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Effect of organic manure inorganic nutrient management on soil fertility and baby corn productivity

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Abstract
An increasing population and rising food demand highlight the need for sustainable crop production. Baby corn, an emerging crop with high market demand, requires balanced nutrient management for better yield and soil sustainability. Trials were carried out to study the effect of organic manure (farmyard manure, FYM) and inorganic fertilizers (NPK) on soil fertility, productivity, nutrient uptake, and economics of baby corn. Results showed that integrated nutrient management (INM), where FYM was combined with recommended doses of NPK, performed better than using either source alone. Baby corn yield increased from about 10 q ha^{-1} in control to 17-18 q ha^{-1} with INM, while green fodder yield reached nearly 36 t ha^{-1}**.** Soil organic carbon improved by 30-40% under INM compared to initial levels, and available nitrogen, phosphorus, and potassium were also higher. Nutrient uptake by the crop was significantly improved in integrated treatments, showing better fertilizer use efficiency. Economic analysis revealed that INM gave higher net returns (90,000-95,000 ₹ ha^{-1}) and a better benefit-cost ratio (1.5-1.6) compared to only inorganic fertilizer use. Although the cost of cultivation was slightly higher with FYM addition, the higher yield and soil health improvement ensured greater profitability and long-term sustainability. The study suggests that integrating FYM with chemical fertilizers not only enhances soil fertility and yield of baby corn but also supports farmers' income, contributing to food and nutritional security under increasing population pressure. Baby corn, being a short-duration, nutrient-rich, and high-value crop, plays a crucial role in meeting the dual objectives of food and nutritional security. Its cultivation under INM ensures higher yield, better profitability, and reduced environmental degradation compared to sole reliance on chemical fertilizers. Thus, INM-based baby corn production systems provide a practical pathway to meet the growing food demand of an increasing population while safeguarding soil and livestock resources for future generations.

Keywords: Soil properties, fertility, baby corn, INM, FYM, nutrient uptake & economics.

Introduction
The Indo-Gangetic plains represent one of the most fertile and agriculturally productive regions of India, covering districts in Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal. Key districts include Haridwar and Dehradun in Uttarakhand; Prayagraj, Varanasi, Kanpur, Rae Bareli, Gorakhpur, and Ghazipur in Uttar Pradesh; Patna, Muzaffarpur, Bhagalpur, Darbhanga, and Buxar in Bihar; Sahibganj and Pakur in Jharkhand; and Malda, Murshidabad, Nadia, Hooghly, and Kolkata in West Bengal. This belt is characterized by fertile alluvial soils, dense river systems, and favourable climatic conditions, supporting intensive farming and high population densities. Maize has become the third most important cereal crop in India after rice and wheat, playing a crucial role in the country's food and nutritional security. It is cultivated on nearly 108.87 lakh hectares, with a production of about 356.73 lakh tonnes during 2023-24 (ANGRAU, 2023) [3]. In Uttar Pradesh, maize is an important kharif crop, grown on around 8.18-8.30 lakh hectares and contributing nearly 21.16 lakh tonnes of production annually (PJTAU, 2025; The Statesman, 2024) [35, 49]. These figures highlight the increasing significance of maize in the Indian cropping system and its role in supporting rural livelihoods, particularly in Uttar Pradesh where it remains a vital component of the agricultural economy.

