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Effect of Different Farming System on Soil Chemical Properties in Soybean-Chickpea Cropping Sequence

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Abstract

A field experiment was conducted during the *kharif* and *rabi* seasons of 2023-24 and 2024-25 at the Centre for Organic Agriculture Research and Training, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, to evaluate Effect of Different Farming System on Soil Chemical Properties in Soybean-Chickpea Cropping Sequence. The experiment was laid out in a Randomized Block Design (RBD) with seven treatments comprising organic farming (F₁), natural farming (F₂), integration of organic and natural farming (F₃), biodynamic farming (F₄), panchagavya farming (F₅), conventional farming (F₆) and control (F₇ no input) each replicated thrice. Although soil pH, electrical conductivity (EC) and organic carbon (OC) did not differ significantly among treatments, the integration of organic and natural farming (F₃) recorded the most favourable values for soybean and chickpea. The highest increase in OC (0.48 %) over the initial was recorded in the integration of organic and natural farming (0.56%, 0.58%), implies that combining organic and natural inputs can effectively build and maintain soil organic matter under Vertisols after chickpea harvest during 2023-24 and 2024-25. Available macronutrients nitrogen, phosphorus and potassium differed significantly, with conventional farming recording the highest increase over the initial status after chickpea harvest. Among the organic modules, the highest increase over the initial status (213 kg ha⁻¹ nitrogen, 13.30 kg ha⁻¹ phosphorus, and 330 kg ha⁻¹ potassium) was recorded under the integration of organic and natural farming after chickpea harvest (pooled), with 247 kg ha⁻¹ nitrogen, 22.55 kg ha⁻¹ phosphorus, and 357 kg ha⁻¹ potassium. However, F₃ was statistically at par with conventional farming for all three nutrients in both crops. These results demonstrate that integrating organic and natural farming inputs, including FYM, vermicompost, ghanjeevamrut, jeevamrut and phosphate-rich organic manure, can effectively sustain soil nutrient status and productivity, offering a viable alternative to conventional input-intensive farming for long-term soil health and agricultural sustainability in the Vidarbha region.

Keywords: Biodynamic farming, Chickpea, Jeevamrut, Natural farming, Organic

Introduction

Soybean (*Glycine max* L.) and chickpea (*Cicer arietinum* L.) are two of the most economically and agronomically important leguminous crops in the Vidarbha region of Maharashtra, India. Both crops are primarily grown under rainfed conditions and contribute substantially to farmers' income while simultaneously enriching soil fertility through biological nitrogen fixation. Soybean, classified under family Leguminaceae, is valued for its high protein content (approximately 40%) and edible oil (20%), along with significant quantities of crude fiber, minerals and carbohydrates (Rashid *et al.*, 2025) [19]. Chickpea is equally important, known for its high protein content ranging from 17 to 31% (Jukanti *et al.*, 2012) [8] and is among the earliest cultivated pulses in Asia and Europe. Intensive farming systems are commonly followed in modern day agriculture owing to the rising population and the need to meet high food demand. In intensive farming, farmers require high economic inputs and technical knowledge to manage land and crops, especially given fast paced crop rotations and high input use. However, the excessive use of chemical inputs, the injudicious exploitation of natural resources, and poor maintenance of soil health make such intensive agricultural practices unsustainable. Hence, careful management of natural resources ensuring agricultural sustainability and promoting

alternative sustainable practices is the need of the hour (Sial *et al.*, 2021) ^[23].

