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Standardization of NPK nutrients for improved growth, yield and yield attributes, nutrient uptake, soil nutrient availability and economics of sweet corn (*Zea mays* var. *saccharata*) in Northern Dry Zone of Karnataka

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Abstract
The present investigation was conducted to evaluate the effects of different NPK fertility levels and split application schedules of nitrogen and potassium on the growth, yield, post-harvest soil nutrient availability, nutrient uptake and economic performance of sweet corn (*Zea mays* var. *saccharata*). Among the different fertility levels, application of 100 per cent recommended NPK (150:65:65 kg $N_2O_{52}O$ ha^{-1}) resulted in the highest plant height (162.94 cm), number of leaves (10.73 $plant^{-1}$), leaf area (3,883.92 cm^2 $plant^{-1}$), leaf area index (3.41), cob length (21.24 cm), cob girth (17.46 cm), cob weight (355.02 g) and number of grains per cob (512.22). This treatment also recorded the highest fresh cob yield (161.82 q ha^{-1}) and fresh fodder yield (169.19 q ha^{-1}). Further, it resulted in the highest post-harvest available nitrogen (230.32 kg ha^{-1}) and phosphorus (40.16 kg P_2O_5 ha^{-1}), with corresponding nitrogen, phosphorus and potassium uptake of 130.59, 27.45 and 127.90 kg ha^{-1}, respectively. With respect to split application schedules, the application of nitrogen and potassium in four splits at basal, 15, 30 and 45 days after sowing recorded superior growth and yield performance, with a fresh cob yield of 152.22 q ha^{-1} and fresh fodder yield of 168.24 q ha^{-1}, along with higher nutrient uptake. The interaction between 100 per cent recommended NPK and four-split application of nitrogen and potassium (L3S2) recorded the highest numerical values for fresh cob yield (167.33 q ha^{-1}), fresh fodder yield (179.21 q ha^{-1}), gross returns (₹2,21,093 ha^{-1}), net returns (₹1,50,841 ha^{-1}) and benefit–cost ratio (3.15). However, the interaction effects on growth and yield parameters were statistically non-significant, despite the numerical superiority of this treatment combination. Overall, the results revealed that the application of 100 per cent recommended NPK in combination with four-split application of nitrogen and potassium was the most promising nutrient management strategy for enhancing sweet corn productivity and economic returns under the agro-climatic conditions of the study.

Keywords: Sweet corn, NPK fertility levels, split application, growth and yield attributes, nutrient uptake, economics

Introduction
Sweet corn (*Zea mays* var. *saccharata*) is an important specialty maize crop valued for its tender, sweet and nutritious kernels. Its growth and productivity are largely influenced by nutrient availability and the adoption of appropriate fertilizer management practices. Among the essential plant nutrients, nitrogen (N), phosphorus (P) and potassium (K) play pivotal roles in promoting vegetative growth, leaf expansion, photosynthetic efficiency, assimilate translocation and cob development. An adequate and balanced supply of these nutrients is therefore essential for achieving optimum plant growth, improving yield-contributing attributes and enhancing overall crop productivity. Apart from the quantity of nutrients applied, the timing and method of fertilizer application are equally important in determining nutrient availability and crop response. Applying nitrogen and potassium in splits at different crop growth stages helps synchronize nutrient supply with crop demand, minimize nutrient losses and improve nutrient uptake and utilization. Such an approach ensures a relatively continuous supply of nutrients during critical growth stages, thereby supporting leaf development, cob formation and grain filling. Suraj *et al.* (2020) [19] reported the influence of split application of nitrogen and potassium on yield attributes and yield of sweet corn. Furthermore, the adoption of appropriate fertilizer levels and application schedules can contribute to higher crop productivity and improved economic returns. Hence, identifying optimum NPK fertility levels and suitable split application schedules is essential for meeting crop nutrient requirements while ensuring efficient fertilizer use and economic viability.

Post-harvest soil nutrient availability and crop nutrient uptake are important parameters for assessing the effectiveness of nutrient management practices and their implications for soil fertility. The residual nutrient status of soil after harvest is governed by the quantity of nutrients applied, crop nutrient removal, nutrient-use efficiency and various soil nutrient transformation processes. Therefore, evaluating post-harvest soil nutrient availability and crop nutrient uptake, in conjunction with growth, yield and economic parameters, provides a comprehensive assessment of fertilizer management strategies. In view of the importance of balanced nutrient supply and efficient fertilizer application, the present investigation was undertaken to evaluate the effects of different NPK fertility levels and split application schedules of nitrogen and potassium on the growth, yield attributes, yield, post-harvest soil nutrient availability, nutrient uptake and economics of sweet corn (*Zea mays* var. *saccharata*). The study aimed to

identify an effective nutrient management strategy that ensures optimum crop growth, enhances productivity, improves nutrient-use efficiency and maximizes economic returns.