In Uttar Pradesh, maize is mainly cultivated during the kharif season, occupying about 8.18-8.30 lakh hectares, which accounts for nearly 7-8% of the national maize area (DES, 2022; PJTSAU, 2025) [14, 35]. The crop is valued not only for food and feed but also as a raw material for starch, feed, and poultry industries (NAARM, 2016) [31]. Alongside grain maize, baby corn cultivation is expanding, particularly in Uttar Pradesh, Haryana, Karnataka, and Andhra Pradesh, often under contract farming (Ramasamy *et al*., 2021) [38]. Although exact nationwide figures are unavailable, India is estimated to produce 20-25 thousand tonnes of baby corn annually, catering to both domestic and export markets (Shubhadarshi and Priyadarshini 2025) [44]. The Indo-Gangetic Plain also exhibits high cropping intensity, often exceeding 200% due to rice - wheat; rice - rice, and maize-based systems (Biyarniya *et al*., 2024; and Biswas *et al*., 2006) [9, 8]. However, intensive cultivation has led to soil fertility challenges such as nutrient depletion and declining organic carbon levels (Bhattacharyya *et al*., 2015; and Das *et al*., 2021) [7, 13]. Despite these constraints, the Gangetic districts continue to play a vital role in ensuring food security, sustaining rural livelihoods, and driving agricultural growth in India. Uttar Pradesh, Bihar, Jharkhand, West Bengal, and parts of Uttarakhand, form the core of the Indo-Gangetic plains. This region is characterized by fertile alluvial soils, high cropping intensity (often exceeding 200-250%), and a dominance of rice-wheat and rice-rice systems covering nearly 14 million hectares (Frontiers in Sustainable Food Systems, 2023) [17]. With dense populations and heavy dependence on agriculture, these districts play a crucial role in ensuring food security and sustaining rural livelihoods (Ministry of Agriculture & Farmers' Welfare, Government of India, 2022) [28]. India has a total geographical area of about 328.7 million hectares, out of which a major share is utilized for agriculture. The cultivable land area is estimated at 180.11 million hectares, while the gross cropped area has expanded to 219.16 million hectares in 2021 - 22 due to the practice of multiple cropping. Nearly 55% of the country's geographical area is under agricultural use, which underscores the vital role of this sector in land utilization. These figures highlight the significance of agriculture in ensuring food security and sustaining rural livelihoods in India (Government of India, Ministry of Agriculture and Farmers Welfare, 2023) [29]. Agriculture remains the backbone of global food security, playing a central role in sustaining human life and livelihoods. Providing sufficient food for the world's rapidly expanding population is one of the greatest challenges of this century. According to the United Nations, the global population was estimated at 8.0 billion in 2022 and is projected to reach 9.7 billion by 2050 (United Nations, 2022) [53]. Meeting the nutritional demands of this population surge will require a substantial increase in agricultural productivity. Estimates by the Food and Agriculture Organization (FAO) suggest that global food production must increase by about 60% by 2050 compared to current levels in order to ensure adequate food availability (FAO, 2009) [15]. These projections highlight the urgency of adopting sustainable agricultural practices that can simultaneously enhance productivity, conserve natural resources, and address climate change challenges. Ensuring global food and nutritional security remains a major challenge in the twenty-first century. According to the *State of Food Security and Nutrition in the World 2025* report, an estimated 673 million people worldwide were undernourished in 2024, representing nearly 8.2% of the global population (FAO *et al*., 2025) [16]. At the same time, demographic pressures are intensifying. In 2023, India overtook China to become the world's most populous country, with an estimated 1.4286 billion people, compared to China's 1.4257 billion (United Nations, 2023; Reuters, 2023) [52, 40]. These demographic and food security trends underline the urgent need for sustainable agricultural intensification to meet the growing demand for food without exacerbating environmental degradation. These soils not only support vigorous root growth but also ensure efficient nutrient uptake, which is vital for cob development and higher yields. A slightly acidic to neutral pH range of 6.0-7.5 has been found to be most suitable for nutrient availability and plant growth. Regions such as Prayagraj, Varanasi, Meerut, and Saharanpur are well known for their deep, fertile alluvial soils that provide excellent conditions for sustainable and profitable baby corn production. However, areas with heavy clay soils prone to water logging are less suitable, as baby corn is sensitive to poor drainage. Thus, in the context of India and Uttar Pradesh, alluvial loamy soils with proper structure, fertility, and drainage remain the most preferred choice for successful baby corn farming. In Uttar Pradesh, where fertile alluvial loamy soils of the Indo-Gangetic plains provide excellent conditions, several baby corn hybrids have shown superior adaptability and yield performance. Among the baby corn genotypes evaluated, Vivek Hybrid-17 produced the highest total de-husked baby corn yield approximate 16.04 q ha^{-1}, while VL Baby Corn delivered a comparable yield of about 15.26 q ha^{-1}. Vivek Hybrid-17 also initiated harvest earlier (fewer days to first pick) and exhibited higher first-picking yields (6.51 q ha^{-1} de-husked). Both Vivek Hybrid-17 and VL Baby Corn maintained consistently strong yields across multiple pickings in the trial, indicating their suitability for intensive baby corn production under the tested conditions (Kumar *et al*., 2016; and AICMIP 2014) [23, 1]. Additionally the hybrid G-5414 has also been reported as a promising variety for baby corn production, combining good cob quality with high productivity, and has gained attention among farmers in Uttar Pradesh for its adaptability to alluvial soils and better recovery of marketable cobs. Considering these options, Vivek, Hybrid-17 emerges as the top choice for maximum yield, followed closely by VL Baby Corn, while Parkash is preferred where both cob and fodder are required, and G-5414 offers another reliable alternative for sustainable and profitable baby corn cultivation in Uttar Pradesh. Baby corn has emerged as a high-value crop in India due to its short duration, export potential, and demand in urban and peri-urban markets. Increasing the production of baby corn requires an integrated approach that combines improved varieties with better crop and soil management practices. Selection of high-yielding hybrids such as Vivek Hybrid-17, VL Baby Corn, Parkash, and G-5414 ensures higher productivity and uniform cob quality. Incorporation of biofertilizers such as *Azotobacter* and *Pseudomonas* further supports nutrient availability and improves soil microbial activity. In addition, intercropping baby corn with legumes and the adoption of improved post-harvest handling practices can increase both profitability and market acceptance. Thus, through the combined use of high-yielding varieties, balanced nutrition, efficient water management, and improved agronomic practices, baby corn production can be significantly enhanced in India and particularly in the Indo-Gangetic plains of Uttar Pradesh. In India, and particularly in Uttar Pradesh, baby corn performs best in fertile, well-drained soils that combine good aeration with adequate moisture-holding capacity. The alluvial loamy soils of the Indo-Gangetic plains, which dominate much of Uttar Pradesh, are especially favourable for baby corn cultivation due to their rich nutrient status, balanced texture, and high organic matter content. These soils not only support vigorous root growth but also ensure efficient nutrient uptake, which is vital for cob development and higher yields. A slightly acidic to neutral pH range of 6.0-7.5 has been found to be most suitable for nutrient availability and plant growth. Equally important are nutrient and water management practices, which directly influence cob development and quality. Research indicates that integrated nutrient management (INM), where a portion of inorganic fertilizers is substituted with farmyard manure (FYM) or vermicompost, improves soil fertility, enhances nutrient uptake, and sustains yields over time (Sharma *et al*., 2020) [41]. Maize is the third most important cereal crop in India after rice and wheat, and it plays a significant role in food, feed, and industrial sectors. At the national level, maize is cultivated on about 11.2 million hectares, producing nearly 42.3 million tonnes with an average productivity of 3.7-3.8 t ha^{-1} (USDA/FAS 2025; GOI 2024) [54, 18]. In Uttar Pradesh, maize covers an area of around 0.83 million hectares and contributes about 2.1 million tonnes annually, with an average productivity of 2.5 t ha^{-1}, which remains below the national average (GOUP 2024) [19]. In combination with recommended doses of NPK fertilizers, they can create a balanced nutrient environment that sustains productivity while gradually rebuilding soil health. Baby corn is a nutrient-hungry crop that removes large amounts of nitrogen, phosphorus, and potassium from the soil. Sole reliance on chemical fertilizers increases costs and can damage soil health. Integrated Nutrient Management (INM), which combines organic manures, biofertilizers, and chemical fertilizers, is a better approach. INM ensures balanced nutrient supply, improves soil organic carbon, enhances microbial activity, and restores soil structure. Integrated Nutrient Management (INM) has been demonstrated to substantially enhance crop productivity compared to unfertilized conditions. Long-term experiments under maize in Alfisols reported that INM practices increased yields by 60-70% over the control, with productivity levels rising to about 1.6-2.1 t ha^{-1}, thereby highlighting its potential to improve soil fertility and sustain crop production (Trivedi *et al.* 2020) [51]. Importantly, INM reduces dependence on costly inputs, lowers risks for farmers, and maintains soil fertility over the long term. For farmers, the economic benefits of INM are very clear. Soil microbial populations are fundamental to soil fertility and crop productivity because they drive organic matter decomposition, nutrient cycling, and the transformation of essential elements into plant-available forms. Beneficial microorganisms such as *Azotobacter* and *Pseudomonas* not only fix atmospheric nitrogen but also solubilize phosphorus, produce growth-promoting substances, and suppress soil-borne pathogens, thereby improving soil health and plant vigor. Biological inoculants have emerged as vital components of sustainable nutrient management strategies in maize and baby corn production. Among these, *Azotobacter* is widely recognized for its ability to fix atmospheric nitrogen and synthesize growth-promoting substances, thereby improving crop performance. Studies have reported that inoculation with *Azotobacter* can enhance growth and yield by 15 - 35% over non-inoculated controls, particularly when applied in conjunction with farmyard manure or reduced doses of chemical fertilizers. In field trials, integration of *Azotobacter* with FYM in maize hybrid Rampur Hybrid-14 resulted in grain yields of 8.41 t ha^{-1}, representing a yield increase of about 58.5% compared with the control (Shrestha *et al.* 2025) [43]. Such evidence highlights that microbial activity, supported by organic inputs, plays a central role in maintaining soil fertility, improving nutrient use efficiency, and sustaining higher productivity of baby corn under integrated nutrient management (INM) systems. In modern agriculture, soil microbial populations play a pivotal role in maintaining soil fertility, nutrient availability, and sustainable crop production. Microorganisms such as bacteria, fungi, and actinomycetes are key drivers of organic matter decomposition, nitrogen fixation, and phosphorus solubilization, thereby supporting better plant nutrition and soil health. In the case of baby corn, which is a short-duration and nutrient-demanding crop, the presence of a diverse microbial community in the rhizosphere enhances root development, nutrient uptake, and overall crop performance. Recent studies have demonstrated that integrated nutrient management, involving the combined use of organic manures and inorganic fertilizers, can significantly improve microbial activity and soil fertility, leading to higher yields of baby corn (Bhattacharyya and Biswas, 2025) [6]. Moreover, inoculation with beneficial microbes such as *Azospirillum brasilense* has been shown to improve cob quality, nutrient uptake, and yield potential (Pelloso *et al*., 2023) [34]. Similarly, plant growth-promoting rhizobacteria (PGPR) contribute to crop growth by producing phytohormones, enhancing nutrient mobilization, and suppressing soil-borne pathogens (Zhang *et al*., 2024) [56]. Thus, maintaining and enhancing soil microbial populations through balanced fertilization and microbial inoculation is essential for sustaining baby corn productivity while preserving long-term soil health. These improvements in yield and profitability are particularly important for small and marginal farmers, as they reduce input costs, increase returns, and provide greater financial stability. Using local organic resources such as farmyard manure and compost also makes INM more affordable and practical for resource-poor households.