Organic farming emerged as a potential alternative for meeting food demand, maintaining soil fertility and increasing soil carbon pool. Increasing awareness about conservation of environment as well as health hazards associated with agrochemicals and consumer preference to safe and hazards free food are the major factors that lead the growing interest in organic agriculture in the world. Organic agriculture without doubt is one of the fastest growing sectors of agricultural production (Paslawar *et al.*, 2023) ^[17]. It helps to maintain the ecology and productivity of systems for future generations along with improving the physical, chemical and biological qualities of the soil (Yadav *et al.*, 2017) ^[26]. Natural Farming (NF) is considered to be agroecology based diversified farming system, which integrates crops, trees and livestock, allowing functional biodiversity (Rosset and Martinez-Torres, 2012) ^[20] to drastically cut down production costs by replacing the chemical fertilizers and pesticides with home-grown product like jeevamritham, beejamritham, neemastra etc., and adopting intercropping and mulching (Palekar, 2005; 2006) ^[14, 15]. Natural farming, as advocated by Palekar (2006) ^[14], operates on the principle that plants derive 98 to 98.5% of their nutrition from air, water and sunlight, with soil contributing the remainder. Inputs such as jeevamrut and ghanjeevamrut, prepared from cow dung and urine, are central to natural farming and function by stimulating soil microbial populations (Sharma *et al.*, 2023) ^[21]. Smith *et al.* (2020) ^[24] emphasized the synergistic effect of plant and animal products on soil fertility and crop establishment under zero-budget natural farming systems. Biodynamic farming, while sharing several features with organic farming in its rejection of synthetic inputs, incorporates eight specialized preparations (numbered 500-508) derived from plant and animal materials. These preparations are intended to enhance soil biological activity and synchronize farm management with natural rhythms (Shukla *et al.*, 2023) ^[22]. Panchagavya, a traditional Ayurvedic formulation prepared from five cow-derived products (milk, curd, ghee, urine and dung), has been identified as a potent liquid organic manure with multiple soil and crop-improving functions (Mathivanan *et al.*, 2006; Natarajan, 2008) ^[11, 12].

The problem arises in nutrient management through organic sources as they are required in bulk quantities. Lack of training makes it hard to switch from chemical farming these are some limitations of the study. It improves and maintains the soil chemical, physical as well as soil biological properties and enzyme activities at different organic manure application rates. Considering this study was conducted to independently evaluated each farming system for soil health improvement, particularly for the soybean-chickpea cropping sequence in Vidarbha.

Materials and Methods

Experimental Site and Soil Characteristics

A two-year field experiment was conducted during the *kharif* season of 2023-24 and 2024-25 (soybean) and the subsequent *rabi* seasons (chickpea) at the Centre for Organic Agriculture Research and Training, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (PDKV), Akola, Maharashtra. The site of the experimental plot was classified as Typic Haplustepts (Inceptisol). The experimental soil was medium black, clayey in texture and slightly alkaline in reaction. Initial soil analysis before the commencement of the experiment revealed an organic carbon content of 0.48%, low available nitrogen (213.00 kg ha⁻¹), very low available phosphorus (13.30 kg ha⁻¹) and high available potassium (330.48 kg ha⁻¹). The experimental site experiences a semi-arid climate. During 2023–24, the mean monthly maximum temperature peaked at 42.7°C in May and the minimum reached 8.7°C in December. Mean daily evaporation varied from a high of 16.9 mm in May to a low of 2.7 mm in July. Total annual rainfall was 767.2 mm in 2023–24 and 995.6 mm in 2024–25. In 2024–25, the maximum temperature reached 43.7°C in May and the minimum temperature was 7.4°C in December. These agro-climatic conditions are well suited for soybean cultivation during the *kharif* season and chickpea during the *rabi* season. The experiment was laid out in a Randomized Block Design (RBD) with seven treatments and three replications. Soybean variety PDKV Amba and chickpea variety JAKI-9218 were sown at a spacing of 45 cm × 10 cm (row × plant) on broad bed furrow (BBF) geometry.

