Research Article:

EVALUATION OF RATOON MANAGEMENT PRACTICES FOR CANE YIELD AND JUICE QUALITY OF SUGARCANE RATOON

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ABSTRACT

Sugarcane is an important industrial crop in Nepal. Low plant population in ratoon crops is a major constraint that reduces cane number and lowers yield. An experiment was conducted in Nawalparasi (west) to evaluate effect of different ratoon management strategies on cane yield and juice quality of sugarcane. A two-factor randomized complete block design was employed to evaluate two fertilizer placement methods (band placement and broadcasting) in combination with seven ratoon management practices: control (M1), earthing up (M2), stubble shaving (M3), M2 + M3 (M4), M4 + off-barring (M5), trash mulching (M6), and M5 + M6+ *Trichoderma* (M7), replicated thrice. Results showed non-significant effect of both the factors on cane length, cane diameter, millable canes and single cane weight. Interaction effect was significant on millable canes and cane yield where combined ratoon management practices (M7) along with band placement of fertilizers recorded the highest value. Major quality traits remain unaffected due to treatments. Sugar yield (5.88 t/ha) from band placement was superior to broadcasting. Also, combined ratoon management practices (M7) resulted the highest sugar yield (6.45 t/ha) while being at par with M6 and M5. Those findings suggested integrated ratoon management strategies for better cane yield and juice quality.

Keywords: Band, broadcast, earthing up, *Saccharum* spp., stubble shaving, trash mulch

INTRODUCTION

Sugarcane (*Saccharum* spp.) is a major industrial crop of Nepal, cultivated over 62,527 ha with an average yield of 50.5 t ha^{-1} (MoALD, 2025). Sugarcane contributes 1.38% to agriculture gross domestic product, the highest by any cash crops grown in the country (MoALD, 2024). In Nepal, sugarcane is primarily grown in the Terai region, particularly across the flat lands of Madhesh, Lumbini, Sudurpaschim, and Koshi Provinces. The crop is the only source of sugar in the nation which is extracted from its juice in sugar mills. Local use of sugarcane for fresh juice, *gud* and *khudo* too is increasing these days. Despite the increasing demand for sugarcane products, the area under sugarcane cultivation has decreased by approximately 31.3% in last 10 years (FAO, 2025), resulting in a rise in annual sugar imports from India. Sugar mills operating in the country fulfills 60% of national demand (NSMA, 2018). On the other hand, limited research on sugarcane production has constrained the development and dissemination of improved varieties and advanced cultivation practices. Consequently, farmers achieve below-potential yields and lower profitability, prompting a shift toward more remunerative alternative

crops (Pokharel et al., 2019). Issues related to minimum support price and subsidy, delay in payments, shortage of labor and quality inputs, low mechanization and irrigation facilities and poor adoption of improved technologies have been major bottlenecks in increasing sugarcane farming in the country (Pandey & Devkota, 2020; Parajuli et al., 2025). Compared to the global average yield of 75 t ha^{-1}, sugarcane productivity in Nepal is approximately 33% lower, which showed a substantial yield gap indicating urgent need for improved crop management practices, technological adoption, and research interventions to enhance national production efficiency (Neupane et al., 2017).

Sugarcane ratooning refers to the regrowth from stubble following the harvest of the main crop. This method allows farmers to grow subsequent crops without replanting, thereby saving production costs by reducing expenditures on seeds, initial land preparation, and labour during the planting, while providing faster maturity and improved benefit-cost ratios (Dlamini et al., 2024). However, the decline in sugarcane ratoon yield is a complex physiological and pathological process arising from the cumulative effects of reduced plant vigor, soil degradation, and higher disease pest attached (Wang et al., 2024; Xu et al., 2021). Mechanical injury to stubble during harvesting, soil compaction, poor drainage, higher disease pest infestation, and nutrient depletion further impair regrowth and root activity, while degrades rhizosphere health for efficient nutrient cycling (Wang et al., 2024). Higher tiller mortality and irregular plant population, particularly in subtropical environments, worsen these issues, leading to a marked reduction in millable cane number and weight.