Materials and Methods

The experiments were conducted during the *Zaid* season of 2021 and 2022 at the Soil Science Research Farm Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, India. The site is geographically situated at 25°24′42″ N latitude, 81°50′56″ E longitude, and an altitude of 98 m above mean sea level**,** The experimental soil was classified as a Typic Ustochrept (Inceptisol) with sandy loam texture. Composite soil samples (0-15 cm depth) were collected from random spots before sowing, air-dried, ground, and sieved (2 mm). The experimental site had a cropping history of **(**Maize-barley - baby corn) cropping system. The site lies in the Indo-Gangetic alluvial plains, classified as Agro-Ecological

Region and within the humid sub tropical climate. The experimental area Prayagraj receives an average annual rainfall of about 959-1042 mm of which nearly 85% occurs during the southwest monsoon (June-September). July is the wettest month, contributing around 330-333 mm followed by August and September, whereas November records the least rainfall, often below 5 mm. During the cropping period, mean maximum and minimum temperatures ranged between 34.5-39.8 °C and 21.2-26.1 °C, respectively, with relative humidity levels of 65-78%**.** The experiment comprised two factors First factor Inorganic factor stands for [I] have four fertility levels [@ 0%, @ 50% RDF, @ 75% RDF, @ 100% RDF]. The Recommended dose of NPK fertilizers (*i.e.* Urea, SSP, & MOP) as 120:60:40 kg ha^{-1} and second factor stands for [FB] combined three biofertilizers levels [B] (Uninoculated, *Azotobacter* and *Pseudomonas*) and FYM stands for (F) [@ 0 t ha^{-1}, @ 5 t ha^{-1}, @ 7.5 t ha^{-1}]. First factor Inorganic [I] have four levels and second factor Organic stand for [FB] have seven levels total treatment combinations are 28 treatments and three replications. The Baby corn seeds variety is G-5414. Before sowing seeds, seeds are already treated with Thiaram. In the experiment of treatment combinations, seeds are treated with biofertilizetrs (*Azotobacter* and *Pseudomonas*) @ 200 g 10 kg seeds at the experimental field. The farm yard manure was applied before sowing according to the treatment and doses to experimental plot wise. The farm yard manure incorporated to the soil. The seeds are sowing according to the treatment wise uninoculated, *Pseudomonas* treated seeds and *Azotobacter* treated seeds. The seed sowing rate of baby corn is 20 kg ha^{-1}. The sources used for applying N, P and K were Urea, SSP and MOP, respectively. The baby corn plant to plant and row to row distance is 30 × 45 cm. The baby corn seed was sowing in the month of March *Zaid* season 2021 and 2022 respectively. Before the experiment, composite soil samples were collected from 0-15 cm depth using zigzag pattern. Samples were air-dried, crushed, passed through a 2 mm sieve and stored for chemical analysis. After harvest, soil samples were again collected from 0-15 cm depth in the same way. Samples were air dried, sieved 2 mm and stored for analysis of soil samples. Soil pH and electrical conductivity (EC) were measured in 1:2.5 (w/v) soil water suspension using a digital pH and conductivity meter. Organic carbon was determined by the Walkley and Black, (1947) [55] method, Available nitrogen was estimated by Subbiah and Asija, (1956) [47], Available Phosphorus was measured by (Olsen *et al.* 1954) [32], Available Potassium was determined by flame Photometer (Toth and Prince, 1949) [50]. Soil texture (Sand, Silt and Clay) was determined by the hydrometer method (Bouyoucus, 1927) [11]. Bulk density.Particle density, water holding capacity (%) and Pore space (%) were estimated by Graduated Measuring cylinder method (Muthuvel *et al.* 1992) [30]. The experimental data were statistically analyzed analysis of variance (ANOVA) appropriate for a factorial randomized block design as described by Panse and Sukhatme (1967) [33]. Treatment means were compared at the 5% level of significance and critical difference (CD) values were calculated where the effects were significant. Statistical computations were performed using standard agricultural statistics software. Initial Soil characterstics were pH (7.28), Electrical Conductivity (0.141 dS m^{-1}), Organic carbon (0.146%), Av. N (290.96 Kg ha^{-1}), Av. P_2O_5 (18.39 Kg ha^{-1}), Av. K_2O (178.89 Kg ha^{-1}), Soil texture (Sand 60.49%, Silt 21.61%, Clay17.90%) Sandy loam. While, bulk density (1.19 Mg m^{-3}), Particle density (2.88 Mg m^{-3}), Water Holding capacity (38.55%) and Pore Space (40.59%).

