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Effect of *Ghanjeevamrut* and *Jeevamrut* on soil microbial activity, nutrient and yield performance of kodo millet under natural farming

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ABSTRACT

A field experiment was conducted during *kharif* 2024 at Gujarat Natural Farming Science University, Halol, to assess the Influence of *Ghanjeevamrut* and *Jeevamrut* on soil microbial activity, nutrient dynamics and yield performance of kodo millet under natural farming. The experiment was laid out in a Randomized Block Design (Factorial) comprising four levels of *Ghanjeevamrut* (0, 2, 3 and 4 t/ha) and three levels of *Jeevamrut* (0, 500 and 1000 L/ha), replicated four times. Application of *Jeevamrut* @ 1000 L/ha (J_2) significantly enhanced grain yield (1243 kg/ha), straw yield (2301 kg/ha) and kodo millet grain equivalent yield (1843 kg/ha). *Jeevamrut* @ 1000 L/ha also resulted in the highest nitrogen uptake by grain (13.74 kg/ha) and potassium uptake by straw (9.02 kg/ha), while *Jeevamrut* @ 500 L/ha (J_1) significantly improved straw and total nitrogen uptake and grain and total potassium uptake over the control. Application of *Ghanjeevamrut* @ 3 t/ha (G_2) recorded the highest total nitrogen uptake (28.25 kg/ha). Both inputs significantly influenced soil microbial populations, with *Ghanjeevamrut* @ 2 t/ha (G_1) and *Jeevamrut* @ 500 L/ha (J_1) showing higher microbial counts compared to control. The combined treatments G_3J_1 and G_1J_2 further enhanced microbial activity after harvest. The study suggests that application of *Jeevamrut* @ 1000 L/ha (J_2) can be an effective and sustainable input for in enhancing yield, nutrient uptake and profitability for kodo millet under natural farming conditions.

Keywords: *Ghanjeevamrut*, *Jeevamrut,* Kodo millet, Natural farming

INTRODUCTION

The Green Revolution boosted food production but led to soil degradation, pollution, biodiversity loss, rising input costs and pest resistance due to heavy agrochemical use (Rahman, 2015). Organic farming supports ecological health but may face higher labour demands and lower early yields, while natural farming reduces external inputs by relying on on-farm resource recycling and low-cost practices. The importance of resource-efficient, low-input ecological farming, demonstrating that organic and natural systems can restore soil health and decrease reliance on synthetic inputs (Bhardwaj *et al.,* 2020).

Natural farming is an ecological farming system that avoids synthetic chemicals. The concept was popularized globally by Masanobu Fukuoka through The One-Straw Revolution (1935), and later formalized as Nature Farming by Mokichi Okada in 1936, and later popularized in India by Shri Bhaskar Save and Subhash Palekar, the proponent of Zero Budget Natural Farming (Sharma *et al.*, 2023). It is defined as a chemical-free, livestock-based system that integrates crops, trees and animals while relying on bio-inputs such as *Beejamrut*, *Jeevamrut*, *Ghanjeevamrut*, mulching and mixed cropping. These practices improve soil structure, enhance organic carbon and support biological activity, thereby reversing soil degradation and improving water retention. Organic inputs enriched with microbial populations have been shown to enhance soil carbon fractions and biological functioning, as demonstrated by Bhardwaj *et al.* (2019) across multiple production systems.

At the core of natural farming, indigenous bio-formulations such as *Jeevamrut* and *Ghanjeevamrut* supply beneficial microorganisms that enhance nutrient mineralization, soil enzyme activity and microbial diversity (Sreenivasa *et al*., 2010; Devakumar *et al*., 2014). *Jeevamrut*, a fermented mixture of cow dung, cow urine, pulse flour, jaggery and soil, and its solid counterpart *Ghanjeevamrut*, act as cost-effective nutrient sources that improve soil health and crop productivity (Kumari *et al*., 2022). Similar observations regarding microbial enhancement under organic bioformulations were made by Kushwaha *et al.* (2020), who reported improved microbial tolerance and activity.

