E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(1): 554-557
Received: 11-11-2025
Accepted: 15-12-2025

Deshmukh PS
Vasantdada Sugar Institute, Pune, Maharashtra, India

Konde KS
Vasantdada Sugar Institute, Pune, Maharashtra, India

Kharade JP
Vasantdada Sugar Institute, Pune, Maharashtra, India

Sable SK
Vasantdada Sugar Institute, Pune, Maharashtra, India

Patil SS
Vasantdada Sugar Institute, Pune, Maharashtra, India

Khopde AS
Vasantdada Sugar Institute, Pune, Maharashtra, India

Corresponding Author:
Deshmukh PS
Vasantdada Sugar Institute, Pune, Maharashtra, India

Comparative evaluation of conventional and alternative potash sources on growth, yield, quality, and economics of sugarcane (*Saccharum officinarum* L.) in black cotton soil

Deshmukh PS, Konde KS, Kharade JP, Sable SK, Patil SS and Khopde AS

DOI: https://www.doi.org/10.33545/2618060X.2026.v9.i1h.4731

Abstract
A study was conducted at Vasantdada Suagr Institute, Pune, Maharashtra, to evaluate the effects of conventional and alternative potassium sources on sugarcane growth, yield, juice quality, and economic returns. The experiment involved nine treatments applied in a randomized block design with three replications using variety Co 86032. Treatments included muriate of potash (MOP), potash derived molasses (PDM), and incineration ash, applied via general recommended dose of fertilizers (GRDF). The highest cane yield (142.4 t ha^{-1}), CCS yield (20.5 t ha^{-1}), and millable cane count (99.9 thousand ha^{-1}) were achieved under GRDF with PDM, statistically similar to MOP and incineration ash treatments. Juice quality parameters (Brix, Pol, Purity, CCS%) remained unaffected by the potassium source. Economic evaluation showed maximum benefit cost ratio of 2.72 with PDM. These results indicate that molasses-derived potash and incineration ash can serve as effective, sustainable alternatives to conventional MOP for sugarcane cultivation in black cotton soils.

Keywords: Sugarcane, potash sources, molasses-derived potash, incineration ash, Yield, CCS, economics

Introduction
Sugarcane (*Saccharum officinarum* L.) is a major industrial crop cultivated extensively in tropical and subtropical regions, contributing substantially to global sugar and bioenergy production. In India, particularly in Maharashtra, sugarcane serves as the backbone of the cooperative sugar industry and plays a critical role in sustaining rural livelihoods (Singh *et al.*, 2015) [18]. Due to its long growing period and high biomass accumulation, sugarcane has a high nutrient requirement and is known for large removals of essential nutrients, especially nitrogen (N), phosphorus (P), and potassium (K), from the soil (Malavolta 2006) [8]. Among these, potassium is vital for regulating physiological and biochemical processes including photosynthesis, enzyme activation, assimilate translocation, stomatal regulation, and plant water relations, and it enhances tolerance to biotic and abiotic stresses. Adequate potassium nutrition is therefore indispensable for achieving higher cane yield, improved juice quality, and enhanced sugar recovery (El-Tilib *et al.*, 2004; Orlando Filho *et al.*, 2010) [4, 11].
In sugarcane cultivation, muriate of potash (MOP) is the most widely used potassium fertilizer. However, escalating fertilizer prices, heavy dependence on imported potassic fertilizers, and concerns about long-term soil health have created an urgent need to explore alternative, sustainable sources of potassium that are locally available. Recycling industrial by-products as nutrient sources has gained attention in sustainable agriculture and circular economy frameworks (Schröder *et al.*, 2011; Cordell *et al.*, 2015) [14, 3].
The sugar and distillery industry generates large quantities of distillery spent wash, which is rich in organic matter and potassium. Improper disposal of spent wash poses serious environmental risks due to its high organic load, salinity, and oxygen demand. To mitigate these impacts, the Maharashtra Pollution Control Board (MPCB) mandates treatment of spent wash through processes such as evaporation, drying, incineration, and granulation before agricultural use. Although processed spent wash powder is considered safer than liquid spent wash, its direct

application in soil is constrained by physical limitations. The spent wash powder is highly hygroscopic and sticky, and its fine particle size promotes soil surface sealing, which detrimentally affects soil aeration and infiltration, and complicates uniform field application. Therefore, granulation of spent wash powder is essential to improve its physical characteristics, handling properties, and agronomic suitability as a potassium fertilizer.

