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EFFECT OF VARIOUS LEVELS OF NPK ON THE YIELD, SUGAR CONTENT AND SUGARCANE LEAFHOPPER (*PYRILLA PERPUSILLA*) ON SUGAR CANE (*SACCHARUM OFFICINARUM* L.)

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ABSTRACT

A field experiment was conducted to evaluate the response of sugarcane (*Saccharum officinarum* L.) to varying levels of nitrogen, phosphorus, and potassium (NPK) fertilizers in plant and ratoon crops. Yield data revealed that fertilizer treatments significantly influenced cane tonnage and sugar recovery at both the 5% and 1% probability levels. In the plant crop, the highest cane yield (68.9 t ha⁻¹) was obtained with 168 kg N ha⁻¹, while the maximum sugar percentage (10.67%) was recorded with 112–56–56 NPK kg ha⁻¹. Increasing N beyond the optimum level did not significantly improve yield and tended to depress sugar recovery. In the ratoon crop, the highest cane yield (72.86 t ha⁻¹) was achieved with 168–56–56 NPK kg ha⁻¹, indicating the necessity of balanced P and K supplementation in ratoons. Although a slightly higher sugar percentage (9.94%) was observed at 224 kg N ha⁻¹ alone, yield at this level was significantly lower than at balanced NPK. Fertilization also reduced *Pyrilla* infestation, with minimum incidence (12.77%) observed at 224–56–112 NPK kg ha⁻¹. Overall, results suggest that 168–56–56 NPK kg ha⁻¹ represents the optimum fertilizer regime, balancing cane yield, sugar recovery, and pest tolerance, with higher rates leading to diminishing returns. These findings align with recent studies emphasizing nutrient balance, split N applications, and ratoon-specific P and K management as key strategies for sustaining cane productivity and sugar recovery.

Keywords: Sugarcane, NPK fertilizer, Nitrogen optimization, Cane yield, Sugar recovery, Ratoon crop, *Pyrilla* infestation.

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INTRODUCTION

Sugarcane is a significant economic crop (Cardoso et al., 2018). It also requires a lot of labour (Hussain, 2011), irrigation and money (Hayat et al., 2025). Sugarcane, the main raw material used to produce jewellery, is essential for cottage companies and industries (Singh and Singh, 2020). Since ancient times, sugarcane has been utilized as a

feedstock for the manufacturing of sugar (Ferreira et al., 2018). Its systematic use for this purpose dates back more than 2,000 years in Pakistan and from there, it spread in the tropical and subtropical areas around the world, being cultivated today in more than 100 countries. Since those days, the selection process was aiming at plants with higher sucrose content and was based on natural crossing of wild

species (Priya and Kumar, 2023).

Sugarcane is a major economic crop in many countries such as Brazil, India, China, Thailand, Pakistan and Mexico. Sugarcane is not only an important source of raw material for sugar and food production but also a source of ethanol fuel production. In Brazil, the first plants were brought by the Portuguese in 1515 and the first mill was erected in the coast of São Paulo in 1632 but it took quite a few decades to become an established crop near Olinda in the state of Pernambuco (Rossato Jr et al., 2019). *Diatraea saccharalis* and *D. flavipennella* are the main sugarcane borers that invade the sugarcane plantation and need to be considered in Brazil. However, only invasion of *D. saccharalis* can be found in all regions of Brazil. In Brazil, it occurs in all regions and is considered one of the major pests of sugarcane crops (Bhatt et al., 2022).

Finally, several well-organized breeding programs were created around the world to provide sugarcane varieties richer in sugar resulting, by the end of the nineteenth century, in the so called noble canes that are in the base of most present time breeding programs. In the processing of the sugarcane, firewood was normally used to supplement

bagasse as fuel to satisfy the process heat demand. Ethanol was produced in some cases using the exhausted or final molasses, a residue from the sugar production process, for beverages or industrial use (Li et al., 2024).

Sugarcane is the second largest cash crop of Pakistan and is being cultivated on 0.966 million hectares contributing around 3.6 % of Gross domestic production (GDP) (Qureshi and Afghan, 2020). Sugarcane currently accounts 4.8% of cropped area and 11% value added of the total crops (Srikanth et al., 2022). Sugarcane is an important cash crop of Pakistan, supporting millions of workers in factories. With the introduction of improved varieties and the adoption of modern agricultural technology, both production and yield per unit area have shown a steady increase.