Several studies indicate that many farmers perceive the ratoon crop as a “gift crop” because it regenerates from the previous planting without the cost of replanting, which often results in minimal management inputs and delayed field operations (Chumphu et al., 2019). This perception contributes to inadequate practices such as poor nutrient application, limited stubble management, and insufficient soil care, ultimately reducing ratoon vigor and yield potential (Singh et al., 2015). Such management neglect has been identified as a key socio-agronomic constraint to improving ratoon productivity in Nepal and other subtropical sugarcane-growing regions. Whereas the improved ratoon management has consistently shown to enhance plant population, cane weight, and overall yield (Gomathi et al., 2013). In many production systems, inadequate management attention to ratoon crops and limited adoption of improved ratoon management practices further widens the gap between potential and realized yield, collectively contributing to the characteristic decline observed in ratoon sugarcane productivity (Dlamini & Zhou, 2022). Poor attention of farmers toward ratoon has led them to harvest a lower-than-potential yield (Prasanna & Pattar, 2014). Also, limited research activities on sugarcane ratoon management have left the field vacant to identify proper technologies adoptable by Nepalese farmers.

Integrated ratoon management, combined with precise fertilizer placement methods, significantly improved the sugarcane yield. Effective fertilizer management from the aspect of placement, ensures the immediate availability of nutrients to regenerating buds and their initial weak ratoon root system, which results in the uniform sprouting and promotes strong tillering ability (De Castro et al., 2023). Crop management like earthing up improves soil aeration, moisture conservation, and root anchorage, while off-barring lowers the soil compaction to enhance the root growth. Furthermore, stubble shaving removes physically damaged and diseased tissue from the previous harvest. This practice reduces the sprouting from the node left above the soil surface, which is assumed as the weak because the root system is weak and tillers are susceptible to lodge even in the mild wind velocity. It also removing a key source of inoculum for pathogens and promotes healthier, more uniform bud emergence. The integration

of trash mulching enhances these effects by moderating soil temperature, conserving moisture, and contributing organic matter to boost soil biological activity and microbial diversity. The application of biocontrol agents such as *Trichoderma* further strengthens the rhizosphere microbiome, suppressing soil-borne pathogens and improving nutrient cycling (Kumar et al., 2024). Collectively, these integrated practices reduce tiller mortality, increase the population of millable canes, and improve overall resource-use efficiency, thereby directly countering the multi-causal factors including reduced vigour, soil degradation, and disease pressure that drive ratoon yield decline (Gomathi et al., 2013). A major gap in Nepalese sugarcane farming is that ratoon cane is still managed with traditional, low-input practices, while the crop already faces lower productivity, weak nutrient management, and delayed or uneven field operations. Integrated practice is necessary as it tests a combined, locally adapted ratoon management approach rather than single interventions, which is important for Nepal's high-potential but underperforming sugarcane systems. In this regard, field research was carried out in Ramgram-17, Nawalparasi (West), to assess the effect of fertilizer placement methods and various ratoon management practices on cane yield and juice quality of sugarcane.

RESEARCH METHODS

The experiment was set up immediately after the harvest of main crop (January 2024) in farmers field and treatments were applied on varying date. The research was designed as randomized complete block comprising 14 treatments replicated thrice in plot size of 21.6 m^2. Rows were distanced at 90 cm. Space between adjacent plots and blocks was 1 m. The experimental treatments were structured as a two-factor combination comprising fertilizer placement method and ratoon management practices. Two fertilizer placement methods were: band application (P1) and broadcasting (P2); and seven ratoon management practices were: control (M1), earthing up (M2), stubble shaving (M3), earthing up combined with stubble shaving (M4), earthing up combined with stubble shaving and off-barring (M5), trash mulching at 6 t ha^{-1} (M6), and earthing up combined with stubble shaving, off-barring, and trash mulching with *Trichoderma* application at 10 ml L^{-1} (M7). These factors were analysed factorially to evaluate their interactive and individual effects. Soil of research site (27º51' N 83º70' E, 116 masl) was loamy (sand 37.38%, silt 41.30% and clay 21.32%). Total rainfall during crop period was 1907.45 mm.