Millets, particularly kodo millet (*Paspalum scrobiculatum* L.), are nutritionally rich crops containing high dietary fibre, essential amino acids, minerals and bioactive compounds such as polyphenols and antioxidants, which support metabolic health and disease prevention (Hadimani and Malleshi, 1993; Bravo, 1998; Chandrasekara and Shahidi, 2012). Being drought-tolerant and suited to marginal soils, kodo millet plays a significant role in sustainable agriculture and nutritional security (De Wet *et al*., 1983; Saxena *et al*., 2018). Microclimatic improvements associated with organic soil management have also been documented by Singh *et al.* (2020), indicating better vegetative growth and nutrient uptake under organic regimes.

Natural farming encourages mixed or intercropping systems, which complement the shallow-rooted nature of kodo millet. Intercropping kodo millet with legumes enhances biological nitrogen fixation and improves system productivity. Increased biodiversity also reduces pest incidence and encourages ecological balance, supporting healthier crop growth. Long-term improvements in soil organic carbon under diversified and organic management systems have also been reported by Thakur *et al.* (2020), reinforcing the ecological benefits of natural farming-based intercropping systems.

MATERIALS AND METHODS

Experimental site

The present investigation was carried out during *kharif* season of the year 2024 at Gujarat Natural Farming Science University, Halol (Gujarat) on a kodo millet crop. Geographically, Halol lies at 22°42' North latitude and 73°54' East longitude, positioned at an elevation of approximately 104 meters above mean sea level. The monsoon season in Halol is typically commences around mid-June and extends through September, with an average annual rainfall of approximately 1649 mm.

Experimental design and treatments

The experimental field soil (0-15 cm depth) was evaluated for its physical, physico-chemical and chemical characteristics using standard analytical methods. The soil was identified as clay loam in texture, containing 24.9% sand, 47.7% silt and 26.7% clay. It exhibited a neutral pH of 7.27 and a low electrical conductivity of 0.18 dS/m, confirming its non-saline nature. The organic carbon level was 0.54%, while the available nitrogen, phosphorus and potassium were 175, 92.45 and 184 kg/ha, respectively. The microbial population recorded was 6.7×10^7 cfu/g. Overall, the soil was moderately fertile, well-drained and appropriate for conducting the study under natural farming conditions.

The experiment was laid out in a Randomized Block Design (Factorial) with four levels of *Ghanjeevamrut* viz., G_0: Control, G_1: 2 t/ha, G_2: 3 t/ha, and G_3: 4 t/ha and three levels of *Jeevamrut* J_0: Control, J_1: 500 L/ha and J_2: 1000 L/ha, replicated four times.

Beejamrut was applied as a seed treatment at the rate of 100 ml per kilogram of seed through seed soaking prior to sowing. *Ghanjeevamrut* was incorporated into the soil one week before sowing as a basal natural nutrient source. *Jeevamrut* was applied in two equal splits, with 50% administered through pre-sowing irrigation and the remaining 50% applied as drenching at 30 and 45 days after sowing (DAS). To promote biodiversity, soybean, maize, green gram and black gram were grown as mixed crops along with the main crop. Marigold was sown as a trap crop along the field border at 7 DAS of the main crop to support biological pest management. Additionally, available weeds were used as mulch at the rate of 5 t/ha to conserve soil moisture, suppress weed growth and enhance soil organic matter under natural farming conditions.

Kodo millet grain equivalent yield (kg/ha)

Kodo millet grain equivalent yield (kg/ha) was calculated for specified treatment by following the formula.

$$\text{Kodo millet grain equivalent yield (kg/ha)} = \text{Yield of kodo millet grain (kg/ha)} + \frac{\text{Yield of mix crops (kg/ha)} \times \text{Price of mix crops (₹/kg)}}{\text{Price of kodo millet grain (₹/kg)}}$$

The recorded data on growth, yield, quality, nutrient content, economics and post-harvest soil status of kodo millet were analyzed using ANOVA for a Randomized Block Design (Factorial). Statistical procedures followed the methods of Panse and Sukhatme (1954).