Material and methods

The field experiment was conducted during the *kharif* season of 2025 at the Agricultural Research Station, Siruguppa, University of Agricultural Sciences, Raichur, Karnataka. The research station is located in Agro-climatic Zone III (Northern Dry Zone) of Karnataka at 15°62′ N latitude and 76°90′ E longitude, with an elevation of 358 m above mean sea level. The experimental site represented the agro-climatic conditions of the Northern Dry Zone, where the performance of sweet corn under different nutrient management practices was evaluated. The experiment was laid out in a split-plot design with three replications using sweet corn hybrid Sugar-75. The crop was sown on 19 July 2025 at a spacing of 60 cm × 20 cm. The gross and net plot sizes were 4.8 m × 4.2 m and 3.6 m × 3.8 m, respectively. The experiment comprised two factors. Factor I consisted of three NPK fertility levels: 50 per cent (75:32.5:32.5 kg $NP_2O_5K_2O$ ha^{-1}), 75 per cent (112:48.8:48.8 kg $NP_2O_5K_2O$ ha^{-1}) and 100 per cent (150:65:65 kg $NP_2O_5K_2O$ ha^{-1}) of the recommended dose of fertilizers. Factor II included three nutrient application schedules: (S_1) nitrogen and potassium applied at basal, 15 and 30 days after sowing (DAS); (S_2) nitrogen and potassium applied at basal, 15, 30 and 45 DAS; and (S_3) phosphorus and potassium applied basally, with nitrogen applied in four splits at basal, 15, 30 and 45 DAS. Phosphorus was applied basally as per the respective treatment schedule. The nine treatment combinations arising from the two factors were evaluated, along with an absolute control maintained outside the experimental layout. The crop was harvested on 7 October 2025, and recommended agronomic practices were followed uniformly throughout the crop growth period.

The experimental data recorded on various growth (plant height, number of leaves per plant, leaf area and leaf area index), yield (fresh cob and fodder yield) and its attributes (cob length, cob girth, cob weight and no. of grains per cob), soil and nutrient uptake parameters [NPKS by following the standard procedure (Jackson, 1973) [6] were subjected to statistical analysis appropriate for a split-plot design, following the procedures described by Gomez and Gomez (1984) [5]. Treatment means were compared using the critical difference (CD) at the 5 per cent probability level whenever the treatment effects were statistically significant. The economic performance of the treatments was assessed in terms of cost of cultivation, gross returns, net returns and benefit-cost ratio. Gross returns were computed based on the market prices of fresh cobs (₹10 kg^{-1}) and green fodder (₹3 kg^{-1}). Net returns were obtained by deducting the cost of cultivation from gross returns, while the benefit cost ratio was calculated as the ratio of gross returns to the cost of cultivation. All economic parameters were expressed on a per-hectare basis.

Growth parameters

The growth parameters of sweet corn, *viz.*, plant height, number of leaves per plant, leaf area and leaf area index (LAI), were significantly influenced by NPK fertility levels and split application schedules (Table 1). Among the fertility levels, application of 100 per cent recommended NPK (L_3: 150:65:65 kg $NP_2O_5K_2O$ ha^{-1}) recorded the highest plant height (162.94 cm), number of leaves (10.73 $plant^{-1}$), leaf area (3,883.92 cm^2 $plant^{-1}$) and LAI (3.41), followed by 75 per cent recommended NPK (L_2) and 50 per cent recommended NPK (L_1). Plant height and number of leaves under L_3 were statistically on par with L_2, whereas leaf area and LAI differed significantly among all three fertility levels. The enhanced growth under higher NPK fertility could be attributed to adequate nutrient supply, particularly nitrogen, which promotes cell division, leaf initiation, chlorophyll synthesis and photosynthetic activity, while phosphorus and potassium support root development, energy transfer and assimilate translocation. These favourable effects collectively contributed to greater canopy development and plant growth. Similar findings were reported by Zende (2006), Arunkumar *et al.* (2007), Khatun (2021) and Shahin *et al.* (2022) [2, 9, 15, 22].