Parameters	Permissible limit / Reference range			Scientist (Year)
	Low	Medium	High	
Soil texture (Sandy loam)				
Sand (%)	< 45	45-65	> 65	Black (1965)
Silt (%)	< 28	28-50	> 50	Black (1965)
Clay (%)	< 20	20-35	> 35	Black (1965)
Bulk density (Mg m^{-3})	< 1.3	1.3-1.6	> 1.6	Brady and Weil (2016)
Particle density (Mg m^{-3})	< 2.4	2.4-2.7	> 2.7	Brady and Weil (2016)
Water holding capacity (%)	< 40	40-50	> 40	Brady and Weil (2016)
Pore Space (%)	< 50	40-60	> 60	Brady and Weil (2016)
Soil pH (1:2.5) w/v	< 6.5	6.5-7.0	> 7.5	Brady and Weil (2016)
Electrical Conductivity (dS m^{-1})	< 1.0	1.0-2.0	> 2.0	Brady and Weil (2016)
Organic Carbon (%)	< 0.5	0.5-0.75	< 0.75	Jackson (1973)
Parameters	Low	Medium	High	Scientist (Year)
Av. N (Kg ha^{-1})	< 280	280-560	> 560	Subbiah and Asija (1956)
Av. P_2O_5 (Kg ha^{-1})	< 10	10-25	> 25	Olsen *et al*. (1954) [32]
Av. K_2O (Kg ha^{-1})	< 110	110-280	> 280	Hanway *et al*. (1952)

ResultS and Discussion

Soil Physical Properties

The pooled data revealed that the maximum soil bulk density was recorded in T_{28} [F_6B_2] 1.54 Mg m^{-3} and followed by T_{24} [F_5B_2] 1.53 Mg m^{-3} and lowest was recorded in T_1 [F_0B_0] 1.41 Mg m^{-3} due to sub factor (FB) main factor (I) and due to interaction (FB × I) it was found to be significant. Similar findings reported by (Pushpendra Kumar *et al*. 2022) [37]. The pool data of 2021 and 2022 revealed that the maximum soil particle density was recorded in T_{28} [F_6B_2] 2.69 Mg m^{-3} and followed by T_{24} [F_5B_1] 2.65 Mg m^{-3} and lowest was recorded in T_1 [F_0B_0] 2.31 Mg m^{-3} due to sub factor (FB) main factor (I) and due to interaction (FB × I) it was found to be significant, similar findings reported by (Shiva Prasad *et al*. 2023) [42]. The pooled data of 2021 and 2022 revealed that the maximum water holding capacity was recorded in T_{28} [F_6B_2] 43.78% and followed by T_{24} [F_5B_1] 42.95% and lowest was recorded in T_1[F_0B_0] 37.40% due to sub factor (FB) main factor (I) and due to interaction (FB × I) it was found to be significant, similar findings reported by (Shiva Prasad *et al.* 2023) [42].