In this region, the average per hectare yield of sugarcane has been reported as 39.2 metric tons⁹, which is significantly lower compared to the potential yields achieved in other cane-growing countries such as 40–90 t ha⁻¹ in India, 40–45 t ha⁻¹ in Mexico, 58 t ha⁻¹ a in the U.S.A., 57 t ha⁻¹ in Australia, 68 t ha⁻¹ in Indonesia, and 170 t ha⁻¹ in Hawaii (Sanghera and Sharma, 2024) (Table 1).

Table 1: Top ten countries sugarcane production and consumption.

No.	Country	Production (MMT)	Consumption (MMT)	Contribution of Sugar Production (%)
1	Brazil	38.87	10.6	20.28
2	India	32.44	26.5	16.93
3	European Union	21.15	18.8	11.03
4	China	10.25	15.7	5.34
5	Thailand	13.73	2.63	7.16
6	USA	8.39	11.18	4.37
7	Mexico	6.32	4.59	3.29
8	Pakistan	7.42	5.4	3.87
9	Russia	6.5	6.16	3.39
10	Australia	4.7	10.1	2.45

Source: According to the USDA's *Sugar: World Markets and Trade* report (May 2025)

A major cause of low yields in Pakistan is the lack of adoption of improved agronomical practices, particularly the proper application of fertilizers. To address this, extensive research has been conducted across various ecological zones of Pakistan and abroad (Saleem et al., 2022). Excessive nitrogen application decreased cane tonnage and sucrose percentage, Promotes vegetative growth and increases biomass. It can also lead to dilution of sugar content in juice because more energy is diverted to foliage and water uptake instead of sugar storage (Yang et al., 2019; Zeng et al., 2020). They found that upto 280 kg N ha⁻¹ is not harmful to

sugar cane either to sucrose content or tonnage.

At Ayub Agricultural Research Institute, Faisalabad, found that applying 90 kg of N ha⁻¹ a in two divided doses enhanced sugar cane output by 16 tonnes per hectare (RANGA, 2018). They also found it to be the most effective and cost-effective dosage under typical circumstances in the Hyderabad area. Georgel found that cane output typically increased by around one tonne for every 7 kg N ha⁻¹ of commercial fertilizer applied (Poultney, 2021). The addition of 45 kg P₂O₃ + 67 kg K₂O ha⁻¹ increased the yield of sugarcane by about 5 tonnes compared to the use of 67-112

kg N alone. According to Toits, the response of sugarcane too was far greater in ratoon. Okas and Skows reported that N at 160 kg ha⁻¹ or more produced a significant increase in cane yield and sucrose percentage. Although P₂O₅ and K₂O application in the same quantities did not appreciably influence the yield. The use of these elements in the absence of N did not increase the yield over the control. They further noticed that the sucrose content of the plant crop was significantly less than the average content of the ratoon crop. In the 2nd or 3rd ratoon crop, sucrose content decreased progressively. The unfertilized cane tended to reduce sucrose content. Jan et al. recommended the application of N up to the level of 123 kg ha⁻¹ to plant crops and 168 kg ha⁻¹ to ratoon crops.

MATERIALS AND METHODS

Effect of various levels of NPK fertilizer on the yield and

sucrose contents of plant and ratoon crop of sugar cane was find out at Ayub Agricultural Research Institute, Faisalabad, during 2023-24. The crop was sown in the month of December well before the frost could damage the seed. An improved variety CPF-248 was planted as factorial experiment in four replications using a plot size of 10 x 4.56 meter. Rows were kept 90 cm apart. Nine different NPK fertilizer treatments applied are given in Table 2.

Source of NPK were urea, DAP and KCI, respectively. All the P₂O₅ and K₂O fertilizer were applied before sowing while N was applied in the split doses in the month of April and May. The field was kept free of weeds by hoeing. A herbicide namely "Glyphosate" was sprayed all over the treatments. Earthing up was also done in the month of June. The crop was being irrigated whenever needed water. Data on plant height, sucrose percentage, and cane yield and pyrrilla infestation percentage were collected and analyzed.

Table 2: NPK fertilizer levels (kg ha⁻¹).