RESULTS AND DISCUSSION

Effect of *ghanjeevamrut* and *jeevamrut* on yield attributes

The results presented in Table 1 indicated that increasing levels of *Ghanjeevamrut* led to a numerical improvement in grain yield, straw yield and kodo millet grain equivalent yield; however, the differences were statistically non-significant. The highest grain (1243 kg/ha), straw (2301 kg/ha) and total yield (3544 kg/ha) were recorded under *Ghanjeevamrut* @ 3 t/ha (G_2), reflecting improvements of 5.5%, 6.4% and 6.1% over the control (G_0), respectively.

Jeevamrut exerted a significant influence on all yield components. Application of *Jeevamrut* @ 1000 L/ha (J_2) produced the highest grain yield (1243 kg/ha), showing an 11.8% increase over control (J_0). Similarly, straw yield (2301 kg/ha) and total biological yield (3544 kg/ha) were significantly enhanced under J_2, registering 9% and 10% increases, respectively. *Jeevamrut* also significantly improved kodo millet grain equivalent yield, with J_2 recording 1843 kg/ha, which was 10% higher than Control (J_0). This yield enhancement can be attributed to the rich microbial diversity in *Jeevamrut* comprising nitrogen fixers, phosphorus solubilizers and growth-promoting rhizobacteria which improves nutrient availability, stimulates root and shoot growth through natural hormones (auxins, gibberellins, cytokinins) and enhances soil structure, moisture retention and microbial enzymatic activity. These findings align with earlier reports by Kaur *et al*. (2021), Kumar *et al*. (2022), Vala *et al*. (2024), Sonawane *et al*. (2024) and Sridhara *et al*. (2022), who also documented improved grain, straw and biological yields in millets, pulses and cereals with *Jeevamrut* -based nutrient management. Interaction effects of *Ghanjeevamrut* and *Jeevamrut* on grain yield, straw yield and kodo millet grain equivalent yield were non-significant, indicating that both inputs acted independently without synergistic yield enhancement. The data presented in Table 1 revealed

Table 1. Effect of different levels of *Ghanjeevamrut* and *Jeevamrut* on grain, straw and kodo millet grain equivalent yield at harvest of kodo millet

Treatments	Yield (kg/ha)			Kodo millet grain equivalent yield (kg/ha)
	Grain	Straw	Total	
Factor: *Ghanjeevamrut* (G)				
G_0: Control	1145	2147	3292	1695
G_1: *Ghanjeevamrut* @ 2 t/ha	1189	2183	3373	1783
G_2: *Ghanjeevamrut* @ 3 t/ha	1207	2286	3493	1805
G_3: *Ghanjeevamrut* @ 4 t/ha	1190	2174	3363	1777
S.Em. ±	41	55	84	72
C.D. (P=0.05)	NS	NS	NS	NS
Factor: *Jeevamrut* (J)				
J_0: Control	1112	2110	3223	1675
J_1: *Jeevamrut* @ 500 L/ha	1192	2181	3373	1776
J_2: *Jeevamrut* @ 1000 L/ha	1243	2301	3544	1843
S.Em. ±	35	48	73	42
C.D. (P=0.05)	102	137	210	120
Interaction (G×J)	NS	NS	NS	NS
C. V. %	11.97	8.67	8.62	9.44

Table 2. Effect of different levels of *Ghanjeevamrut* and *Jeevamrut* on nitrogen, phosphorus and potassium uptake by grain and straw after harvest of kodo millet

Treatments	Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Factor: *Ghanjeevamrut* (G)									
G_0: Control	11.52	13.17	24.69	2.54	3.01	5.56	3.39	8.58	11.97
G_1: *Ghanjeevamrut* @ 2 t/ha	12.24	13.73	25.97	2.79	3.05	5.84	3.71	8.66	12.37
G_2: *Ghanjeevamrut* @ 3 t/ha	13.54	14.71	28.25	2.99	3.34	6.33	3.63	8.64	12.27
G_3: *Ghanjeevamrut* @ 4 t/ha	13.31	13.49	26.80	2.87	2.90	5.77	3.78	8.49	12.26
S.Em. ±	0.62	0.53	0.84	0.14	0.12	0.21	0.15	0.23	0.32
C.D. (P=0.05)	NS	NS	2.42	NS	NS	NS	NS	NS	NS
Factor: *Jeevamrut* (J)									
J_0: Control	11.58	12.71	24.29	2.62	3.07	5.69	3.27	8.14	11.41
J_1: *Jeevamrut* @ 500 L/ha	12.63	14.13	26.76	2.77	3.11	5.88	3.73	8.61	12.34
J_2: *Jeevamrut* @ 1000 L/ha	13.74	14.49	28.23	3.01	3.05	6.05	3.88	9.02	12.90
S.Em. ±	0.54	0.46	0.73	0.12	0.10	0.19	0.13	0.20	0.28
C.D. (P=0.05)	1.56	1.32	2.09	NS	NS	NS	0.37	0.57	0.81
Interaction (G×J)	NS	NS	NS	NS	NS	NS	NS	NS	NS
C. V. %	17.10	13.37	11.01	17.73	13.31	12.64	14.26	9.17	9.21