Treatment details for soybean						
Package of practices for soybean				Plant protection		
Treatments	Farming system	Seed treatment	Nutrient management	PGR	Weed	Pest and disease
F ₁	Organic farming	Biofertilizers	Compost (2500 kg ha ⁻¹), Neem cake (100 kg ha ⁻¹) Vermicompost (600 kg ha ⁻¹) PROM (400 kg ha ⁻¹)	Jeevamrut 300 liter ha ⁻¹ in 3 split	Hoeing and Weeding	IPM practices + Trichoderma+ Biomix
F ₂	Natural farming	Beejamrut	Ghanjeevamrut (500 kg ha ⁻¹)	Butter milk, Jeevamrut 500 liter ha ⁻¹ four times (2000)	Mulching	Neemastra, Agnistra and Brahmastra.
F ₃	Integrated (Organic+ Natural)	Beejamrut + Biofertilizers	Vermicompost (300 kg ha ⁻¹) Ghanjeevamrut (250 kg ha ⁻¹), PROM (200 kg ha ⁻¹), Compost (1250 kg ha ⁻¹), Neem cake (50 kg ha ⁻¹),	Jeevamrut 1150 liter ha ⁻¹ in 3 split and butter milk	Hoeing + Mulching	IPM practices+ Trichoderma and Biomix+ Butter milk or 5% NSKE
F ₄	Biodynamic farming	S-9 culture	Biodynamic compost 3000 kg ha ⁻¹ , PROM (400 kg ha ⁻¹)	Urja and Shakti	Hoeing and Weeding	5% NSKE, and Sticky traps, Biodynamic Taralkhad
F ₅	Panchgavya farming	Beejamrut	Vermicompost 2000 kg ha ⁻¹ , PROM (400 kg ha ⁻¹)	3% Panchgavya 5 times	Hoeing and Weeding	5% NSKE and Dashparni ark
F ₆	Conventional farming	Thimethaxom and Vitavax	30:60: 30 NPK Kg ha ⁻¹	19:19:19 spray	Herbicide (Imazethapyr + Imazamox) /b H.W.	Profenofos
F ₇	Control (Do nothing)	-	-	-	-	-

Note: PROM- Phosphorous rich organic matter

Treatment details for chickpea

Package of practices for chickpea				Plant protection		
Treatments	Farming system	Seed treatment	Nutrient management	PGR	Weed	Pest and disease
F ₁	Organic farming	Biofertilizers	Compost (1200 kg ha ⁻¹), Neem cake (100 kg ha ⁻¹) Vermicompost (500 kg ha ⁻¹) PROM (350 kg ha ⁻¹)	Jeevamrut 300 liter ha ⁻¹ in 3 split	Hoeing & Weeding	IPM practices + Trichoderma + Biomix
F ₂	Natural farming	Beejamrut	Ghanjeevamrut (500 kg ha ⁻¹)	Butter milk, Jeevamrut 500 liter ha ⁻¹ once in every week upto fulfil RDF (1700 l ha ⁻¹)	Mulching	Neemastra, Agnistra and Brahmastra.
F ₃	Integrated (Organic+ Natural)	Beejamrut + Biofertilizers	Vermicompost (250 kg ha ⁻¹) Ghanjeevamrut (250 kg ha ⁻¹), PROM (200 kg ha ⁻¹), Compost (600 kg ha ⁻¹), Neem cake (50 kg ha ⁻¹)	500 liter ha ⁻¹ in 3 split and butter milk	Hoeing + Mulching	IPM practices+ Trichoderma and Biomix + Butter milk or 5% NSKE
F ₄	Biodynamic farming	S-9 culture	Biodynamic compost 3000 kg ha ⁻¹ , PROM (400 kg ha ⁻¹)	Urja and Shakti Jeevamrut	Hoeing & Weeding	5% NSKE, and Sticky traps, Biodynamic Taralkhad
F ₅	Panchgavya farming	Beejamrut	Vermicompost 2500 kg ha ⁻¹ , PROM (300 kg ha ⁻¹)	3% Panchgavya	Hoeing & Weeding	5% NSKE and Dashparni ark
F ₆	Conventional farming	Thimethaxom and Vitavax	25:50:30 NPK Kg ha ⁻¹	19:19:19 spray	Weeding	Profenofos
F ₇	Control (Do nothing)	-	-	-	-	-

Table 1: Soil pH, EC (dSm⁻¹), OC (%) and available NPK at initial and after harvesting of soybean as influenced by different farming modules during 2023-24, 2024-25 and pooled