Urea, DAP and MoP were applied as fertilizers with dose of 200:60:100 N, P_2O_5, K_2O kg/ha. A narrow band was made 5 cm away from cane clump using hoe and fertilisers were put 2-3 cm below soil and covered with soil. Commercial formulation of *Trichoderma viride* (10^8 cfu/ml) was sprayed over trash mulch using knapsack sprayer. Light irrigation was done in field prior to application of treatments. 50 % RDF was applied as basal dose on first week whereas remaining 50 % was applied in 9th week after harvest of main crop. Earthing up was done after two months of harvest while stubble shaving, off-baring, Trash Mulching and *Trichoderma* spray (10 ml/ litre) were done within 10 days of harvest. CO 98014, an early maturing sugarcane variety, was used in the experiment. Harvesting was done in December 2024.

Observation on yield attributes and yield were recorded from 10 randomly selected plants from each plot at harvest. Cane length was taken from sampled canes after detoping and detrashing. Cane diameter was measured using vernier slide caliper from top, middle and bottom portion of cane and averaged out. Number of millable canes were counted manually from 3 square meter area of each plot before harvest and converted to hectare.

Weight of ten detopped and detrashed canes were taken with weighing balance and averaged to calculate single cane weight. Selected samples were crushed for juice extraction and quality test of juice was done as per ICUSMA standards. Brix value was recorded using brix hydrometer and readings were corrected to room temperature. Pol values were observed in polarimeter using clear filtrate obtained from dry lead acetate method. Pol percentage was calculated from Schmitz's table using brix and pol readings. MS excel and R studio (V 4.5.2) were used for tabulation and analysis of data.

RESULTS AND DISCUSSION

Data of cane length, cane diameter, number of millable canes, single cane weight and cane yield are shown in Table 1. Results showed that cane length, cane diameter remain unaffected due to different fertilizer application methods and ratoon management practices. However, band application of fertilizers and combination of different ratoon management practices (M7) performed better in this study. Band placement resulted in greater cane length (187 cm) and diameter (1.93 cm). Also, integrated ratoon management practices (M7) recorded maximum cane length (198.83 cm) and cane diameter (1.97 cm). Number of millable canes were also higher with band application (P2) and combined ratoon management practices (M7). Although there was no noticeable difference due to different factors alone, their interaction effect of fertilizer placement methods and the ratoon management practices was significant for number of millable canes (Fig. 1). Better nutrient uptake through band placement of fertilizers and various ratoon management practices promoted cane length and diameter through increased vegetative growth and profuse tillering (Johnston & Bruulsema, 2014; Kumar et al., 2023). Graham et al. (2002) opined that improved soil structure, nutrient mineralization, soil floral and faunal activities due to trash mulch is vital for suitability of sugarcane ratoon.

Single cane weight was unaffected by broadcast and band application of fertilizers. Yet, localized placement of fertilizers produced cane with higher weight (516.97 g). Compared to control, when sugarcane ratoon was managed with combined application of earthing up, stubble shaving, off-baring and trash mulch with *Trichoderma* (M7), 22.1% increment was observed in single cane weight. Among different ratoon management practices, the highest single cane weight (532.85 g) was observed in M7 which was statistically similar to all other treatments. Increase in soil porosity, deep root penetration, improved organic matter content due to cultural management practices of ratoon led to better plant growth and yield (Bhargavi et al., 2024; Singh et al., 2008).