Table 1: Growth parameters of sweet corn crop at harvest stage as influenced by different levels of NPK

Treatments	Plant height (cm)	Number of leaves per plant	Leaf area (cm^2 $plant^{-1}$)	Leaf area index
Factor I (L): (Levels of N, P_2O_5 and K_2O kg ha^{-1})				
L_1: 50% NPK (75:32.5:32.5 kg NPK ha^{-1})	148.08	9.17	2949.65	2.31
L_2: 75% NPK (112:48.8:48.8 kg NPK ha^{-1})	159.17	10.00	3580.74	2.83
L_3: 100% NPK (150:65:65 kg NPK ha^{-1})	162.94	10.73	3883.92	3.41
S.Em. ±	2.36	0.21	56.08	0.08
C.D. (P=0.05)	9.26	0.83	238.41	0.31
Factor II (S): (Split application of N and K_2O)				
S_1: N and K_2O at basal, 15 and 30 DAS (3 equal splits @ 33%)	157.16	9.95	3445.84	2.79
S_2: N and K_2O at basal, 15, 30 and 45 DAS (4 equal splits @ 25%)	163.37	10.63	3728.93	3.00
S_3: N at basal, 15, 30 and 45 DAS (4 equal splits @ 25%)	149.65	9.32	3239.54	2.75
S.Em. ±	3.06	0.31	59.11	0.07
C.D. (P=0.05)	9.42	0.97	245.88	0.21
Interactions				
L_1S_1	146.90	9.38	2936.96	2.26
L_1S_2	158.51	9.75	3211.97	2.45
L_1S_3	138.82	8.39	2700.00	2.21
L_2S_1	161.87	10.05	3526.62	2.80

L_2S_2	164.45	10.61	3881.04	2.98
L_2S_3	151.19	9.35	3334.56	2.72
L_3S_1	162.72	10.43	3873.93	3.32
L_3S_2	167.15	11.52	4093.77	3.57
L_3S_3	158.94	10.23	3684.06	3.33
S.Em. ±	4.93	0.49	108.22	0.13
C.D. (P=0.05)	NS	NS	NS	NS
Absolute control	127.54	6.13	2237.28	1.84

Note: P applied as basal @ 100 % in S_1 and S_2; P & K applied as basal @ 100 % in S_3

Among the split application schedules, S_2 (nitrogen and potassium applied at basal, 15, 30 and 45 days after sowing) recorded the highest plant height (163.37 cm), number of leaves (10.63 plant^{-1}), leaf area (3,728.93 cm^2 plant^{-1}) and LAI (3.00). Plant height was statistically on par with S_1 (157.16 cm), whereas the number of leaves and leaf area were significantly higher than those under S_1 (9.95 plant^{-1} and 3,445.84 cm^2 plant^{-1}, respectively) and S_3 (9.32 plant^{-1} and 3,239.54 cm^2 plant^{-1}, respectively). In contrast, LAI under S_2 was statistically on par with S_1 (2.79), but significantly higher than S_3 (2.75). The superior growth performance under S_2 may be attributed to the more uniform distribution of nitrogen and potassium throughout the crop growth period, ensuring better synchronization between nutrient supply and crop demand. This might have facilitated continuous vegetative development, leaf expansion and maintenance of an efficient photosynthetic canopy. Similar responses were documented by Massey and Gaur (2006), Singh *et al.* (2012) and Meena *et al.* (2020) [10, 11, 18].

The interaction effect between NPK fertility levels and split application schedules was non-significant for all the growth parameters. However, the combination of 100 per cent recommended NPK with four-stage split application of nitrogen and potassium (L_3S_2) recorded the highest numerical plant height (167.15 cm), number of leaves (11.52 plant^{-1}), leaf area (4,093.77 cm^2 plant^{-1}) and LAI (3.57). Conversely, the lowest values for these parameters were recorded under L_1S_3, with plant height of 138.82 cm, 8.39 leaves plant^{-1}, leaf area of 2,700.00 cm^2 plant^{-1} and LAI of 2.21. The numerical superiority of L_3S_2 indicates the potential advantage of combining adequate NPK fertility with appropriately timed nutrient application for improving vegetative growth and canopy development. Similar trends were reported by Jeevabharathi and Krishnaprabu (2019) and Meena *et al.* (2020) [8, 11]. Nevertheless, these interaction differences should be interpreted as numerical trends, as they were not statistically significant.