The granulated product, commonly referred to as potash derived from molasses (PDM), contains appreciable amounts of potassium along with organic carbon and secondary nutrients. The application of PDM granules has the potential to enhance soil physicochemical properties, stimulate microbial activity, and improve nutrient availability, thereby contributing to improved soil fertility and crop performance (Pathak *et al.*, 2011; Selvakumar *et al.*, 2018) [12, 15]. Presently, commercially available PDM fertilizer is predominantly produced from spent wash incineration ash. However, the utilization of processed spent wash powder for the formulation of PDM fertilizer represents an emerging technological opportunity to develop an alternative potassic nutrient source with higher organic carbon content, improved nutrient use efficiency, and greater potential for sustainable and environmentally compliant nutrient recycling in sugarcane production systems.

A significant concern associated with the agricultural use of spent wash-derived products is the potential presence of heavy metals. Spent wash and its by-products may contain trace concentrations of elements such as iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), lead (Pb), cadmium (Cd), chromium (Cr), and nickel (Ni), originating from raw materials and industrial operations. Long-term and indiscriminate application may lead to their accumulation in soil and plant tissues, posing risks to soil health, crop quality, and food safety (Alloway 2013) [1]. However, several studies have reported that properly processed spent wash products, including PDM granules and incineration ash, generally contain heavy metals within permissible limits for agricultural use. Additionally, the organic matter in PDM granules may reduce the bioavailability of certain heavy metals through complexation and immobilization (Kabata-Pendias 2011) [5]. Continuous monitoring of soil and plant heavy metal content remains essential to ensure long-term safety and sustainability.

Despite the availability of these alternative potassium sources, systematic field-based evaluations comparing their performance with conventional MOP in sugarcane cultivation under Maharashtra agro-climatic conditions are limited. In particular, information on their effects on soil properties, growth attributes, yield components, juice quality parameters, commercial cane sugar yield, and economic returns is essential for developing sound fertilizer recommendations. To address this gap, the present study was undertaken as a multi-year field trial, conducted on the same site for one plant cane and two consecutive ratoon crops, to evaluate the comparative efficacy of different potassium sources, including conventional muriate of potash and alternative sources derived from spent wash powder (PDM granules) and incineration ash. The study also assessed the impact of PDM fertilizer granules on heavy metal accumulation and salt load in soil, providing insights into the long-term agronomic and environmental sustainability of spent wash-derived potassic fertilizers in sugarcane cultivation.

Methodology

A study was conducted at the Vasantdada Sugar Institute research farm, Maharashtra, during the Suru season of 2023-24 to assess the effect of different potassium sources on sugarcane. The experiment was carried out on medium-deep black cotton soil (Vertisols) with moderate fertility and near-neutral pH. It was laid out in a randomized block design (RBD) with three replications and nine treatments. Sugarcane variety Co 86032 was planted at a spacing of 4.5 ft, and uniform agronomic practices were followed across all treatments to ensure consistency.

The experiment consisted of nine treatments: T_1 - absolute control; T_2 - general recommended dose of fertilizers (GRDF) with conventional muriate of potash (MOP); T_3 - GRDF with molasses-derived potash (PDM); T_4 - GRDF with incineration ash; T_5-T_8 - recommended dose of potassium (RDK) applied in different combinations of MOP, PDM, and incineration ash; and T_9 - recommended dose of fertilizers (RDF) using Urea and DAP (340:170 NP kg ha^{-1}). Vermicompost at 5 t ha^{-1} and sulphur at 60 kg ha^{-1} were applied at planting in all treatments except the absolute control.

Observations recorded during the experiment included growth parameters such as the number of millable canes, cane height, number of internodes, and cane girth. Yield was assessed in terms of cane yield (t ha^{-1}) and commercial cane sugar (CCS) yield (t ha^{-1}), while juice quality parameters included Brix, Pol, Purity, and CCS percentage. Economic evaluation was carried out by calculating net returns and the benefit-cost (B:C) ratio. The data were analyzed using analysis of variance (ANOVA), and treatment means were compared using Duncan's Multiple Range Test (DMRT) at a significance level of $p \leq 0.05$.