Table 1. Effect of fertilizer application methods and ratoon management strategies on yield attributes and cane yield of sugarcane ratoon in Nawalparasi (west), 2024

Treatments	Cane length (cm)	Cane diameter (cm)	Millable canes ('000/ha)	Single cane weight (g)	Cane yield (t ha^{-1})
Fertilizer application methods					
Broadcast (P1)	179.67	1.91	102.68	494.83	49.18[b]
Band (P2)	187.04	1.93	105.10	516.97	53.31[a]
SEm (±)	3.832	1.505	2.984	14.56	0.359
$LSD_{0.05}$	ns	ns	ns	ns	1.04***
Ratoon management practices					
Control (M1)	170.66	1.86	94.41	436.19	44.76[d]
Earthing up (M2)	172.00	1.91	95.12	513.33	45.90[d]
Stubble shaving (M3)	178.33	1.93	106.41	486.54	47.93[c]
M2 + M3 (M4)	181.33	1.93	107.55	514.28	55.82[b]
M4 + Off-barring (M5)	188.33	1.96	113.40	526.31	56.56a[b]
Trash mulching (M6)	194.00	1.94	95.72	531.67	49.67[c]
M5 + Trash mulch and *Trichoderma* (M7)	198.83	1.97	114.63	532.85	58.08[a]
SEm (±)	7.16	2.81	5.58	27.25	0.67
$LSD_{0.05}$	ns	ns	ns	ns	1.95***
CV, %	9.57	3.57	13.16	13.20	3.21
Grand mean	183.35	1.93	103.89	505.90	51.25

Notes: Treatments mean sharing the common letter (s) within column are not significantly different among each other according to DMRT at 5% level; t, ton: ha, hectare;/, per; ns, non-significant; SEm, standard error of mean; LSD, least significant difference; CV, coefficient of variation; :*,** and *** represent level of significance at 5,1 and 0.1 % respectively.

In sugarcane ratoon, fertilizer application methods, ratoon management practices, and their interaction displayed highly significant effect on yield. Band and broadcast application of equal fertilizers resulted in 53.31 and 49.18 t/ha cane yield, respectively. Band placement exerted statistical superiority over broadcast method. Kumar et al. (2023) observed improved yield attributes and cane yield of ratoon sugarcane due to reduced nutrient loss via erosion, fixation and other losses in band placement compared to surface application. In ratoon management practices, control plot (M1) recorded the lowest cane yield (44.76 t/ha) though it stood at par with earthing up (45.90 t/ha). Yield from trash mulched (M6) and stubble shaved (M3) plots were at par to each other but superior to control (M1) and earthing up (M2). Stubble shaving accelerated bud sprouting and facilitated root growth from underground buds whereas earthing up, off-baring, and trash mulching favored moisture and organic matter retention, improved soil health, suppressed weed and disease that positively affected ratoon yield (Singh et al., 2012; Sundara, 2006).

Interaction results indicated that number of millable canes were statistically higher and similar when each ratoon management practices was done with band application whereas the significant dropped in the number of millable canes with control, earthing up and trash mulching when fertilizer was applied with the broadcasting methods (Fig. 1). Band application concentrates nutrients near the active root zone, improving uptake efficiency in ratoon crops where root proliferation is limited by stubble decay and soil compaction (Jaiswal et al., 2025). In contrast, broadcasting of fertilizers leads to nutrient fixation in surface soils and losses through volatilization or leaching, resulting in the observed decline in millable cane numbers under control, earthing up, and trash mulching treatments. In subtropical conditions like Nepal, where

sugarcane ratoons often face nutrient dilution from harvesting during the dry season, band application of fertilizers is suitable for resource-poor farmers aiming to sustain productivity beyond the plant crop.