Soil Chemical Properties

The pooled data of 2021 and 2022 revealed that the maximum soil pH was recorded in T_{28} [F_6B_1] 7.35 and followed by T_{24} [F_5B_2] 7.33 and lowest was recorded in T_1[F_0B_0] 6.92 due to sub factor (FB) main factor (I) and due to interaction (FB × I) it was found to be significant. Similar findings by (Shiva Prasad *et al*. 2023) [42]. The pooled data of 2021 and 2022 revealed that the maximum electrical conductivity (dS m^{-1}) was recorded in T_{28} [F_6B_2] 0.25 dS m^{-1} and followed by T_{24} [F_5B_2] 0.21 dS m^{-1} and lowest was recorded in T_1 [F_0B_0] 0.12 dS m^{-1} due to sub factor (FB) main factor (I) and due to interaction (FB × I) it was found to be significant. Similar findings by (Bhattacharyya *et al*. 2023) [5]. The pool data of 2021 and 2022 revealed that the maximum organic carbon (%) was recorded in T_{28} [F_6B_2] 0.69% and followed by T_{24} [F_5B_1] 0.68% and lowest was recorded in T_1 [F_0B_0] 0.37% due to sub factor (S) main factor (M) and due to interaction (M × S) it was found to be significant, similar findings reported by (Kumar *et al*. 2023) [26]. The pool data of 2021 and 2022 revealed that the maximum available nitrogen (kg ha^{-1}) was recorded in T_{28} [F_6B_2] 280.50 kg ha^{-1} and followed by T_{24} [F_5B_2] 277.50 kg ha^{-1} and lowest was recorded in T_1 [F_0B_0] 265.34 kg ha^{-1} due to sub factor (FB) main factor (I) and due to interaction (FB × I) it was found to be significant, similar findings reported by (Gupta *et al*. 2024) [20]. The pool data of 2021 and 2022 revealed that the maximum available phosphorus (kg ha^{-1}) was recorded in T_{28} [F_6B_2] 24.12 kg ha^{-1} and followed by T_{24} [F_5B_1] 23.10 kg ha^{-1} and lowest was recorded in T_1 [F_0B_0] 19.01 kg ha^{-1} due to sub factor (FB) main factor (I) and due to interaction (FB × I) it was found to be significant. Similar findings by (Sofyan *et al*. 2023) [45]. As depicted in table 6 the effect of various level of N, P, K, biofertilizers and organic manures on Yield (q ha^{-1}) of baby corn crop the maximum was recorded in treatment T_{28} [F_6B_2] 33.00 followed by T_{24} [F_5B_2] 31.70 and minimum in T_1 [F_0B_0] 17.07 and T_{28} [F_6B_2] 33.67 followed by T_6 [F_5B_2] 32.30 and minimum were recorded in T_1 [F_0B_0] 17.40 in 2021 and 2022 respectively, due to sub factor biofertilizers (Farm yard manure and *Azotobacter*, *Pseudomonas)*, main factor (Inorganic fertilizers) and due to interaction (FB × I) it was found to be significant. The pooled data of 2021 and 2022 revealed that the maximum available potassium (kg ha^{-1}) was recorded in T_{28} [F_6B_2] 235.00 kg ha^{-1} and followed by T_{24} [F_5B_1] 233.53 kg ha^{-1} and lowest was recorded in T_1 [F_0B_0] 175.00 kg ha^{-1} due to sub factor (FB) main factor (I) and due to interaction (FB × I) it was found to be significant. Similar findings by Shiva Prasad *et al*. 2023) [42].

Biological Properties

The pool data of 2021 and 2022 revealed that the maximum fungal population (cfu × 10^4 g^{-1}) was recorded in T_{28} [F_6B_2] 30.67 and followed by T_{24} [F_5B_1] 29.65 and lowest was recorded in T_1 [F_0B_0] 8.57 due to sub factor (FB) main factor (I) and due to interaction (FB × I) it was found to be significant. Similar findings by (Preetham *et al*. 2023) [36]. The pool data of 2021 and 2022 revealed that the maximum bacterial population (cfu × $10^7 g^{-1}$) was recorded in T_{28}[F_6B_2] 37.84 and followed by T_{24}[F_5B_1] 37.69 and lowest was recorded in T_1 [F_0B_0] 27.32 due to sub factor (FB) main factor (I) and due to interaction (FB × I) it was found to be significant. Similar findings by (Baiwara *et al*. 2021) [4]. The pool data of 2021 and 2022 revealed that the maximum actinomycets population (cfu × $10^7 g^{-1}$) was recorded in T_{28} [F_6B_2] 38.02 and followed by T_{24} [F_5B_2] 36.35 and lowest was recorded in T_1 [F_0B_0] 14.87 due to sub factor (FB) main factor (I) and due to interaction (FB × I) it was found to be significant. Similar findings by (Baiwara *et al*. 2021) [4]. Organic manures like FYM and vermicompost undergo decomposition processes that release nutrients into the soil, providing a favourable environment for fungal growth. Biofertilizers such as *Azotobacter* and *Pseudomonas* stimulate microbial activity in the soil, leading to increased microbial populations.

Table 2: Effect of Various level of N P K Biofertilizers and Organic Manure on Bulk density, Particle density and Pore space (%) of Soil

(FB)	Soil Bulk density (Mg m^{-3}) Pooled				Mean (FB) I_0	Soil Particle density (Mg m^{-3}) Pooled				Mean (FB)	Water Holding Capacity (%) Pooled				Mean (FB)
	I					I					I				
	I_0	I_1	I_2	I_3		I_1	I_2	I_3	I_3		I_1	I_2	I_3	I_3	
F_0B_0	1.41	1.43	1.48	1.36	1.42	2.31	2.46	2.53	2.60	2.47	37.40	38.26	40.74	42.04	39.61
F_1B_1	1.42	1.44	1.49	1.37	1.43	2.39	2.47	2.54	2.61	2.50	37.29	39.44	40.79	41.56	39.77
F_2B_1	1.36	1.38	1.43	1.50	1.42	2.42	2.48	2.55	2.62	2.52	38.33	39.72	40.24	42.28	40.14
F_3B_1	1.37	1.39	1.44	1.51	1.43	2.42	2.49	2.56	2.63	2.53	38.41	40.17	40.75	41.28	40.15
F_4B_2	1.38	1.40	1.45	1.52	1.44	2.43	2.50	2.57	2.64	2.53	39.21	39.42	40.28	43.16	40.52
F_5B_2	1.39	1.41	1.46	1.53	1.45	2.44	2.51	2.58	2.65	2.55	38.36	40.20	41.15	42.95	40.67
F_6B_2	1.40	1.42	1.47	1.54	1.46	2.45	2.52	2.59	2.69	2.56	38.10	40.17	41.13	43.78	40.80
Mean (I)	1.39	1.41	1.46	1.48	1.34	2.41	2.49	2.56	2.63		38.16	39.63	40.73	42.44	
		F-test	S. Em. (±)	C.D. at 5%			F-test	S. Em. (±)	C.D. at 5%			F-test	S. Em. (±)	C.D. at 5%	
Sub factor (FB)		S	0.007	0.014			S	0.006	0.013			S	0.215	0.438	
Main factor (I)		S	0.009	0.018			S	0.008	0.017			S	0.284	0.580	
Interaction (FB × I)		S	0.018	0.036			S	0.016	0.033			S	0.568	1.159	

Note: Inorganic Fertilizers [I] Levels [I_0] @ 0% RDF, [I_1] @50%, [I_2] @75% RDF, [I_3] @100% RDF ha^{-1} respectively.

