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The authors' details and affiliations are provided below, following the reference section

Effect of integrated nutrient management on yield, quality, nutrient uptake, and soil properties of sweet corn (*Zea mays convar*) under lateritic soils of Konkan

Karekar AV, Khobragade NH, Meshram NA, Rajemahadik VA, Kadam JJ, Nagle SS, Nevase SV, Biswas A, Bhuvad DD, Patil IR, Amberkar PD, Nalawde AB, Ingale PJ and Jadhav SS

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Abstract
A field experiment was conducted to evaluate the effect of biofertilizers and inorganic fertilizers on yield, quality, nutrient uptake, and soil properties of sweet corn during *Rabi 2024-25* at the Research and Instruction Farm, Department of Agronomy, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The study was laid out in a Randomized Block Design with eight treatments: absolute control (T_1), biofertilizers only (T_2), 100% RDF (T_3), 100% RDF + biofertilizers (T_4), 125% RDF (T_5), 125% RDF + biofertilizers (T_6), RDF through Konkan Annapurna Briquettes (KAB) (T_7), and RDF through KAB + biofertilizers (T_8). Results revealed that application of KAB + biofertilizers (T_8) recorded the highest green cob yield of 26.42 t/ha with total sugar of 14.21%, while 125% RDF + biofertilizers (T_6) recorded the highest dry fodder yield (15.86 t/ha), protein content (12.44%), and total N uptake (708.07 kg/ha). Further, post-harvest soil analysis indicated significantly higher available N (382.59 kg/ha) and P (3.53 kg/ha) with T_8, Thus, integrated use of biofertilizers with inorganic fertilizers, particularly KAB + biofertilizers, proved most effective for sustainable sweet corn production in lateritic soils of Konkan.

Keywords: Sweet corn, biofertilizers, Konkan Annapurna Briquettes, nutrient uptake, soil fertility, Integrated Nutrient Management

Introduction
Sweet corn (*Zea mays convar*) is a specialty maize crop grown for its sweet, tender kernels, rich in sugars, protein, vitamins, and minerals, making it an important food and industrial crop (USDA, 2019). In India, sweet corn cultivation is expanding, particularly in Maharashtra's Konkan region, where farmers are adopting it as a high-value cash crop. However, sweet corn is highly nutrient-exhaustive, requiring substantial nitrogen (N), phosphorus (P), and potassium (K) inputs for optimum growth, yield, and quality.

Lateritic soils of Konkan are inherently low in available N, very low in P due to high fixation, and medium in K (Dongale, 1989) [3]. Heavy reliance on chemical fertilizers improves productivity but degrades soil health and nutrient use efficiency over time (Adesemoye and Kloepper, 2009) [1]. Integrated Nutrient Management (INM) offers a sustainable approach, combining chemical fertilizers with biofertilizers and slow-release fertilizers to enhance yield while maintaining soil fertility.

Biofertilizers such as *Azotobacter* and phosphate-solubilizing bacteria (PSB) improve nutrient availability by fixing atmospheric N and solubilizing insoluble phosphates (Cooper, 1959) [2]. Konkan Annapurna Briquettes (KAB), a slow-release multi-nutrient source, can further enhance nutrient use efficiency and reduce losses. Synergistic use of these components not only improves nutrient uptake and crop performance but also promotes microbial activity and enzymatic processes crucial for long-term soil health.

The present study aimed to evaluate the combined effects of biofertilizers, inorganic fertilizers, and KAB on (i) yield and quality of sweet corn, (ii) nutrient content and uptake, and (iii) soil physico-chemical properties in lateritic soils of Konkan.

Corresponding Author:
Karekar AV
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Materials and Methods

Experimental Site and Soil

The field experiment was conducted during *Rabi 2024-25* at the Research and Instruction Farm of the Department of Agronomy, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra. The site is characterized by lateritic soils, which are low to medium in available nitrogen, very low in available phosphorus due to high fixation, and medium in available potassium. Initial soil analysis revealed a pH of 4.7, EC of 0.07 dS/m, organic carbon 10.86 g/kg, available N 373.1 kg/ha, P_2O_5 6.94 kg/ha, and K_2O 149.6 kg/ha.