that the harvest index of kodo millet was not significantly influenced by the application of *GhanJeevamrut*, *Jeevamrut*, or their interaction.

Effect of *ghanjeevamrut* and *jeevamrut* on nutrient uptake by grain and straw of kodo millet

The uptake of nitrogen, phosphorus, and potassium by kodo millet as influenced by *Ghanjeevamrut* and *Jeevamrut* is presented in Table 2. Nitrogen uptake by grain and straw did not vary significantly with different levels of *Ghanjeevamrut*; however, total nitrogen uptake was significantly influenced, with the highest value (28.25 kg/ha) recorded under *Ghanjeevamrut* @ 3 t/ha (G_2), indicating enhanced nutrient mineralization and microbial activity at this dose. *Jeevamrut* application significantly affected nitrogen uptake, where the maximum grain, straw and total N uptake (13.74, 14.49 and 28.23 kg/ha, respectively) were obtained with *Jeevamrut* @ 1000 L/ha (J_2), which remained superior to the control. Similar study by Kumari *et al*. (2021), Jain *et al*. (2022) and Sonawane *et al*. (2024) confirm that combining *Jeevamrut* with organic inputs like vermicompost or FYM improves soil health, boosts microbial activity and promotes better root growth, resulting in higher nutrient uptake and improved crop productivity. Phosphorus uptake by grain, straw and total was not significantly influenced by either *Ghanjeevamrut* or *Jeevamrut*, indicating limited responsiveness of phosphorus uptake under the applied treatments.

Potassium uptake was unaffected by *Ghanjeevamrut* but significantly enhanced by *Jeevamrut* levels. The highest grain, straw and total K uptake (3.88, 9.02 and 12.90 kg/ha) observed under *Jeevamrut* @ 1000 L/ha (J_2), followed by J_1. The interaction effects (G×J) for all three nutrients were non-significant. Higher K uptake was observed with *Jeevamrut* application, primarily might be due to increased grain and straw yield. *Jeevamrut* is rich in microbial activities due to that enhance better root growth, microbial activity and good drainage might have received optimum moisture and nutrients for its growth. The findings were in accordance with Kumari *et al*. (2021), Jain *et al*. (2022), Sonawane *et al*. (2024) and Hameedi *et al*. (2018).

Effect of *ghanjeevamrut* and *jeevamrut* on microbial properties of soil

The application of *Ghanjeevamrut* and *Jeevamrut* significantly enhanced soil microbial populations after harvest, as presented in Table 3. *Ghanjeevamrut* levels exerted a marked influence, with the highest microbial count (129×10^7 cfu/g) recorded under *Ghanjeevamrut* @ 4 t/ha (G_3), followed by G_2 and G_1, all of which were superior to the control, indicating the positive role of organic carbon and native microbes in stimulating microbial proliferation. *Ghanjeevamrut* serves as an excellent carbon source and contains partially decomposed cow dung and crop residues, which provide a favourable substrate for microbial multiplication.