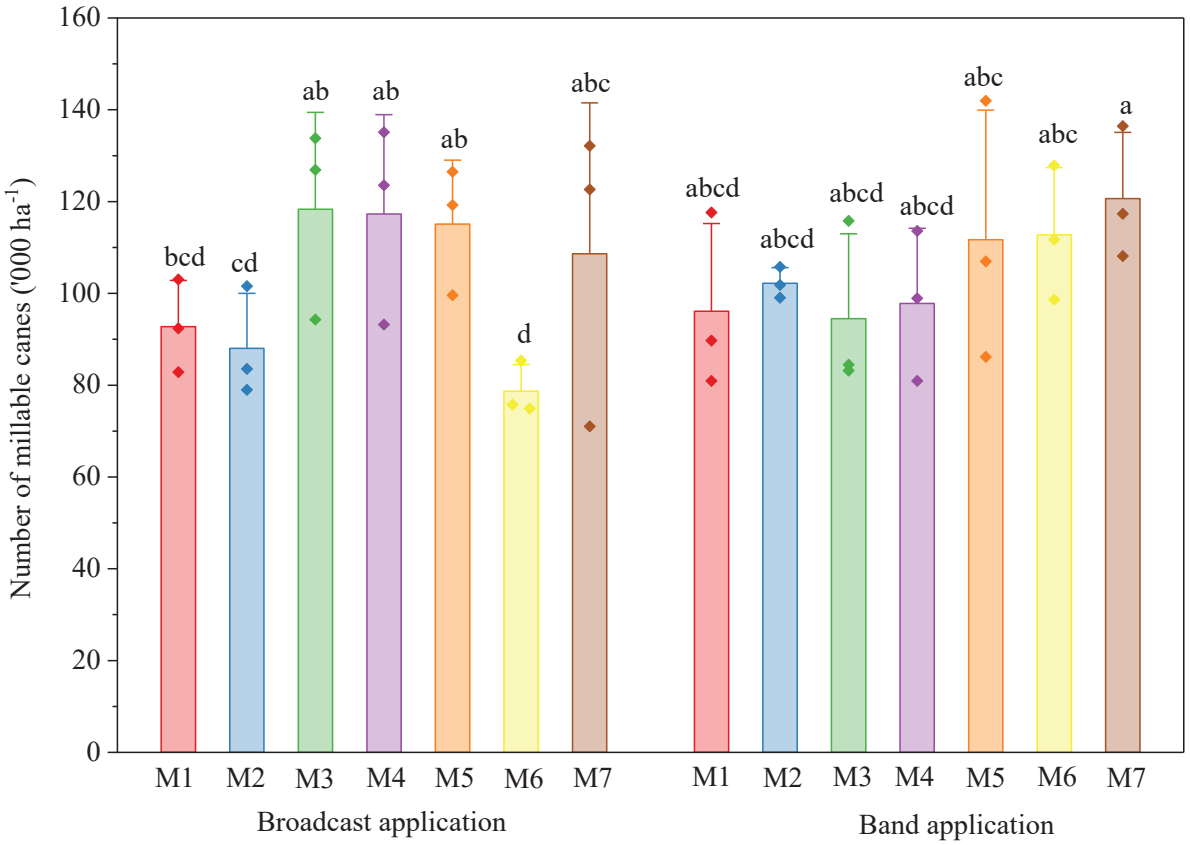

Fig. 1. Interaction effect of fertilizer application methods and ratoon management practices on number of millable canes of sugarcane ratoon in Nawalparasi (west), 2024

Notes: Treatments mean sharing the common letter (s) are not significantly different among each other according to DMRT at 5% level. M1, control; M2, earthing up; M3, stubble shaving; M4, M2+M3; M5, M4 + off barring; M6, trash mulching; M7, M5 + M6 + *Trichoderma*.

Higher yield was obtained when fertilizers were band placed along with combined ratoon management treatments M5 (earthing up, stubble shaving and off bearing) and M7 (earthing up, stubble shaving, off bearing, trash mulching and *Trichoderma*) (Fig. 2). Liu et al. (2024) reported improvement in sugarcane yield (37.1%) through integrated field management strategies. These integrated practices promote tiller vigor and cane elongation by reducing the physical barriers to root and shoot growth. Like, earthing up break the hard layer and conserves moisture, stubble shaving reduces the problems of forming the poor tillers, i.e. tillering from the node above the soil, and disease pressure, trash mulching suppresses weeds while recycling organic matter, and *Trichoderma* mitigates fungal pathogens in humid environments and improve the nutrient and water uptake in the drier season (Yadav et al., 2009; Xu et al., 2021). Comparable yield boosts from band fertilization in ratoons have been reported in tropical systems, with gains of 15-25% over broadcasting due to better nutrient supplement in the root system (Jaiswal et al., 2025).