Experimental Design and Treatments

The experiment was laid out in a Randomized Block Design (RBD) with three replications and eight treatments:

- T_1: Absolute control
- T_2: Biofertilizers only (*Azotobacter* + PSB @ 5 kg/ha each)
- T_3: 100% RDF (200:60:60 N:P_2O_5:K_2O kg/ha)
- T_4: 100% RDF + Biofertilizers
- T_5: 125% RDF
- T_6: 125% RDF + Biofertilizers
- T_7: RDF through Konkan Annapurna Briquettes (KAB, N-based)
- T_8: RDF through KAB + Biofertilizers

Crop and Fertilizer Management

Sweet corn variety (sweet 70) was sown at 60cm x 20cm following recommended agronomic practices. Chemical fertilizers were applied as per treatment requirements, with KAB placed @ two briquettes per plant at the three-to four-leaf stage. Biofertilizers (*Azotobacter* and PSB) were mixed with manure and incorporated into the top 5-10 cm of soil at sowing.

Observations Recorded

- **Yield and Quality:** Green cob yield, dry fodder yield, protein content, total sugar, reducing sugar, and non-reducing sugar.
- **Nutrient Content and Uptake:** Nitrogen, phosphorus, and potassium content in cob and total uptake by plant and cob.
- **Soil Properties:** Post-harvest available N, P, and K.

Statistical Analysis

Data were analyzed using ANOVA appropriate for RBD. Treatment means were compared using Critical Difference (CD) at 5% probability level.

Results and Discussion

1. Yield and Quality of Sweet Corn

1.1 Green Cob and Dry Fodder Yield

Application of biofertilizers and inorganic fertilizers significantly influenced green cob and dry fodder yield (Table 1). Green cob yield ranged from 8.47 t/ha under control (T_1) to 26.42 t/ha with RDF through Konkan Annapurna Briquettes + biofertilizers (T_8). Among RDF treatments, 125% RDF + biofertilizers (T_6) recorded a yield of 24.63 t/ha, which was statistically comparable to T_8 but significantly superior to 100% RDF (18.54 t/ha).

Dry fodder yield followed a similar trend, with the highest value (15.86 t/ha) recorded under 125% RDF + biofertilizers (T_6), followed by KAB + biofertilizers (T_8) at 15.34 t/ha. The yield advantage in integrated treatments can be attributed to improved nutrient availability, better root growth, and enhanced photosynthetic activity, as reported in similar studies by Suthar *et al.* (2012) [12].

1.2 Protein Content

Protein content in sweet corn cobs varied from 6.83% (T_1) to 12.44% (T_6). Application of 125% RDF along with biofertilizers significantly enhanced protein concentration, likely due to increased nitrogen uptake and improved assimilation of amino acids into protein. Shakunthala *et al.* (2022) [11].

1.3 Sugar Content

Total sugar, reducing sugar, and non-reducing sugar ranged from 8.93-14.21%, 1.84-2.66%, and 7.09-11.55%, respectively. The highest values for all sugar fractions were recorded under KAB + biofertilizers (T_8), indicating that slow-release N from KAB maintained a steady carbohydrate supply, favoring sugar accumulation. These findings align with observations by shakunthala *et al.* (2022) [11], who reported enhanced sweetness under integrated nutrient regimes.

In summary, KAB + biofertilizers (T_8) excelled in green cob yield and sugar content, while 125% RDF + biofertilizers (T_6) was superior for dry fodder yield and protein content, suggesting complementary benefits of these integrated approaches.

2. Nutrient Content and Uptake by Sweet Corn

2.1 Nutrient Content in Cob

Application of biofertilizers and inorganic fertilizers significantly influenced the concentration of nitrogen (N), phosphorus (P), and potassium (K) in sweet corn cobs (Table 2). Nitrogen content ranged from 1.09% in control (T_1) to 1.99% in 125% RDF + biofertilizers (T_6). Phosphorus and potassium concentrations followed similar trends, with maximum values of 0.274% and 0.806%, respectively, under T_6. The improved nutrient concentration under T_6 can be attributed to enhanced nutrient availability and uptake efficiency facilitated by biofertilizers, as also reported by Sanjivkumar (2014) [9] and Rasool *et al.* (2016) [8].

2.2 Total Nutrient Uptake

Total N uptake varied markedly among treatments, from 138.36 kg/ha (T_1) to 708.07 kg/ha (T_6). Total P and K uptake were highest in KAB + biofertilizers (T_8) at 77.35 kg/ha and 360.51 kg/ha, respectively. While T_6 excelled in total nitrogen uptake due to higher biomass and N concentration, T_8 promoted greater P and K uptake by maintaining consistent nutrient release and reducing fixation losses, corroborating findings by Savant *et al.* (2000) [10].