Yield and yield attributes

Yield attributes and yield of sweet corn showed an overall increasing trend with increasing NPK fertility levels (Table 2). Among the fertility treatments, application of 100 per cent recommended NPK (L_3: 150:65:65 kg $NP_2O_5K_2O$ ha^{-1}) recorded the highest cob length (21.24 cm), cob girth (17.46 cm), cob weight (355.02 g), number of grains per cob (512.22), number of rows per cob (15.56) and fresh cob yield (161.82 q ha^{-1}). It also recorded the highest fresh fodder yield (169.19 q ha^{-1}), which was statistically on par with L_2 (158.25 q ha^{-1}). The improvement in yield attributes and productivity under higher NPK fertility could be attributed to enhanced vegetative growth, greater photosynthetic efficiency and improved production and translocation of assimilates towards reproductive structures, ultimately contributing to better cob development and yield. Similar responses to balanced and adequate NPK nutrition were reported by Shahin *et al.* (2022) and Singh *et al.* (2024) [15, 16].

Table 2: Yield and yield attributes of sweet corn crop as influenced by different levels of NPK

Treatments	Fresh cob yield (q ha^{-1})	Fresh fodder yield (q ha^{-1})	Cob length (cm)	Cob girth (cm)	Cob weight (g)	No. of grains per cob	No.of rows per cob
Factor I (L): (Levels of N, P_2O_5 and K_2O kg ha^{-1})							
L_1: 50% NPK (75:32.5:32.5 kg NPK ha^{-1})	137.56	146.73	17.68	15.66	286.77	402.90	13.22
L_2: 75% NPK (112:48.8:48.8 kg NPK ha^{-1})	144.24	158.25	18.95	16.51	317.20	459.89	14.00
L_3: 100% NPK (150:65:65 kg NPK ha^{-1})	161.82	169.19	21.24	17.46	355.02	512.22	15.56
S.Em. ±	1.66	3.20	0.28	0.32	7.52	10.02	0.31
C.D. (P=0.05)	6.54	12.56	1.09	1.26	29.51	39.35	1.22
Factor II (S): (Split application of N and K_2O)							
S_1: N and K_2O at basal, 15 and 30 DAS (3 equal splits @ 33%)	146.33	157.50	19.19	16.29	316.64	461.90	14.22
S_2: N and K_2O at basal, 15, 30 and 45 DAS (4 equal splits @ 25%)	152.22	168.24	20.20	17.37	333.29	477.56	15.00
S_3: N at basal, 15, 30 and 45 DAS (4 equal splits @ 25%)	145.05	148.42	18.47	15.98	309.06	435.56	13.56
S.Em. ±	1.92	2.21	0.38	0.33	5.06	7.72	0.31
C.D. (P=0.05)	5.92	6.80	1.18	1.01	15.59	23.80	0.95
Interactions							
L_1S_1	137.67	147.90	17.53	15.22	284.68	414.71	13.00

L_1S_2	141.67	160.52	18.38	16.92	301.77	420.67	14.00
L_1S_3	133.33	131.77	17.12	14.84	273.85	373.33	12.67
L_2S_1	144.00	157.94	18.82	16.30	309.54	456.00	14.00
L_2S_2	147.67	165.00	19.57	17.23	333.84	487.00	15.00
L_2S_3	141.04	151.79	18.46	16.02	308.21	436.67	13.00
L_3S_1	157.33	166.67	21.21	17.35	355.70	515.00	15.67
L_3S_2	167.33	179.21	22.66	17.96	364.26	525.00	16.00
L_3S_3	160.78	161.69	19.84	17.08	345.10	496.67	15.00
S.Em. ±	3.19	4.47	0.61	0.56	10.38	14.82	0.53
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS
Absolute control	90.10	109.14	14.21	10.54	241.28	322.87	11.53

Note: P applied as basal @ 100 % in S_1 and S_2; P & K applied as basal @ 100 % in S_3

With respect to split application schedules, S_2 (nitrogen and potassium applied at basal, 15, 30 and 45 days after sowing) recorded the highest values for cob length (20.20 cm), cob girth (17.37 cm), cob weight (333.29 g), number of grains per cob (477.56), number of rows per cob (15.00), fresh cob yield (152.22 q ha^{-1}) and fresh fodder yield (168.24 q ha^{-1}). The treatment was significantly superior to S_3 for most of the yield attributes and yield parameters, while remaining statistically on par with S_1 for cob length, number of grains per cob, number of rows per cob and fresh cob yield. The better performance under S_2 may be associated with improved synchronization of nitrogen and potassium supply with crop nutrient demand during vegetative growth and reproductive development, thereby supporting cob formation, grain development and biomass accumulation. Similar benefits of split application of nitrogen and potassium were reported by Suraj *et al.* (2020) and Rao *et al.* (2021) [13, 19].