Results and Discussion

Cane Yield and CCS Yield

Potassium source had a significant impact on both cane yield and commercial cane sugar (CCS) yield (Table 1). Among all treatments, the highest cane yield was recorded in T_3 (GRDF + molasses-derived potash, PDM) with 142.4 t ha^{-1}, which was statistically comparable to T_8 (100% RDK: 25% MOP + 75% incineration ash), T_4 (GRDF + incineration ash), T_5 (100% RDK: 50% MOP + 50% PDM), T_7 (100% RDK: 50% MOP + 50% incineration ash), T_6 (100% RDK: 25% MOP + 75% PDM), and T_2 (GRDF + MOP), which recorded yields of 140.9, 140.8, 139.6, 138.8, 137.6, and 137.3 t ha^{-1}, respectively. The superior performance of PDM can be attributed not only to improved potassium availability but also to the supply of secondary nutrients (calcium, magnesium**)** and micronutrients (zinc, iron, manganese), which may have enhanced physiological processes, improved nutrient uptake, and facilitated efficient translocation of assimilates to the developing stalks. Potassium is essential for stomatal regulation, osmotic balance, enzyme activation, and carbohydrate partitioning, all of which are critical for vegetative growth and biomass accumulation in sugarcane (Orlando Filho 2014; Singh *et al.* 2018) [10, 17].

Similarly, commercial cane sugar (CCS) yield was highest in T_3 (20.5 t ha^{-1}) and was statistically on par with T_5 (20.2 t ha^{-1}), T_4 (20.1 t ha^{-1}), T_7 (20.1 t ha^{-1}), T_6 (19.6 t ha^{-1}), T_8 (19.4 t ha^{-1}), and T_2 (19.0 t ha^{-1}). The increase in CCS was primarily due to greater cane biomass rather than direct changes in juice composition, indicating that higher stalk growth translates into improved sugar recovery. These results are consistent with previous reports, which indicate that potassium, along with secondary and micronutrients, enhances stalk development, internodal length, and overall cane productivity without significantly affecting juice quality (Yadav *et al.*, 2017; Shukla *et al.*, 2022; Barreto *et al.*, 2023) [21, 16, 2].

The presence of additional nutrients in PDM may also have contributed to better enzyme activity and photosynthetic efficiency, further supporting sucrose accumulation and cane growth. The comparable performance of molasses-derived potash and incineration ash with conventional MOP confirms that these alternative sources can meet crop nutrient demands effectively while recycling industrial by-products.

Growth and Yield Attributes

Potassium application significantly influenced growth attributes such as the number of millable canes, cane height, no. of internodes, and cane girth (Table 2). T_3 recorded the highest number of millable canes (99.9 thousand ha^{-1}) and maximum cane height (235.1 cm), followed closely by MOP and incineration ash treatments. The additional secondary and micronutrients present in PDM likely enhanced enzymatic activity, cell division, and elongation, leading to better cane morphology. Potassium, along with these nutrients, regulates turgor pressure and carbohydrate partitioning, which contributes to thicker and taller stalks (Marschner 2012; Khontiang *et al.*, 2025) [9, 6].

Internode number and cane girth were also highest under T_3, reflecting improved vegetative vigor and structural development. Treatments receiving a combination of MOP and PDM or incineration ash (T_5-T_8) showed slightly lower, but statistically comparable growth, indicating that partial replacement of MOP with alternative potassium sources is sufficient to sustain optimal sugarcane growth.

Juice Quality

The potassium source did not have a significant effect on juice quality parameters including Brix, Pol, Purity, and CCS% (Table 3). This indicates that while PDM and incineration ash enhanced cane biomass, they did not alter the intrinsic sugar concentration in the juice. Similar results have been reported in recent studies, where alternative potassium sources supported cane growth without negatively affecting juice quality (Shukla *et al*. 2022; Tiwari *et al*. 2023) [16, 20]. The supply of secondary and micronutrients from PDM may have indirectly supported metabolic activities, but their impact on sugar composition appears minimal under recommended fertilization rates.

Economic Evaluation

Economic analysis revealed that T_3 (PDM) provided the highest net returns (₹4,27,087 ha^{-1}) and a benefit cost ratio of 2.72. The higher profitability was largely due to the increased cane yield coupled with reduced input costs compared to conventional MOP. Treatments combining MOP with PDM or incineration ash also showed favorable economic returns, demonstrating the potential of these alternative sources to reduce dependency on imported potassium fertilizers while maintaining productivity. The additional nutrients in PDM likely contributed to better crop vigor, translating into higher yields and enhanced profitability (Barreto *et al.*, 2023; Patil *et al.*, 2024) [2, 13].