2.3 Nutrient Use Dynamics

The synergy between biofertilizers and slow-release fertilizers likely enhanced root activity, facilitated microbial solubilization of P, and improved K assimilation. These results align with the hypothesis that integrated nutrient management optimizes both concentration and uptake, leading to improved nutrient-use efficiency.

Overall, 125% RDF + biofertilizers (T_6) was most effective for improving cob nutrient concentrations and total N uptake, while KAB + biofertilizers (T_8) enhanced total P and K uptake, indicating the complementary roles of these nutrient sources.

3. Post-harvest Soil Fertility

The application of biofertilizers and inorganic fertilizers significantly influenced the nutrient status of lateritic soils after harvest (Table 3).

3.1 Available Nitrogen (N)

Available N ranged from 312.81 kg/ha in the control (T_1) to 382.59 kg/ha in KAB + biofertilizers (T_8). Treatments with biofertilizers consistently recorded higher N values than their sole fertilizer counterparts, suggesting the role of *Azotobacter* in biological N fixation and improved nitrogen cycling. The slow-release nature of KAB likely minimized N losses, enhancing residual availability.

3.2 Available Phosphorus (P)

Available P was lowest in T_1 (1.33 kg/ha) and highest in T_8 (3.53 kg/ha). Phosphate-solubilizing bacteria (PSB) likely contributed to the solubilization of insoluble soil phosphates, while KAB ensured a steady supply of P, reducing fixation losses typical of lateritic soils. Similar findings were reported by Phonde (1987) [7], emphasizing the role of integrated approaches in enhancing P availability in high P-fixation soils.

3.3 Available Potassium (K)

Available K ranged from 153.08 kg/ha (T_1) to 226.18 kg/ha (T_5). Interestingly, 125% RDF + biofertilizers (T_6) recorded 209.65 kg/ha, higher than KAB treatments. This suggests that higher K inputs in RDF-based treatments contributed to elevated residual K, while briquettes primarily enhanced N and P efficiency. Overall, KAB + biofertilizers (T_8) excelled in improving available N and P, whereas 125% RDF + biofertilizers (T_6) maintained higher residual K. These results indicate that integrating biofertilizers with slow-release fertilizers is particularly effective for sustaining soil fertility in lateritic soils.

Application of biofertilizers and inorganic fertilizers significantly influenced yield, quality, nutrient uptake, and soil fertility of sweet corn (Tables 1-3).

Yield and Quality: Green cob yield increased from 8.47 t/ha (control) to 26.42 t/ha under KAB + biofertilizers (T_8), while 125% RDF + biofertilizers (T_6) produced the highest dry fodder yield (15.86 t/ha). Quality parameters improved with integrated nutrient management; T_8 recorded the highest total sugar (14.21%), reducing sugar (2.66%), and non-reducing sugar (11.55%), whereas T_6 had the highest protein content (12.44%). These enhancements can be attributed to improved nutrient availability and balanced nutrition, consistent with findings of Kaur *et al*. (2019) [6].

Nutrient Content and Uptake: Nitrogen, phosphorus, and potassium concentrations in cobs were highest in T_6 (1.99%, 0.274%, and 0.806%), resulting in the maximum total nitrogen uptake (708.07 kg/ha). However, T_8 achieved the highest total phosphorus (77.35 kg/ha) and potassium uptake (360.51 kg/ha). The synergy of biofertilizers with slow-release KAB likely enhanced nutrient use efficiency, as also reported by Savant *et al*. (2000) [10].

Soil Fertility: Post-harvest soil analysis showed significant improvement in available nutrients. T_8 recorded the highest available nitrogen (382.59 kg/ha) and phosphorus (3.53 kg/ha), while T_6 maintained higher residual potassium (209.65 kg/ha). This demonstrates the complementary effects of biofertilizers and nutrient sources in sustaining soil fertility, aligning with earlier reports by Kadrekar and Talashilkar (1977) [5] and Phonde (1987) [7].

Overall, KAB + biofertilizers enhanced cob yield and sugar quality, while 125% RDF + biofertilizers improved fodder yield, protein content, and total nitrogen uptake, indicating that integrated nutrient management is essential for optimizing productivity and soil fertility in lateritic soils of Konkan.