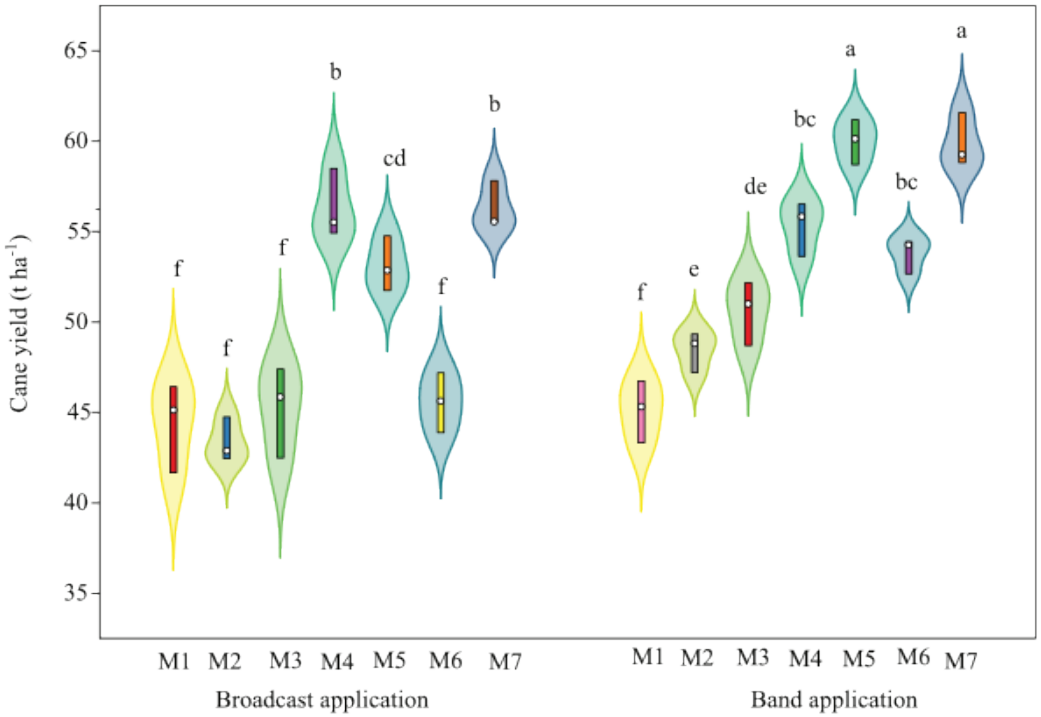

Fig. 2. Interaction effect of fertilizer application methods and ratoon management practices on cane yield of sugarcane ratoon in Nawalparasi (west), 2024

Notes: Treatments mean sharing the common letter (s) are not significantly different among each other according to DMRT at 5% level. M1, control; M2, earthing up; M3, stubble shaving; M4, M2+M3; M5, M4 + off barring; M6, trash mulching; M7, M5 + M6 + *Trichoderma*.

Data related to juice quality parameters and sugar yield are shown in Table 2. Results revealed non-significant effect of both factors on juice recovery, brix, and pol percentage. Contrastingly, sugar yield was affected by both the factors. Band application of fertilizer enhanced juice recovery rate of sugarcane ratoon. In case of ratoon management activities, juice recovery ranged from 55.58 to 58.98%, with the highest and the lowest recovery rate recorded on M7 and M1 treatments, respectively. Brix, a measure of total soluble solid in cane juice, did not vary due to treatments. Similarly, Pol percentage, a measure of sucrose percentage in cane juice, too remained unaffected with the application of various treatments. However, both of those quality traits were numerically higher when fertilizers were applied in band (18.54 and 16.05%) and combined ratoon management practices were applied. Improvement in brix and pol value indicates better sucrose accumulation in stalk, which is crucial for better sugar recovery. Unlike those aforementioned quality traits, sugar yield varied significantly due to both factors. Band placement of fertilizers resulted in 8.5% higher sugar yields compared to broadcasting the same quantity. Sugar yield ranged from 4.92 to 6.45 t/ha due to different ratoon management practices. Combined application of various ratoon management practices (M7) registered the highest sugar yield (6.45 t/ha) though it is statistically similar to M5 and M6 but superior to all other treatments. Compared to control, when earthing up and stubble shaving were done in ratoon (M4), it produced 6.3% higher sugar yield, which further rose to 29.4% when off-barring was added (M5). Those results are consistent with findings of Bhilala et al. (2023). Application of fertilizers in band, near crop root zone ensures higher nutrient uptake which lead to greater biomass accumulation and ultimately the yield (Nkebiwe et al., 2016) . Nutrient management practices improve photosynthetic efficiency, enzyme activity, and sucrose translocation to the stalk, thereby increasing brix and pol values in sugarcane (Banerjee et al., 2024). Stubble shaving, earthing up, and *Trichoderma*-treated trash mulch boost brix (total soluble solids) and