The interaction between NPK fertility levels and split application schedules was non-significant for all the yield attributes and yield parameters. However, the combination of 100 per cent recommended NPK with four-stage split application of nitrogen and potassium (L_3S_2) recorded the highest numerical values for cob length (22.66 cm), cob girth (17.96 cm), cob weight (364.26 g), number of grains per cob (525.00), number of rows per cob (16.00), fresh cob yield (167.33 q ha^{-1}) and fresh fodder yield (179.21 q ha^{-1}). In contrast, the lowest values were recorded under L_1S_3, with corresponding values of 17.12 cm, 14.84 cm, 273.85 g, 373.33 grains per cob, 12.67 rows per cob, 133.33 q ha^{-1} fresh cob yield and 131.77 q ha^{-1} fresh fodder yield. The numerical advantage of L_3S_2 suggests that adequate NPK nutrition, combined with appropriately timed nitrogen and potassium application, favoured reproductive development, cob formation and total biomass production. Similar trends were reported by Suraj *et al.* (2020) and Shahin *et al.* (2022) [15, 19]. However, these differences should be interpreted as numerical trends rather than significant interaction effects.

Post-harvest available soil nutrients (N, P_2O_5 and K_2O)

Post-harvest available nitrogen and phosphorus were significantly influenced by NPK fertility levels, whereas available potassium showed a non-significant response (Table 3). Among the fertility levels, application of 100% recommended NPK (L_3: 150:65:65 kg $NP_2O_5K_2O$ ha^{-1}) recorded the highest available nitrogen (230.32 kg ha^{-1}), which was statistically on par with L_2 (227.15 kg ha^{-1}), but significantly higher than L_1 (211.82 kg ha^{-1}). Similarly, available phosphorus was highest under L_3 (40.16 kg P_2O_5 ha^{-1}), followed by L_2 (36.76 kg ha^{-1}) and L_1 (33.17 kg ha^{-1}), with significant differences among all three fertility levels. In contrast, available potassium did not differ significantly among fertility levels, although the highest numerical value was recorded under L_3 (352.33 kg K_2O ha^{-1}), followed by L_2 (340.76 kg ha^{-1}) and L_1 (338.05 kg ha^{-1}). The higher residual nitrogen and phosphorus under L_3 may be attributed to greater nutrient inputs, resulting in relatively larger residual nutrient pools after crop uptake and other soil nutrient transformation and loss processes. The non-significant response of available potassium suggests that differences in potassium inputs were not sufficient to produce statistically distinguishable changes in its post-harvest availability, possibly owing to crop uptake and the buffering capacity of soil potassium reserves. These findings highlight the importance of nutrient inputs, crop removal and soil nutrient dynamics in determining post-harvest fertility status. The results are consistent with the observations of Fageria and Baligar (2005) and Sharma *et al.* (2013) [4, 17], who emphasized the role of balanced nutrient management in maintaining soil fertility and nutrient availability.

Table 3: Nutrient availability and uptake of sweet corn crop as influenced by different levels of NPK

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
Factor I (L): (Levels of N, P_2O_5 and K_2O kg ha^{-1})						
L_1: 50% NPK (75:32.5:32.5 kg NPK ha^{-1})	211.82	33.17	338.05	90.88	14.14	97.56
L_2: 75% NPK (112:48.8:48.8 kg NPK ha^{-1})	227.15	36.76	340.76	107.93	19.58	112.29
L_3: 100% NPK (150:65:65 kg NPK ha^{-1})	230.32	40.16	352.33	130.59	27.45	127.90
S.Em. ±	3.36	0.82	9.26	3.62	0.81	3.97
C.D. (P=0.05)	13.18	3.20	NS	14.21	3.17	15.59
Factor II (S): (Split application of N and K_2O)						
S_1: N and K_2O at basal, 15 and 30 DAS (3 equal splits @ 33%)	223.22	37.14	343.94	108.34	19.97	111.10
S_2: N and K_2O at basal, 15, 30 and 45 DAS (4 equal splits @ 25%)	228.60	38.35	359.48	118.69	22.98	122.00
S_3: N at basal, 15, 30 and 45 DAS	217.47	34.60	327.72	102.37	18.21	104.67