Table 1: Effect of biofertilizers and inorganic fertilizers on yield and quality of sweet corn

Treatments	Green Cob Yield (t/ha)	Dry Fodder Yield (t/ha)	Protein (%)	Total Sugar (%)	Reducing Sugar (%)	Non-Reducing Sugar (%)
T_1: Control	8.47	6.24	6.83	8.93	1.84	7.09
T_2: Biofertilizers only	10.77	7.41	6.83	11.56	2.11	9.45
T_3: 100% RDF	18.51	10.12	8.13	12.51	2.16	10.35
T_4: 100% RDF + BF	20.57	10.97	8.61	12.83	2.25	10.58
T_5: 125% RDF	21.75	14.02	11.02	13.18	2.19	10.98
T_6: 125% RDF + BF	23.82	15.86	12.44	14.13	2.37	11.76
T_7: KAB	24.50	10.72	9.83	13.43	2.42	11.01
T_8: KAB + BF	26.42	11.07	10.46	14.21	2.66	11.55
S.Em (±)	2.83	0.40	0.55	0.49	0.13	0.50
CD (P=0.05)	8.01	1.22	1.692	1.48	0.40	1.52

Table 2: Nutrient content and nutrient uptake by sweet corn

Treatments	N in Cob (%)	P in Cob (%)	K in Cob (%)	Total N Uptake (kg/ha)	Total P Uptake (kg/ha)	Total K Uptake (kg/ha)
T_1: Control	1.09	0.185	0.627	138.36	19.32	114.54
T_2: Biofertilizers only	1.09	0.207	0.693	180.14	26.85	147.09
T_3: 100% RDF	1.30	0.227	0.745	349.58	46.98	236.62
T_4: 100% RDF + BF	1.38	0.239	0.765	419.21	53.67	267.69
T_5: 125% RDF	1.76	0.268	0.771	563.11	66.79	314.04
T_6: 125% RDF + BF	1.99	0.274	0.806	708.07	77.35	360.51
T_7: KAB	1.57	0.249	0.737	505.90	68.37	279.52
T_8: KAB + BF	1.67	0.254	0.745	571.17	73.21	299.41
S.Em (±)	0.089	0.017	0.020	45.970	7.125	19.164
CD (P=0.05)	0.27	0.052	0.060	139.437	21.612	58.129

Table 3: Post-harvest soil fertility of sweet corn field

Treatments	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
T_1: Control	312.81	1.33	153.08
T_2: Biofertilizers only	330.32	1.57	161.41
T_3: 100% RDF	334.51	1.86	164.81
T_4: 100% RDF + BF	337.64	1.97	174.94
T_5: 125% RDF	340.77	1.90	199.76
T_6: 125% RDF + BF	348.96	2.49	209.65
T_7: KAB	350.18	3.14	182.42
T_8: KAB + BF	382.59	3.53	192.55
S.Em (±)	9.72	0.24	10.83
CD (P=0.05)	29.47	0.72	32.85

Conclusion

The study demonstrated that integrated nutrient management significantly enhanced yield, quality, nutrient content, and soil fertility in sweet corn grown on lateritic soils of Konkan. Green cob yield ranged from 8.47 t/ha in control to 26.42 t/ha under Konkan Annapurna Briquettes (KAB) + biofertilizers (T_8), which also produced the highest total (14.21%), reducing (2.66%), and non-reducing (11.55%) sugar content. 125% RDF + biofertilizers (T_6) recorded the highest dry fodder yield (15.86 t/ha) and protein content (12.44%), as well as maximum total nitrogen uptake (708.07 kg/ha).

Nutrient dynamics in soil revealed that KAB + biofertilizers (T_8) significantly improved available nitrogen (382.59 kg/ha) and available phosphorus (3.53 kg/ha), whereas 125% RDF + biofertilizers (T_6) maintained higher available potassium (209.65 kg/ha). These findings indicate that combining biofertilizers with KAB or RDF improves nutrient use efficiency, crop performance, and sustains soil fertility.

For sweet corn production in lateritic soils of Konkan, KAB + biofertilizers is recommended for maximizing green cob yield and sugar quality, while 125% RDF + biofertilizers is more effective for improving fodder yield, protein content, and overall nitrogen uptake.

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Author details

Karekar AV
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Khobragade NH
Assistant Professor, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Meshram NA
Scientist, Assistant Professor, Department of Soil Science and Agricultural Chemistry, All India Coordinated Research Project on Agroforestry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Rajemahadik VA
Assistant Professor, Department of Agronomy, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Kadam JJ
Associate Professor, Department of Plant Pathology, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Nagle SS
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Nevase SV
Department of Soil Science and Agricultural Chemistry, College

of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Biswas A
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Bhuvad DD
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Patil IR
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Amberkar PD
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Nalawde AB
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Ingale PJ
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

Jadhav SS
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India