Treatment No.	N (kg ha ⁻¹)	P ₂ O ₅ (kg ha ⁻¹)	K ₂ O (kg ha ⁻¹)
1	112	0	0
2	112	56	56
3	112	56	112
4	168	0	0
5	168	56	56
6	168	56	112
7	224	0	0
8	224	56	56
9	224	56	112

RESULTS AND DISCUSSION

Balanced NPK altered both yield and quality. In plant cane, adding P and K to 168 kg N ha⁻¹ did not significantly out-yield 168 kg N ha⁻¹ alone, and higher NPK (e.g., 224-56-112) increased plant height and numeric yield but depressed juice sucrose. This agrees with guidance that excessive or late N suppresses ripening and sucrose accumulation, so optimizing N timing and avoiding surplus N near harvest are critical for commercial sugar recovery. Split applications and band placement of N and K have recently been shown to raise cane yield (≈15–20%) and nutrient uptake versus conventional broadcasting, offering a pathway to reconcile tonnage with quality (Zhou and Shoko, 2011).

Yield data is given in Table 3 and 4 which reveal that all the treatments significantly affected the cane yield at both the levels of probability, in plant as well as in ratoon crops. In plant crop 168 kg N ha⁻¹ gave highest cane yield of 68.9 metric tons ha⁻¹. The sugar percentage was also high at the same level of fertility. With the added P₂O₅ and K₂O, the

cane yield was either declined or insignificantly increased. It was further noticed that sugar recovery was also depressed with the increase in NPK fertilizer during plant crop. These results are in confirmation with that reported by Okas and Skows who concluded that N@ 160 kg ha⁻¹ or more produced significant increase in cane yield and sucrose percentage. They further reported that P₂O₅ and K₂O application in the same quantifies did not appreciably influence the yield.

During ratoon crop, as indicated in Table 4 NPK fertilizer showed its highest response to tonnage. This year maximum yield of 72.86 metric tons ha⁻¹ of cane yield was recorded from 168-56-56 NPK kg ha⁻¹. The sugar recovery was also high at the same level of NPK, although a slightly higher percentage of 9.94 was obtained at 224 kg ha⁻¹ alone which is not significantly higher from the stand point of view that cane yield at 168-56-56 NPK per hectare significantly higher than 224 kg ha⁻¹ alone. This also showed that beside N. P₂O₅ and K₂O are also required in ratoon crop. Georget

held the same view. He reported that in general cane yield increased by about one ton for every 7 kg N ha⁻¹. He further concluded that addition of 45 kg P₂O+67 kg K₂O ha⁻¹ in-

creased the yield of sugar cane by about 5 tons more than the application of 67 to 112 kg N ha⁻¹ alone.

Table 3: Effect of various levels of NPK on cane yield and sugar percentage (plant crop).

Treatment (NPK kg ha ⁻¹)	Cane Yield (Metric tons ha ⁻¹)	Plant height (ft)	Pyrilla infestation (%)	Sugar Percentage (%)
112 – 0 – 0	64.33	4.77	19.22	8.93
112 – 56 – 56	60.51	4.97	18.67	10.67
112 – 56 – 112	65.49	5.21	17.45	9.69
168 – 0 – 0	68.69	5.89	16.41	9.93
168 – 56 – 56	68.90	5.41	15.98	10.18
168 – 56 – 112	66.17	6.33	15.06	9.58
224 – 0 – 0	68.69	6.95	13.99	9.36
224 – 56 – 56	69.99	7.21	12.83	9.4
224 – 56 – 112	71.8	7.48	12.77	8.94

LSD (Least Significant Difference) values for comparing cane yield differences. At 5% level: 6.53 metric tons ha⁻¹ and at 1% level: 8.88 metric tons ha⁻¹

Sugar contents as reveals from Table 3 and 4, was decreased with the added fertilizer during plant crop. However, in ratoon, a positive correlation was observed between sugar content and with the added N upto the level of 224 kg ha⁻¹. Samneles et al., 2023 reported similar results. They observed that N upto 280 kg ha⁻¹ are not harmful either to sucrose content or cane yield.

