.** Average cane yield and sugar recovery in India.

drought during the 2015–16 and 2016–17 seasons which appreciably reduced the cane yield, particularly 2015–16 in Maharashtra (74.7 t/ha) and 2016–17 in Karnataka (69 t/ha). However, the effect of drought in Maharashtra during 2016–17 was mitigated by large-scale adoption of drip irrigation. Similarly, drought in Tamil Nadu during 2016–17 resulted in reduction in cane yield to 87.1 t/ha (Table 3). Hence, it is evident that the spread of Co 0238 in the subtropical states not only compensated for the reduction in cane yield and sugar recovery in the tropical states, but also led to

overall improvement at the national level.

Economic impact of Co 0238

Gross economic value

Economic impact of Co 0238 was assessed based on its area covered in the five subtropical states (Uttar Pradesh, Punjab, Haryana, Bihar and Uttarakhand) from 2014–15 to 2017–18. During this period, 2750.6 lakh tonnes cane of ₹ 86,237 crores value and 319.0 lakh tonnes sugar

worth ₹ 116,982 crores were produced from Co 0238 (Table 4). This variety also produced 357.6 lakh tonnes fodder fetching ₹ 1848 crores, 123.8 lakh tonnes molasses worth ₹ 5249 crores, 825.2 lakh tonnes bagasse worth ₹ 16,257 crores and 8.3 lakh tonne of pressmud worth ₹ 16.3 crores. The cumulative gross value of Co 0238 from sugar and additional quantity of its by-products was estimated to be ₹ 120,770 crores during the four years of its cultivation.

Additional profit to farmers and sugar mills

By virtue of its high yielding potential, Co 0238 has produced additional 450.1 lakh tonnes sugarcane worth ₹ 14,076 crores during 2014–15 to 2017–18 (Table 5). Similarly, higher sugar recovery of Co 0238 led to the production of an additional 67.38 lakh tonnes sugar worth ₹ 25,007 crores.

Co 0238 yielded an additional return of ₹ 28,795 crores in four years (2014–15 to 2017–18) from sugar and by-products (58.5 lakh tonnes of fodder worth ₹ 305 crores, 135.0 lakh tonnes of bagasse worth ₹ 2643 crores, 20.3 lakh tonnes of molasses worth ₹ 837 crores and 1.35 lakh tonnes of pressmud worth about ₹ 2.7 crores). Hence, the total

additional benefit from sugar and by-products was estimated to be ₹ 7199 crores per year. During this period, Co 0238 has fetched an additional return of ₹ 14,381 crores to the farmers (from sugarcane and fodder) in Uttar Pradesh, Punjab, Haryana, Bihar and Uttarakhand. As a result, the profit of farmers increased by about ₹ 45,405/ha. The economic surplus model was fitted to estimate the total gain to society/economy due to adoption of Co 0238, and its distribution among consumers and producers. Accordingly, the total annual economic gain (surplus) was Rs 10,064.3 crores, distributed in the share of 40 : 60, between the consumers and producers respectively.

In the context of the Government of India's priority of doubling the income of farmers, Co 0238 has made a significant contribution. Mere cultivation of Co 0238 brings ₹ 45,405/ha additional in-

come and with the adoption of more crop husbandry packages, including intercropping and wide row spacing, Co 0238 has the potential of multifold increase in the income of farmers, as has already been demonstrated by 12 farmers associated with ICAR-SBI.

Co 0238 has greatly contributed towards achieving the 32.1 mt sugar production (about 7 mt in excess than the consumption) in the country during 2017–18, which in turn led to a policy decision by the Government on permitting direct conversion of sugarcane juice into ethanol. Recent reports are more encouraging. A record sugar production of 33.2 mt was reported during 2018–19 season.

Aforesaid analysis illustrates how a single technology could bring about tremendous impact at the national level. Co 0238 thus has brought in a 'sweet revolution' benefitting lakhs of farmers, and for

the sugar industry which has been in the doldrums, this variety is bringing fresh cheer and hope. Crossing the zonal boundaries, this wonder variety continues to elevate the living conditions of lakhs of Indian sugarcane farmers. Co 0238 thus stands as a quotable example of the power of plant breeding to bring about drastic surge in agricultural production and farmers' economic condition, thereby improving the national economy. A technology easily acceptable, and cheaply adoptable, varieties like Co 0238 reinforces the need for investments in plant breeding research to reap multifold benefits to agrarian countries like India.

Bakshi Ram and G. Hemaprabha are in the ICAR-Sugarcane Breeding Institute, Coimbatore 641 007, India.*

**e-mail: bryadav2003@yahoo.com*

Imported superfood quinoa versus Indian nutriceal millets

Annvi Dhaka and Manoj Prasad

Millets are highly nutritious cereal crops that have been the traditional crops of our ancestors for ages. However, with the popularization of other cereal crops, we started to lose interest in these nutritious traditional crops irrespective of their numerous health benefits. Further, the absence of adequate processing technologies and government policies have added to this negligence. In addition to this, globalization has introduced foreign cereals to Indian markets. There is a need to emphasize the development and proliferation of millets since these crops are capable of fulfilling nutrient requirements of every section of society and are well suited to the geographical conditions of our country.

Superfoods are those food items that are either nutritionally rich or contain bioactive phytochemicals and provide added health benefits¹. This definition allows including grains like millets, quinoa, oats, amaranth, chia seeds, banana, avocado, spinach, berries, lentils and many others into the category of superfoods². Increasing research and awareness have inspired people around the world to include superfoods in their daily diets. Globalization has allowed people the option to choose among various types of superfoods outside their geographical boundaries (<https://agritrop.cirad.fr/575493/>). This has flooded the food markets with all kinds of superfood varieties of the world. Big brands such as Quakers and Kelloggs have been successful in making

oats, quinoa, and similar products accessible to the Indian consumers. On the other hand, native varieties of superfoods like millets and amaranth are still struggling to make it to the shelves of shops and homes. Among various grains of foreign origin, quinoa and oats have captured a significant portion of the Indian food market.

Quinoa (*Chenopodium quinoa*) is native to Latin America and has been grown for the last 5000 years. It was still a local crop until the 1990s when research into its potential led quinoa to spread to other countries. Quinoa is a member of the Goosefoot family (Chenopodiaceae) and is considered a superfood because of its high protein value. NASA's CELSS Programme included

quinoa feed for long-duration human space flights (<https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19940015664.pdf>).

Due to its excellent nutritional content, the primary use of quinoa seed is consumption. The protein content in quinoa seeds varies from 13.8% to 16.5% (ref. 3). All of the 10 essential amino acids are present in significant amounts in quinoa seed. The carbohydrate source is starch and falls in the range of 58.1–64.2%, with 11% amylose constituent⁴. With high mineral contents like calcium, magnesium, iron, copper and zinc, quinoa can be a constituent of a balanced human diet⁵. When compared to other crops like wheat, rice and barley, quinoa has a high amount of riboflavin (B2), α -tocopherol (vitamin E), and carotene. Oil