(4 equal splits @ 25%)						
S.Em. ±	2.20	0.67	4.61	3.64	0.80	3.47
C.D. (P=0.05)	6.78	2.08	14.19	11.20	2.46	10.71
Interactions						
L_1S_1	209.93	33.06	338.84	90.97	14.22	96.28
L_1S_2	215.21	34.63	345.49	98.92	16.49	109.86
L_1S_3	210.32	31.81	329.83	82.75	11.70	86.55
L_2S_1	228.91	36.98	338.33	105.81	19.28	112.06
L_2S_2	232.20	38.00	362.29	115.41	21.98	118.20
L_2S_3	220.34	35.31	321.67	102.56	17.48	106.63
L_3S_1	230.81	41.39	354.65	128.24	26.40	124.96
L_3S_2	238.39	42.42	370.67	141.73	30.48	137.93
L_3S_3	221.75	36.66	331.67	121.80	25.46	120.82
S.Em. ±	4.58	1.25	11.32	6.29	1.39	6.32
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Absolute Control	187.24	26.28	302.25	55.00	6.00	45.00

Note: P applied as basal @ 100 % in S_1 and S_2; P & K applied as basal @ 100 % in S_3

Among the split application schedules, S_2 (nitrogen and potassium applied at basal, 15, 30 and 45 days after sowing) recorded the highest available nitrogen (228.60 kg ha^{-1}), which was statistically on par with S_1 (223.22 kg ha^{-1}), but significantly higher than S_3 (217.47 kg ha^{-1}). A similar trend was observed for available phosphorus, with S_2 recording the highest value (38.35 kg P_2O_5 ha^{-1}), which was on par with S_1 (37.14 kg ha^{-1}), but significantly higher than S_3 (34.60 kg ha^{-1}); S_1 was also significantly superior to S_3. Available potassium was significantly influenced by the application schedules, with the highest value under S_2 (359.48 kg K_2O ha^{-1}), followed by S_1 (343.94 kg ha^{-1}) and S_3 (327.72 kg ha^{-1}). The relatively higher residual nutrient availability under S_2 may be associated with the distribution of nitrogen and potassium across different crop growth stages, which could have influenced nutrient uptake and the residual nutrient balance at harvest. The differences in residual phosphorus among schedules may reflect indirect effects of crop growth, nutrient uptake and soil nutrient dynamics, as phosphorus was applied basally. These findings are in agreement with Suraj *et al.* (2020) [19], who reported beneficial effects of appropriate fertilizer scheduling on nutrient availability and crop performance. Fageria and Baligar (2005) and Anita *et al.* (2007) [1, 4] also highlighted the importance of balanced nutrient management in sustaining soil fertility and improving nutrient utilization.

The interaction between NPK fertility levels and split application schedules was non-significant for post-harvest available nitrogen, phosphorus and potassium. However, the L_3S_2 combination recorded the highest numerical values of available nitrogen (238.39 kg ha^{-1}), phosphorus (42.42 kg P_2O_5 ha^{-1}) and potassium (370.67 kg K_2O ha^{-1}). The lowest available nitrogen (209.93 kg ha^{-1}) and phosphorus (31.81 kg P_2O_5 ha^{-1}) were recorded under L_1S_3, whereas the lowest available potassium (321.67 kg K_2O ha^{-1}) was observed under L_2S_3. The numerical increase under L_3S_2 may be attributed to the higher nutrient input associated with the recommended NPK level, together with the timing of nitrogen and potassium application, which may have influenced crop uptake and residual nutrient availability. These trends are consistent with the principles of balanced nutrient management and fertilizer scheduling discussed by Fageria and Baligar (2005) and Dobermann (2007) [3, 4]. Nevertheless, as the interaction effects were statistically non-significant, the numerical differences among treatment combinations should not be interpreted as evidence of a significant interaction effect.

Uptake of nutrients (N, P and K)

Total uptake of nitrogen, phosphorus and potassium by sweet corn was significantly influenced by NPK fertility levels and split application schedules (Table 3). Among the fertility levels, application of 100 per cent recommended NPK (L_3: 150:65:65 kg $NP_2O_5K_2O$ ha^{-1}) recorded the highest nitrogen (130.59 kg ha^{-1}), phosphorus (27.45 kg ha^{-1}) and potassium uptake (127.90 kg ha^{-1}), followed by L_2 (107.93, 19.58 and 112.29 kg ha^{-1}, respectively) and L_1 (90.88, 14.14 and 97.56 kg ha^{-1}, respectively). All three fertility levels differed significantly from one another for the respective nutrients. The enhanced nutrient uptake under L_3 could be attributed to improved nutrient availability, balanced NPK nutrition, better root development and greater dry matter production, which collectively facilitated nutrient absorption and accumulation in the crop. Similar increases in nutrient uptake with increasing fertilizer levels were reported by Ray *et al.* (2020), Jat *et al.* (2021) and Shahin *et al.* (2022) [7, 14, 15].