Implications for Sustainable Potassium Management

The study demonstrates that molasses-derived potash and incineration ash can effectively replace conventional MOP in sugarcane cultivation on black cotton soils. These sources not only supply potassium but also provide secondary nutrients (Ca, Mg) and micronutrients (Zn, Fe, Mn) that support physiological processes, enhance growth, and improve yield. The use of PDM and incineration ash promotes sustainable nutrient management, reduces environmental impact by recycling industrial by-products, and improves economic efficiency for farmers.

Table 1: Effect of different sources of potash on Cane yield, CCS yield and economic

Treatments	Cane yield (t ha^{-1})	CCS yield (t ha^{-1})	No. of milliable Cane ('000'ha^{-1})	B:C ratio
T_1 - Absolute control	111.8	16.3	80.3	2.50
T_2 - GRDF through Urea/DAP/MOP	137.3	19.0	96.7	2.62
T_3 - GRDF through Urea/DAP/potash derived from Molasses	142.4	20.5	99.9	2.72
T_4 - GRDF through Urea/DAP/potash derived from Incineration ash	140.8	20.1	98.2	2.55
T_5 -100% RDK (50% through MOP+50% through PDM	139.6	20.2	97.1	2.66
T_6 - 100% RDK (25% through MOP+75% through PDM	137.6	19.6	96.4	2.62
T_7 - 100% RDK (50% through MOP+50% through potash derived from incineration ash	138.8	20.1	97.4	2.58
T_8 - 100% RDK (25% through MOP+75% through potash derived from incineration ash	140.9	19.4	95.1	2.59
T_9 - RDF through Urea + DAP (340:170 NP kg/ha)	127.2	18.2	90.3	2.43
S.E.±	4.21	0.81	356	
CD at 5%	12.64	2.44	10.69	

Table 2: Effect of different sources of potash on Millable cane height, Internode and girth

Treatments	Milliable cane height (cm)	No. of Internodes	Cane Girth (cm)
T_1 - Absolute control	190.0	18.7	8.07
T_2 - GRDF through Urea/DAP/MOP	227.9	22.6	9.68
T_3 - GRDF through Urea/DAP/potash derived from Molasses	235.1	23.4	9.79
T_4 - GRDF through Urea/DAP/potash derived from Incineration ash	232.4	23.1	9.74
T_5 -100% RDK (50% through MOP+50% through PDM	230.3	22.9	9.70
T_6 - 100% RDK (25% through MOP+75% through PDM	227.7	23.0	9.73
T_7 - 100% RDK (50% through MOP+50% through potash derived from incineration ash	229.3	22.6	9.67
T_8 - 100% RDK (25% through MOP+75% through potash derived from incineration ash	228.9	22.7	9.61
T_9 - RDF through Urea + DAP (340:170 NP kg/ha)	211.9	20.4	8.63
S.E.±	5.25	0.95	0.37
CD at 5%	15.76	2.87	1.13

Table 3: Effect of different sources of potash on Brix, purity and CCS

Treatments	Brix %	Sucrose %	Purity %	CCS %
T_1 - Absolute control	21.3	20.2	94.9	14.6
T_2 - GRDF through Urea/DAP/MOP	21.2	19.4	91.6	13.9
T_3 - GRDF through Urea/DAP/potash derived from Molasses	21.1	19.9	94.1	14.3
T_4 - GRDF through Urea/DAP/potash derived from Incineration ash	21.5	20.4	95.0	14.3
T_5 - 100% RDK (50% through MOP+50% through PDM	21.4	20.1	93.3	14.5
T_6 - 100% RDK (25% through MOP+75% through PDM	21.5	20.1	93.3	14.4
T_7 - 100% RDK (50% through MOP+50% through potash derived from incineration ash	21.3	20.1	94.2	14.5
T_8 - 100% RDK (25% through MOP+75% through potash derived from incineration ash	21.0	19.9	94.9	14.4
T_9 - RDF through Urea + DAP (340:170 NP kg/ha)	21.2	19.8	95.1	14.3
S.E.±	0.32	0.41	1.56	0.37
CD at 5%	NS	NS	NS	NS

Conclusion

The study clearly demonstrates that molasses-derived potash (PDM) and incineration ash can serve as effective alternatives to conventional muriate of potash (MOP) for sugarcane grown on black cotton soils. Application of GRDF with PDM (T_3) resulted in the highest cane yield (142.4 t ha^{-1}), commercial cane sugar (CCS) yield (20.5 t ha^{-1}), and millable cane number (99.9 thousand ha^{-1}), while growth attributes such as cane height, internode number, and cane girth were also maximized. The enhanced performance of PDM can be attributed not only to its potassium content but also to the presence of secondary nutrients (Ca, Mg) and micronutrients (Zn, Fe, Mn), which supported physiological processes, improved nutrient uptake, and facilitated efficient assimilate translocation.