Farm Yard Manure [F] = Levels [F_0] @ 0 t ha^{-1}, [F_1] @ 5 t ha^{-1}, [F_2] = @ 5 t ha^{-1} [F_3] = @ 5 t ha^{-1}, [F_4] = @ 7.5 t ha^{-1} [F_5] = @ 7.5 t ha^{-1}, [F_6] = @ 7.5 t ha^{-1}.

Biofertilizers [B] (*Pseudomonas fluorescens* + *Azotobacter*) Levels [B_0] = @ Uninoculated, [B_1] = @ *Pseudomonas fluorescens* 200 g 10 kg seeds,

[B_2]= @ *Azotobacter* 200 g 10 kg seeds.

Table 3: Effect of Various level of N P K Biofertilizers and Organic Manure on pH (1:2.5) w/v, Electrical conductivity (dS m^{-1}) and Organic carbon (%) of Soil

(FB)	Soil pH (1:2.5) Pooled				Mean (FB)	Electrical Conductivity (dS m^{-1}) Pooled				Mean (FB)	Organic Carbon (%) Pooled				Mean (FB)
	I					I					I				
	I_0	I_1	I_2	I_3		I_0	I_1	I_2	I_3		I_0	I_1	I_2	I_3	
F_0B_0	6.92	6.91	7.17	7.13	7.03	0.12	0.17	0.18	0.19	0.16	0.37	0.51	0.65	0.65	0.54
F_1B_1	6.73	6.99	7.09	7.21	7.00	0.14	0.17	0.18	0.20	0.17	0.39	0.53	0.63	0.66	0.55
F_2B_1	6.79	7.03	7.14	7.28	7.06	0.15	0.17	0.18	0.20	0.17	0.41	0.55	0.61	0.67	0.56
F_3B_1	6.89	7.15	7.19	7.36	7.15	0.15	0.17	0.18	0.20	0.17	0.43	0.57	0.59	0.68	0.56
F_4B_2	6.82	7.05	7.18	7.21	7.06	0.15	0.17	0.19	0.21	0.18	0.45	0.59	0.57	0.69	0.57
F_5B_2	6.92	7.04	7.08	7.33	7.10	0.15	0.17	0.19	0.21	0.18	0.49	0.63	0.53	0.68	0.58
F_6B_2	6.90	7.04	7.10	7.35	7.09	0.16	0.18	0.19	0.25	0.19	0.47	0.61	0.55	0.69	0.58
Mean (I)	6.85	7.03	7.13	7.27		0.15	0.17	0.18	0.21		0.43	0.57	0.59	0.67	
		F-test	S. Em. (±)	C.D. at 5%		F-test	S. Em. (±)	C.D. at 5%				F-test	S. Em. (±)	C.D. at 5%	
Sub factor (FB)		S	0.008	0.017		S	0.003	0.006				S	0.006	0.012	
Main factor (I)		S	0.011	0.022		S	0.004	0.008				S	0.008	0.016	
Interaction (FB × I)		S	0.021	0.044		S	0.008	0.016				S	0.015	0.031	

Note: Inorganic Fertilizers [I] Levels [I_0] @ 0% RDF, [I_1] @50%, [I_2] @75% RDF, [I_3] @100% RDF ha^{-1} respectively.
Farm Yard Manure [F] = Levels [F_0] @ 0 t ha^{-1}, [F_1] @ 5 t ha^{-1}, [F_2] = @ 5 t ha^{-1} [F_3] = @ 5 t ha^{-1}, [F_4] = @ 7.5 t ha^{-1} [F_5] = @ 7.5 t ha^{-1}, [F_6] = @ 7.5 t ha^{-1}.
Biofertilizers [B] (*Pseudomonas fluorescens* + *Azotobacter*) Levels [B_0] = @ Uninoculated, [B_1] = @ *Pseudomonas fluorescens* 200 g 10 kg seeds,
[B_2]= @ *Azotobacter* 200 g 10 kg seeds.

Table 4: Effect of Various level of N P K Biofertilizers and Organic Manure on Available Nitrogen Phosphorus and;Potassium of Soil

(FB)	Av. Nitrogen (kg ha^{-1}) Pooled				Mean (FB)	Av. Phosphorus (kg ha^{-1}) Pooled				Mean (FB)	Av. Potassium (kg ha^{-1}) Pooled				Mean (FB)
	I					I					I				
	I_0	I_1	I_2			I_1	I_2	I_3	I_3		I_0	I_1	I_2	I_3	
F_0B_0	265.34	272.67	276.00	20.62	175.00	188.59	207.77	226.26	199.41	20.62	175.00	188.59	207.77	226.26	199.41
F_1B_1	268.50	273.17	274.84	20.81	176.14	190.94	210.40	227.29	201.19	20.81	176.14	190.94	210.40	227.29	201.19
F_2B_1	269.00	273.34	276.34	20.96	177.32	193.33	213.28	228.93	203.22	20.96	177.32	193.33	213.28	228.93	203.22
F_3B_1	270.34	274.00	275.33	21.08	178.72	195.73	216.25	229.67	205.09	21.08	178.72	195.73	216.25	229.67	205.09
F_4B_2	270.50	274.17	276.00	21.20	180.48	198.38	219.12	231.59	207.39	21.20	180.48	198.38	219.12	231.59	207.39
F_5B_2	270.84	275.00	276.67	21.44	182.80	201.24	221.84	233.53	209.85	21.44	182.80	201.24	221.84	233.53	209.85
F_6B_2	272.34	274.34	277.00	21.80	185.41	204.43	223.32	235.00	212.04	21.80	185.41	204.43	223.32	235.00	212.04
Mean (I)	269.55	273.81	276.02	278.21	179.41	196.09	216.00	230.32			179.41	196.09	216.00	230.32	
		F-test	S. Em. (±)	C.D. at 5%		F-test	S. Em. (±)	C.D. at 5%				F-test	S. Em. (±)	C.D. at 5%	
Sub factor (FB)		S	0.312	0.636		S	0.238	0.486				S	0.238	0.486	
Main factor (I)		S	0.412	0.842		S	0.315	0.643				S	0.315	0.643	
Interaction (FB × I)		S	0.824	1.683		S	0.630	1.286				S	0.630	1.286	