pol (sucrose content) in sugarcane ratoons by enhancing nutrient uptake, root health, and sugar partitioning while minimizing stresses that dilute juice quality (Kumar et al., 2024; Singh et al., 2008; Singh et al., 2019).

Table 2. Effect of fertilizer placement methods and ratoon management practices on juice quality and sugar yield of sugarcane in Nawalparasi (west), 2024

Treatments	Juice recovery (%)	Brix (%)	Pol (%)	Sugar yield (t ha^{-1})
Fertilizer application methods				
Broadcast (P1)	56.31	18.29	16.04	5.42
Band (P2)	57.61	18.54	16.05	5.88[a]
SEm (±)	1.57	0.35	0.20	0.20
$LSD_{0.05}$	ns	ns	ns	0.31**
Ratoon management practices				
Control (M1)	55.58	17.29	15.36	4.92[b]
Earthing up (M2)	57.87	18.18	15.94	5.10[b]
Stubble shaving (M3)	57.61	18.42	16.01	5.21[b]
M2+M3 (M4)	57.16	18.45	16.04	5.23[b]
M4 + Off-barring (M5)	57.61	18.63	16.37	6.37[a]
Trash mulching (M6)	57.87	18.61	16.19	6.30[a]
M5 + Trash mulch and *Trichoderma* (M7)	58.98	18.68	16.40	6.45[a]
SEm (±)	0.84	0.17	0.38	0.11
$LSD_{0.05}$	ns	ns	ns	0.59***
CV, %	6.75	3.47	5.84	8.83
Grand mean	57.12	18.41	16.04	5.65

Notes: Treatments mean sharing the common letter (s) within column are not significantly different among each other according to DMRT at 5% level; t, ton; ha, hectare; /, per; NS, non-significant; SEm, standard error of mean; LSD, least significant difference; CV, coefficient of variation; :*,** and *** represent level of significance at 5,1 and 0.1 % respectively.

CONCLUSION

The study demonstrated that although individual effects of fertilizer placement and ratoon management practices were mostly non-significant for yield attributes and juice quality parameters, their interaction significantly influenced number of millable canes and cane yield. Sugar yield was significantly influenced by fertilizer application method and ratoon management practices where 31% difference was observed between control and the best treatment. Band placement of fertilizers consistently outperformed broadcasting in terms of cane and sugar yield. Among ratoon management strategies, the integrated approach (M7) produced the highest cane and sugar yields while maintaining juice quality. This study concludes that integrated ratoon management is essential for improving sugarcane yield, juice quality, and sugar recovery in Nepal. Such practices will help to build a more resilient, profitable, and sustainable sugarcane farming. Further researches on time and dose of fertiliser application, use of different biofertilizers, mechanisation of different ratoon management practices are necessary to enhance productivity of sugarcane ratoon.

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AUTHOR CONTRIBUTIONS

TP: Conceptualization, Investigation, Formal analysis, Data curation, Writing – original draft; **SM:** Conceptualization, Methodology, Writing – review & editing, Supervision; **LPA:** Conceptualization, Methodology, Writing – review & editing, Supervision; **SCD:** Conceptualization, Methodology, Writing – review & editing, Supervision.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICAL APPROVAL AND PERMITS

Not applicable.

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