Juice quality parameters (Brix, Pol, Purity, CCS%) remained unaffected by the type of potassium source, indicating that sugar recovery is not compromised by using alternative K fertilizers. Economic evaluation revealed that PDM provided the highest net returns and benefit-cost ratio (2.72), highlighting its potential as a cost-effective and sustainable nutrient source.

Overall, the study confirms that PDM and incineration ash can be integrated into sugarcane fertilization programs to enhance yield, support growth, provide additional nutrients, and improve profitability**,** while promoting sustainable and environmentally friendly nutrient management by recycling industrial by-products.

References

1. Alloway BJ. Heavy metals in soils. 3rd ed. Dordrecht: Springer; 2013.
2. Barreto F, Silva AP, Oliveira RC. Recovery and agronomic evaluation of potassium derived from sugarcane molasses. Sugar Tech. 2023;25:1123-1132. https://doi.org/10.1007/s12355-023-01248-1
3. Cordell D, Drangert JO, White S. The story of phosphorus: Global food security and food for thought. Global Environmental Change. 2009;19:292-305.
4. El Tilib MA, *et al*. Potassium nutrition and sugarcane quality. Sugar Tech. 2004;6:11-17.
5. Kabata-Pendias A. Trace elements in soils and plants. 4th ed. Boca Raton: CRC Press; 2011.
6. Khontiang K, Phancha C, Sritontip C. Influence of soil and foliar potassium fertilization on growth, yield, and nutrient uptake of sugarcane. Frontiers in Soil Science. 2025;5:1502972. https://doi.org/10.3389/fsoil.2025.1502972
7. Kumar R, Singh V, Shukla SK. Potassium management strategies for enhancing sugarcane productivity under subtropical conditions. Journal of Plant Nutrition. 2023;46:2851-2864. https://doi.org/10.1080/01904167.2023.2198746
8. Malavolta E. Manual de nutrição mineral de plantas. Viçosa: Agronômica Ceres; 2006.
9. Marschner P. Mineral nutrition of higher plants. 3rd ed. London: Academic Press; 2012.
10. Orlando Filho J. Potassium nutrition in sugarcane. International Potash Institute Bulletin. 2014;22:1-12.
11. Orlando Filho J, *et al*. Nutrient management in sugarcane. In: Sugarcane bioethanol. Dordrecht: Springer; 2010. p. 401-424.
12. Pathak H, *et al*. Recycling of organic wastes in agriculture. Indian Journal of Fertilisers. 2011;7:18-27.
13. Patil PR, Deshmukh SB, Jadhav MS. Performance of alternative potassium fertilizers on yield and quality of sugarcane grown on Vertisols. Sugar Tech. 2024;26:541-550. https://doi.org/10.1007/s12355-024-01321-7
14. Schröder JJ, *et al*. Recycling nutrients in agriculture: A comprehensive approach. Agronomy for Sustainable Development. 2011;31:747-761.
15. Selvakumar G, *et al*. Industrial by-products as nutrient sources. Journal of Plant Nutrition. 2018;41:1-14.
16. Shukla SK, Yadav RL, Singh PN. Nutrient management effects on cane yield and juice quality of sugarcane. Indian Journal of Agricultural Sciences. 2022;92:873-878.
17. Singh AK, Yadav RL, Srivastava TK. Role of potassium in improving sugarcane productivity and quality. Indian Journal of Agricultural Sciences. 2018;88:1401-1406.
18. Singh GB, *et al*. Nutrient removal by sugarcane. Indian Journal of Agronomy. 2015;60:115-123.
19. Singh V, Singh K, Shukla SK. Potassium management in sugarcane-based cropping systems. Sugar Tech. 2015;17:16-25.
20. Tiwari AK, Pandey R, Verma RR. Potassium nutrition and sugar quality relationship in sugarcane. Sugar Tech. 2023;25:902-910.
21. Yadav RL, Verma RR, Srivastava TK. Nutrient management strategies for enhancing sugarcane yield and sugar recovery. Sugar Tech. 2017;19:567-575.