Note: Inorganic Fertilizers [I] Levels [I_0] @ 0% RDF, [I_1] @50%, [I_2] @75% RDF, [I_3] @100% RDF ha^{-1} respectively.
Farm Yard Manure [F] = Levels [F_0] @ 0 t ha^{-1}, [F_1] @ 5 t ha^{-1}, [F_2] = @ 5 t ha^{-1} [F_3] = @ 5 t ha^{-1}, [F_4] = @ 7.5 t ha^{-1} [F_5] = @ 7.5 t ha^{-1}, [F_6] = @ 7.5 t ha^{-1}.
Biofertilizers [B] (*Pseudomonas fluorescens* + *Azotobacter*) Levels [B_0] = @ Uninoculated, [B_1] = @ *Pseudomonas fluorescens* 200 g 10 kg seeds,
[B_2]= @ *Azotobacter* 200 g 10 kg seeds.

Table 5: Effect of Various level of N P K Biofertilizers and Organic Manure on Microbial Population of Soil

(FB)	Fungal Population (cfu × 10^4 g^{-1}) Pooled				Mean (FB)	Bacterial Population (cfu × 10^5 g^{-1}) Pooled				Mean (FB)	Actinomycetes Population (cfu × 10^7 g^{-1}) Pooled				Mean (FB)
	I					I					I				
	I_0	I_1	I_2	I_3		I_0	I_1	I_2	I_3		I_0	I_1	I_2	I_3	
F_0B_0	8.57	13.85	21.10	21.12	16.16	19.37	22.70	25.80	27.32	23.80	14.87	16.75	22.07	24.80	19.62
F_1B_1	9.89	15.84	21.77	24.75	18.06	20.19	23.23	23.45	30.85	24.43	13.89	21.39	23.80	29.75	22.21
F_2B_1	10.54	15.84	20.80	26.03	18.30	20.40	24.02	26.42	30.80	25.41	16.85	20.17	25.37	32.72	23.78
F_3B_1	11.20	18.15	24.75	28.02	20.53	20.70	25.07	27.53	32.84	26.53	13.20	22.15	29.75	32.39	24.37
F_4B_2	14.85	20.45	25.40	29.70	22.60	21.85	27.62	29.47	34.62	28.39	17.42	24.70	27.44	28.70	24.56
F_5B_2	14.84	23.40	24.08	29.65	22.99	24.02	28.32	32.25	37.69	30.57	16.52	22.82	26.12	36.35	25.45
F_6B_2	15.82	22.77	26.05	30.67	23.58	23.55	30.34	31.05	37.84	30.69	18.08	21.40	28.42	38.02	26.48
Mean (I)	12.24	18.61	23.42	27.13		21.44	25.90	27.99	33.13		15.83	21.34	26.14	31.82	
		F-test	S. Em. (±)	C.D. at 5%			F-test	S. Em. (±)	C.D. at 5%			F-test	S. Em. (±)	C.D. at 5%	
Sub factor (FB)		S	0.109	0.223			S	0.107	0.218			S	0.267	0.545	
Main factor (I)		S	0.145	0.295			S	0.141	0.289			S	0.353	0.721	
Interaction (FB × I)		S	0.289	0.591			S	0.283	0.577			S	0.707	1.443	

Note: Inorganic Fertilizers [I] Levels [I_0] @ 0% RDF, [I_1] @50%, [I_2] @75% RDF, [I_3] @100% RDF ha^{-1} respectively.
Farm Yard Manure [F] = Levels [F_0] @ 0 t ha^{-1}, [F_1] @ 5 t ha^{-1}, [F_2] = @ 5 t ha^{-1} [F_3] = @ 5 t ha^{-1}, [F_4] = @ 7.5 t ha^{-1} [F_5] = @ 7.5 t ha^{-1}, [F_6] = @ 7.5 t ha^{-1}.
Biofertilizers [B] (*Pseudomonas fluorescens* + *Azotobacter*) Levels [B_0] = @ Uninoculated, [B_1] = @ *Pseudomonas fluorescens* 200 g 10 kg seeds,
[B_2]= @ *Azotobacter* 200 g 10 kg seeds.

Table 6: Effect of Various level of N P K Biofertilizers and Organic Manure on Baby Corn Yield (q ha^{-1})

(FB)	Baby Corn Yield (q ha^{-1}) 2021				Mean (FB)	Baby Corn Yield (q ha^{-1}) 2022				Mean (FB)	Baby Corn Yield (q ha^{-1}) Pooled				Mean (FB)
	I					I					I				
	I_0	I_1	I_3	I_3		I_0	I_1	I_2	I_3		I_0	I_1	I_2	I_3	
F_0B_0	17.07	20.07	20.93	22.97	20.26	17.40	20.47	21.33	23.43	20.66	17.23	20.27	21.13	23.20	20.46
F_1B_1	17.37	21.13	21.90	24.70	21.28	17.67	21.53	22.33	25.20	21.68	17.52	21.33	22.12	24.95	21.48
F_2B_1	18.07	23.80	23.73	24.00	22.40	18.43	24.27	24.20	24.50	22.85	18.25	24.03	23.97	24.25	22.63
F_3B_1	18.47	21.70	24.83	24.93	22.48	18.83	22.10	25.33	25.40	22.92	18.65	21.90	25.08	25.17	22.70
F_4B_2	20.70	26.57	25.93	30.57	25.94	21.10	27.07	26.47	31.17	26.45	20.90	26.82	26.20	30.87	26.20
F_5B_2	22.10	27.67	27.10	31.70	27.14	22.50	28.23	27.63	32.30	27.67	22.30	27.95	27.37	32.00	27.40
F_6B_2	22.37	28.63	29.83	33.00	28.46	22.80	29.20	30.40	33.67	29.02	22.58	28.92	30.12	33.33	28.74
Mean (M)	19.45	24.22	24.90	27.41		19.82	24.70	25.39	27.95		19.63	24.46	25.14	27.68	
		F-test	S.Em. (±)	C.D. at 5%			F-test	S. Em. (±)	C.D. at 5%			F-test	S. Em. (±)	C.D. at 5%	
Sub factor (S)		S	0.400	0.816			S	0.406	0.828			S	0.403	0.822	
Main factor (M)		S	0.529	1.080			S	0.537	1.096			S	0.533	1.088	
Interaction (M × S)		S	1.058	2.160			S	1.073	2.192			S	1.065	2.175	