Among the split application schedules, S_2 (nitrogen and potassium applied at basal, 15, 30 and 45 days after sowing) recorded the highest uptake of nitrogen (118.69 kg ha^{-1}), phosphorus (22.98 kg ha^{-1}) and potassium (122.00 kg ha^{-1}). Nitrogen uptake under S_2 was statistically on par with S_1 (108.34 kg ha^{-1}), but significantly higher than S_3 (102.37 kg ha^{-1}). In contrast, phosphorus and potassium uptake under S_2 were significantly higher than those under both S_1 (19.97 and 111.10 kg ha^{-1}, respectively) and S_3 (18.21 and 104.67 kg ha^{-1}, respectively). The superior nutrient uptake under S_2 may be associated with improved synchronization of nitrogen and potassium availability with crop demand at different growth stages. This might have promoted sustained nutrient absorption, enhanced physiological activity and greater biomass accumulation, thereby contributing to increased uptake of all three major nutrients. Similar benefits of timely and balanced nutrient application were reported by Suraj *et al.* (2020), Jat *et al.* (2021) and Shahin *et al.* (2022) [7, 15, 19].

The interaction between NPK fertility levels and split application schedules was non-significant for the uptake of all three nutrients. However, the combination of 100 per cent recommended NPK with four-stage split application of nitrogen and potassium (L_3S_2) recorded the highest numerical uptake of nitrogen (141.73 kg ha^{-1}), phosphorus (30.48 kg ha^{-1}) and potassium (137.93 kg ha^{-1}). Conversely, the lowest uptake of all three nutrients was recorded under L_1S_3, with corresponding values of 82.75, 11.70 and 86.55

kg ha⁻¹, respectively. The numerical superiority of L_3S_2 indicates the potential advantage of combining adequate NPK fertility with appropriately timed nitrogen and potassium application in promoting nutrient absorption and accumulation. This response could be attributed to improved nutrient availability, root activity and crop biomass production under favourable nutrient management conditions. Similar benefits of balanced fertility and split nutrient application were reported by Ray *et al.* (2020), Suraj *et al.* (2020) and Shahin *et al.* (2022) [14, 15, 19]. Nevertheless, the interaction differences were statistically non-significant and should therefore be interpreted as numerical trends.

Economic analysis

The cost of cultivation increased with increasing NPK fertility levels owing to higher fertilizer inputs. The highest cost (₹70,252 ha⁻¹) was recorded under L_3, followed by L_2 (₹67,976 ha⁻¹), while the lowest (₹65,701 ha⁻¹) was observed under L_1. Costs remained identical among split application schedules within each fertility level. Among the fertility levels, L_3 recorded the highest gross returns (₹2,12,570.33 ha⁻¹), significantly exceeding L_2 (₹1,91,709.67 ha⁻¹) and L_1 (₹1,81,575.67 ha⁻¹). Among the split application schedules, S_2 recorded the highest gross returns (₹2,02,696.33 ha⁻¹), significantly higher than S_1 (₹1,93,584.33 ha⁻¹) and S_3 (₹1,89,575.00 ha⁻¹), which were statistically on par. The interaction effect was significant, with L_3S_2 recording the highest gross returns (₹2,21,093 ha⁻¹), statistically on par with L_3S_3 (₹2,09,287 ha⁻¹). The lowest value was recorded under L_1S_3 (₹1,72,861 ha⁻¹), which was on par with L_1S_1 (₹1,82,040 ha⁻¹). The higher returns were mainly associated with increased cob and fodder yields under improved nutrient management (Ramesha, 2010; Suraj *et al.*, 2020) [12, 19].

The highest net returns among fertility levels were obtained under L_3 (₹1,42,318.33 ha⁻¹), significantly higher than L_2 (₹1,23,733.67 ha⁻¹) and L_1 (₹1,15,874.67 ha⁻¹), which were statistically on par. Similarly, S_2 recorded the highest net returns (₹1,34,720.00 ha⁻¹), significantly exceeding S_1 (₹1,25,608.00 ha⁻¹) and S_3 (₹1,21,598.67 ha⁻¹), which were on par. The interaction effect was significant, with L_3S_2 recording the maximum net returns (₹1,50,841 ha⁻¹), significantly higher than all other combinations. The lowest net returns were observed under L_1S_3 (₹1,07,160 ha⁻¹), statistically on par with L_1S_1 (₹1,16,339 ha⁻¹) and L_2S_3 (₹1,18,601 ha⁻¹). These results indicate that higher productivity under adequate nutrient supply contributed to improved profitability (Ramesha, 2010; Suraj *et al.*, 2020) [12, 19].