Table 3. Effect of different levels of *Ghanjeevamrut* and *Jeevamrut* on soil microbial count after harvest of kodo millet

Treatments	Soil microbial count (*cfu*/g)
Initial	6.7×10^7
Factor: *Ghanjeevamrut* (G)	
G_0: Control	8.98 (95×10^7)
G_1: *Ghanjeevamrut* @ 2 t/ha	9.08 (120×10^7)
G_2: *Ghanjeevamrut* @ 3 t/ha	9.04 (109×10^7)
G_3: *Ghanjeevamrut* @ 4 t/ha	9.11 (129×10^7)
S.Em. ±	4
C.D. (P=0.05)	11
Factor: *Jeevamrut* (J)	
J_0: Control	8.54 (35×10^7)
J_1: *Jeevamrut* @ 500 L/ha	9.17 (148×10^7)
J_2: *Jeevamrut* @ 1000 L/ha	9.20 (157×10^7)
S.Em. ±	3
C.D. (P=0.05)	10
Interaction (G×J)	19
C. V. %	11.93

Note: Data in parenthesis are original values

Similar result findings by Mevada and Makwana (2023).

Similarly, *Jeevamrut* application significantly increased microbial activity, with J_2 (1000 L/ha) recording the maximum count (157×10^7 cfu/g), followed by J_1, both outperforming the control due to the introduction of diverse beneficial microorganisms and enhanced soil enzymatic activity.

These results are in conformity with Kaur *et al*. (2020), Singh *et al*. (2024) and Raut *et al*. (2022) show increased populations of bacteria, fungi and actinomycetes with *Jeevamrut* application. It also enhances soil enzyme activities (e.g., dehydrogenase, phosphatase), indicating higher microbial activity. Under natural farming, as shown by Bindushree *et al*. (2023) and Yadav *et al*. (2024), *Jeevamrut* outperformed conventional practices in boosting beneficial microbes, supporting soil health and nutrient cycling.

The combined application of *Ghanjeevamrut* and *Jeevamrut* showed a significant interaction effect (Table 4), wherein the treatment combination G_3J_2 registered the highest microbial population (681×10^7 cfu/g), statistically at par with G_3J_1 and G_1J_2, while the lowest count was observed under G_0J_0. This synergistic response indicates that higher levels of both amendments create a favourable environment for microbial growth by improving organic matter availability, soil aeration and enzymatic activity. These findings suggested that higher *Jeevamrut* (J_2) and *Ghanjeevamrut* levels (G_3) contributed to improve microbial activity, demonstrating the beneficial impact of organic amendments on soil biological health. These results are in conformity with those of Choudhary *et al*. (2022) and Bindushree *et al*. (2023).

CONCLUSION

Based on the one-season experiment, it can be concluded that *Jeevamrut* @ 1000 L/ha (J_2) proved most effective by recording the highest grain, straw and kodo millet grain equivalent yield, along with superior N uptake by grain and K uptake by straw. *Ghanjeevamrut* @ 3 t/ha (G_2) significantly enhanced total nitrogen uptake. Application of *Jeevamrut* @ 500 L/ha (J_1) improved N uptake by straw and K uptake by grain. Soil microbial population increased notably with the individual application of *Jeevamrut* @ 500 L/ha (J_1) and *Ghanjeevamrut* @ 2 t/ha (G_2), whereas their combined treatments G_3J_1 and G_1J_2, further boosted microbial counts after harvest.

Table 4. Effect of different levels of *Ghanjeevamrut* and *Jeevamrut* on interaction effect of soil microbial count after harvest of kodo millet

Treatments	Soil microbial count (*cfu*/g)			
	G_0 (Control)	G_1 (*Ghanjeevamrut* @ 2 t/ha)	G_2 (*Ghanjeevamrut* @ 3 t/ha)	G_3 (*Ghanjeevamrut* @ 4 t/ha)
J_0 (Control)	8.95 (14×10^7)	9.22 (167×10^7)	9.26 (184×10^7)	9.27 (188×10^7)
J_1 (*Jeevamrut* @ 500 L/ha)	9.72 (524×10^7)	9.78 (598×10^7)	9.75 (562×10^7)	9.83 (678×10^7)
J_2 (*Jeevamrut* @ 1000 L/ha)	9.78 (601×10^7)	9.83 (672×10^7)	9.75 (559×10^7)	9.83 (681×10^7)
S. Em±	7			
C.D. at 5 %	19			
C.V. %	11.93			

Note: Data in parenthesis are original values

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