Note: Inorganic Fertilizers [I] Levels [I_0] @ 0% RDF, [I_1] @50%, [I_2] @75% RDF, [I_3] @100% RDF ha^{-1} respectively.
Farm Yard Manure [F] = Levels [F_0] @ 0 t ha^{-1}, [F_1] @ 5 t ha^{-1}, [F_2] = @ 5 t ha^{-1} [F_3] = @ 5 t ha^{-1}, [F_4] = @ 7.5 t ha^{-1} [F_5] = @ 7.5 t ha^{-1}, [F_6] = @ 7.5 t ha^{-1}.
Biofertilizers [B] (*Pseudomonas fluorescens* + *Azotobacter*) Levels [B_0] = @ Uninoculated, [B_1] = @ *Pseudomonas fluorescens* 200 g 10 kg seeds,
[B_2]= @ *Azotobacter* 200 g 10 kg seeds

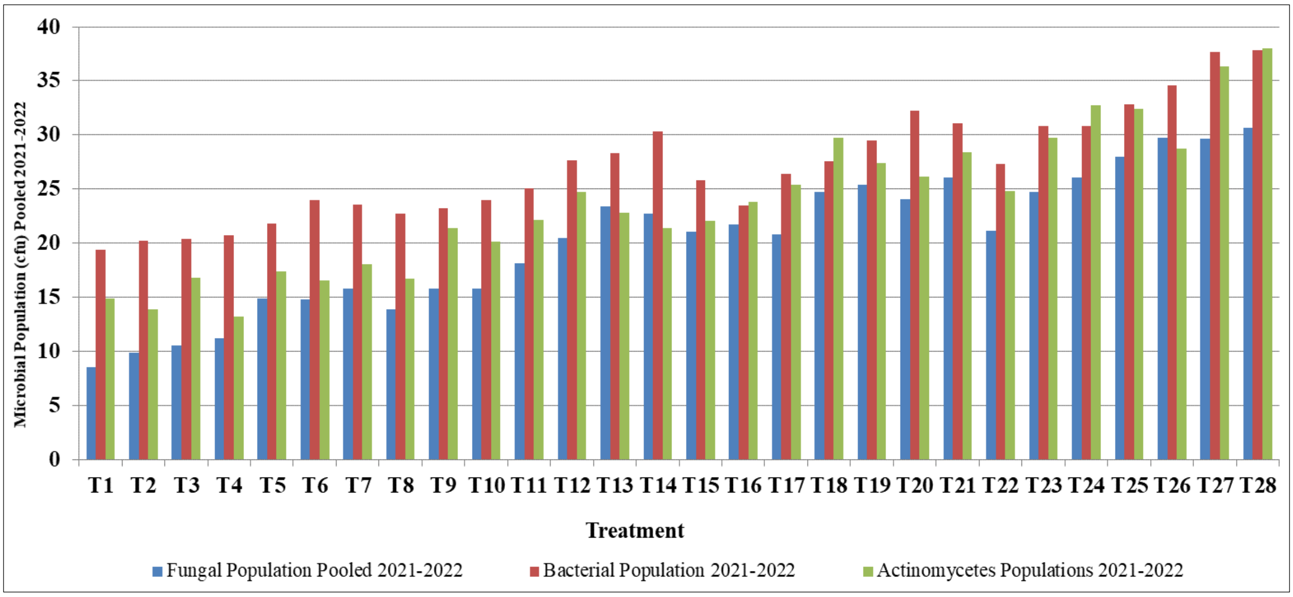

Fig 1: Effect of Various levvel of N P K Biofertilizer and Organic Manure on Microbial Population of Soil

Summary

The findings highlight that combining organic manures with inorganic fertilizers is more effective than using either source alone in improving soil fertility and baby corn productivity. Organic manures enriched the soil by increasing organic carbon, improving structure, and stimulating microbial activity, whereas inorganic fertilizers ensured a quick and steady nutrient supply for crop growth. While chemical fertilizers gave immediate results, reliance on them alone posed risks to long-term soil health. On the other hand, organic manures enhanced sustainability but could not always meet the short-term nutrient requirements of the crop. Integrated nutrient management (INM) successfully brought together the strengths of both sources, creating a balanced system that supported higher yields, better nutrient uptake, and healthier soils over time.

Conclusion

It can be concluded from the findings that conjoint use of FYM @ 100% and RDF @ 75% NPK and *Pseudomonas* significantly improved soil physical, chemical and biological properties and fertility of soil. Further, incorporation of FYM with chemical fertilizers and biofertilizers increased soil OC, available N, P and K as well Soil microbial population increased in soil. Integrated application of organic and inorganic fertilizer increases crop productivity and soil quality over control and helps to improve soil health.

Baby corn cultivation under integrated nutrient management (INM) improves yield, strengthens soil health, and increases farmers' profitability through a better cost-benefit ratio. Farmers are encouraged to adopt balanced nutrient practices for sustainable income and soil conservation. Researchers and policymakers should work together to spread awareness and provide support for wider adoption. Overall, baby corn farming with INM offers a sustainable pathway for agricultural growth and food security.

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