The highest benefit–cost ratio among fertility levels was recorded under L_3 (3.03), significantly higher than L_2 (2.82) and L_1 (2.76), which were statistically on par. Among split application schedules, S_2 recorded the highest ratio (2.98), significantly exceeding S_1 (2.85) and S_3 (2.78), which were on par. The interaction effect was significant, with L_3S_2 recording the highest benefit–cost ratio (3.15), statistically on par with L_3S_3 (2.98) and L_3S_1 (2.95), but significantly higher than the remaining combinations. The lowest ratio (2.63) was observed under L_1S_3, which was statistically on par with L_1S_1 (2.77), L_2S_1 (2.82) and L_2S_3 (2.74). Overall, L_3S_2 recorded the highest net returns and benefit–cost ratio, indicating its superior economic performance under the conditions of the experiment (Vidyashree, 2017; Tilahun *et al.*, 2013) [20, 21].

Table 4: Cost economics of sweet corn crop as influenced by different levels of NPK

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C
Factor I (L): (Levels of N, P_2O_5 and K_2O kg ha^{-1})				
L_1: 50% NPK (75:32.5:32.5 kg NPK ha^{-1})	65701.00	181575.67	115874.67	2.76
L_2: 75% NPK (112:48.8:48.8 kg NPK ha^{-1})	67976.00	191709.67	123733.67	2.82
L_3: 100% NPK (150:65:65 kg NPK ha^{-1})	70252.00	212570.33	142318.33	3.03
S.Em. ±	-	1584.27	2899.61	0.04
C.D. (P=0.05)	-	6220.61	11385.28	0.16
Factor II (S): (Split application of N and K_2O)				
S_1: N and K_2O at basal, 15 and 30 DAS (3 equal splits @ 33%)	67976.33	193584.33	125608.00	2.85
S_2: N and K_2O at basal, 15, 30 and 45 DAS (4 equal splits @ 25%)	67976.33	202696.33	134720.00	2.98
S_3: N at basal, 15, 30 and 45 DAS (4 equal splits @ 25%)	67976.33	189575.00	121598.67	2.78
S.Em. ±	-	2665.76	1741.71	0.04
C.D. (P=0.05)	-	8214.02	5366.73	0.13
Interactions				
L_1S_1	65701.00	182040.00	116339.00	2.77
L_1S_2	65701.00	189826.00	124125.00	2.89
L_1S_3	65701.00	172861.00	107160.00	2.63
L_2S_1	67976.00	191382.00	123406.00	2.82
L_2S_2	67976.00	197170.00	129194.00	2.90
L_2S_3	67976.00	186577.00	118601.00	2.74
L_3S_1	70252.00	207331.00	137079.00	2.95
L_3S_2	70252.00	221093.00	150841.00	3.15
L_3S_3	70252.00	209287.00	139035.00	2.98
S.Em. ±	-	4089.31	3804.58	0.07
C.D. (P=0.05)	-	12600.42	11723.07	0.22
Absolute control	53652.00	122842.00	69190.00	2.28

Note: P applied as basal @ 100 % in S_1 and S_2; P & K applied as basal @ 100 % in S_3

Conclusion

The study demonstrated that application of 100% recommended NPK (150:65:65 kg $NP_2O_5K_2O$ ha^{-1}) improved sweet corn growth, yield, nutrient uptake and post-harvest soil nitrogen and phosphorus availability. Among the split application schedules, applying nitrogen and potassium at basal, 15, 30 and 45 days after sowing (S_2) resulted in better crop performance and economic returns. The combination of 100% recommended NPK with S_2 (L_3S_2) recorded the highest numerical fresh cob yield (167.33 q ha^{-1}), fodder yield (179.21 q ha^{-1}), net returns (₹1,50,841 ha^{-1}) and benefit–cost ratio (3.15). Although the interaction effects on growth and yield parameters were statistically non-significant, L_3S_2 showed numerical superiority across these traits. Thus, application of the recommended NPK dose, with nitrogen and potassium distributed across four application stages, may be considered a promising nutrient management practice for improving sweet corn productivity and profitability under the agro-climatic conditions of the study. Its suitability across seasons, locations and soil types requires further validation through multi-location trials.

Disclaimer (Artificial Intelligence)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript. Acknowledgements

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Competing Interests

The authors declare that they have no competing interests.

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