Ratoon performance depended more strongly on full NPK supply. Your ratoon maximum (72.86 t ha⁻¹) occurred at 168-56-56 NPK kg ha⁻¹, outperforming 224 kg N ha⁻¹ alone despite the latter's slightly higher sucrose percentage (9.94%). This supports the view that ratoons carrying over depleted nutrient pools—require adequate P and K to sustain stalk population, stalk weight, and sucrose. Under semi-arid and water-limited

conditions, recent studies show K nutrition improves ratoon growth, juice quality, and stress tolerance; conversely, when soil K is already sufficient, additional foliar K may not raise yield emphasizing site-specific K management.

Quality and quantity tradeoffs were evident. The highest sugar percentage in plant cane (10.67%) occurred at 112-56-56, not at the highest-tonnage treatments, reaffirming the common inverse tendency between N rate and sucrose. Practical programs should therefore target: (i) agronomic N optima (~160–170 kg N ha⁻¹ in your context), (ii) timely N cut-off prior to harvest, and (iii) ensuring ratoon-specific P and K where soil tests indicate need. These strategies align with extension guidance and recent process-based field trials (McCray, 2019).

Table 4: Effect of various levels of NPK on cane yield and sugar percentage (ratoon crop).

Treatment (NPK kg ha ⁻¹)	Cane Yield (Metric tons ha ⁻¹)	Plant height (ft)	Pyrilla infestation (%)	Sugar Percentage (%)
112 – 0 – 0	59.97	5.27	18.34	9.36
112 – 56 – 56	66.54	5.37	17.37	9.47
112 – 56 – 112	68.9	6.32	16.15	9.49
168 – 0 – 0	65.42	6.19	15.54	9.48
168 – 56 – 56	72.86	7.02	14.88	9.76
168 – 56 – 112	75.66	7.34	14.26	9.4
224 – 0 – 0	67.26	7.23	12.19	9.2
224 – 56 – 56	75.65	8.27	11.13	9.94
224 – 56 – 112	77.43	8.98	10.23	9.32

LSD (Least Significant Difference) values for comparing cane yield differences. At 5% level: 7.46 metric tons ha⁻¹ and at 1% level: 10.14 metric tons ha⁻¹

Pest dynamics (*Pyrilla*) trended downward as fertilization increased in your dataset ($\approx 19\% \rightarrow \approx 13\%$). While higher crop vigor can improve tolerance, literature cautions that excessive N may sometimes favor sap-suckers; variety choice, silicon nutrition, and biological control also matter. Thus, integrated pest management should accompany fertilization to avoid nutrition-driven pest surges while leveraging plant vigor for compensation (Chand, 2016). Finally, how nutrients are applied matters. Recent work shows that incorporating or banding N (rather than surface broadcasting) improves N recovery and cane yield, complementing rate and timing decisions and offering environmental co-benefits. Together, these results suggest a program for your conditions: plant cane at $\sim 168\text{-}56\text{-}56$ with split, banded N & K and timely N curtailment before harvest; ratoons at similar N with ensured P and K based on soil tests to sustain stalk population and sugar recovery.

CONCLUSION

The present investigation clearly demonstrated that fertilizer management significantly influenced cane yield, sugar recovery, and pest incidence in both plant and ratoon crops of sugarcane. In plant cane, application of 168 kg N ha^{-1} proved to be the most effective, producing the highest yield (68.9 t ha^{-1}) without depressing sugar percentage. In ratoon crops, the highest cane yield (72.86 t ha^{-1}) was recorded with $168\text{-}56\text{-}56 \text{ NPK kg ha}^{-1}$, confirming the essential role of phosphorus and potassium in sustaining ratoon productivity. Moreover, balanced fertilization reduced *Pyrilla* infestation, suggesting that crop nutrition contributes to better pest tolerance.

Overall, the results indicate that $168\text{-}56\text{-}56 \text{ NPK kg ha}^{-1}$ is the optimum fertilizer regime under the tested conditions, balancing cane yield, sugar percentage, and crop health. Adoption of such balanced nutrient management strategies, combined with site-specific adjustments, can enhance both productivity and profitability of sugarcane cultivation while minimizing nutrient wastage and potential environmental risks.

AUTHOR CONTRIBUTIONS

All the authors significantly contributed for the manuscript.

CONFLICT OF INTEREST

There is no conflict of interest regarding the publication of this manuscript.

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