Treatment	pH			EC (dSm ⁻¹)			OC (%)			N (kg ha ⁻¹)			P ₂ O ₅ (kg ha ⁻¹)			K ₂ O (kg ha ⁻¹)		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
F ₁ (Organic farming)	8.09	8.08	8.09	0.25	0.23	0.24	0.51	0.56	0.54	217	232	224	19.3	21.57	20.43	349	355	352
F ₂ (Natural farming)	8.07	8.00	8.04	0.26	0.22	0.24	0.50	0.54	0.52	201	212	206	18.84	20.28	19.56	337	342	339
F ₃ (OF + NF)	8.08	8.01	8.05	0.24	0.2	0.22	0.52	0.57	0.55	221	245	233	19.75	22.02	20.88	351	357	354
F ₄ (Biodynamic farming)	7.98	7.80	7.89	0.25	0.23	0.24	0.49	0.52	0.51	183	191	187	15.13	17.4	16.27	327	334	331
F ₅ (Panchagavya farming)	7.94	7.92	7.93	0.26	0.2	0.23	0.50	0.53	0.52	193	205	199	16.57	19.67	18.12	332	336	334
F ₆ (Conventional farming)	8.13	8.20	8.17	0.28	0.27	0.28	0.49	0.50	0.5	223	249	236	20.58	24.06	22.32	356	366	361
F ₇ (Control)	7.9	7.64	7.77	0.23	0.2	0.22	0.51	0.53	0.52	178	188	183	12.49	13.62	13.05	314	316	315
SE(m)±	0.15	0.18	0.17	0.02	0.02	0.02	0.02	0.02	0.02	7	9	7	0.74	1.21	0.77	2.68	2.66	1.00
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	20	28	22	2.27	3.72	2.35	8.21	8.16	4.00
GM	8.03	7.95	7.99	0.25	0.22	0.24	0.50	0.54	0.52	202	217	210	17.52	19.80	18.66	338	344	341
Initial value	8.11	8.09	8.10	0.27	0.25	0.26	0.48	0.49	0.49	213	220	224	13.30	17.10	-	330	342	-

Table 2: Soil pH, EC (dSm⁻¹), OC (%) and available NPK at initial and after harvesting of chickpea as influenced by different farming modules during 2023-24, 2024-25 and pooled

Treatment	pH			EC (dSm ⁻¹)			OC (%)			N (kg ha ⁻¹)			P ₂ O ₅ (kg ha ⁻¹)			K ₂ O (kg ha ⁻¹)		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
F ₁ (Organic farming)	7.98	7.93	7.96	0.24	0.22	0.23	0.55	0.56	0.56	222	239	230	20.51	22.78	21.64	353	359	356
F ₂ (Natural farming)	8.03	8.00	8.02	0.24	0.21	0.23	0.53	0.55	0.54	205	225	215	19.67	21.94	20.81	341	345	343
F ₃ (OF + NF)	8.01	8.00	8.06	0.23	0.18	0.21	0.56	0.58	0.57	238	256	247	21.49	23.61	22.55	354	359	357
F ₄ (Biodynamic farming)	7.89	7.80	7.85	0.23	0.22	0.23	0.51	0.53	0.52	184	197	191	17.10	19.52	18.31	331	336	333
F ₅ (Panchagavya farming)	7.93	7.87	7.9	0.24	0.19	0.22	0.52	0.54	0.53	198	211	205	17.40	20.88	19.14	336	338	337
F ₆ (Conventional farming)	8.19	8.2	8.2	0.26	0.28	0.27	0.50	0.51	0.52	243	263	253	23.00	26.41	24.71	364	370	367
F ₇ (Control)	7.7	7.6	7.65	0.18	0.19	0.19	0.53	0.54	0.52	178	193	185	11.96	13.77	12.86	316	317	316
SE(m)±	0.17	0.19	0.09	0.03	0.03	0.03	0.02	0.02	0.02	9	9	8	0.58	0.91	0.60	1.61	2.00	1.57
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	28	28	24	1.77	2.79	1.84	4.95	6.15	4.81
GM	7.96	7.91	7.95	0.23	0.22	0.23	0.53	0.54	0.54	210	226	218	18.73	21.27	20.00	342	346	344
Initial value	8.09	8.07	-	0.25	0.22	-	0.49	0.51	-	226	238	230	15.89	18.79	-	348	354	-

Soil Sampling and Analytical Methods

Soil samples were collected from the experimental plots before sowing (initial) and after harvesting of each crop. Soil pH and electrical conductivity were determined using standard pH meter and EC meter, respectively, following the methodology of Jackson (1973) [7]. Organic carbon was estimated using the Walkley-Black wet oxidation method. Available nitrogen was determined by the alkaline permanganate method using microprocessor based automatic distillation system (Subbiah and Asija, 1956) [25].

Available phosphorus was extracted using 0.5 M sodium bicarbonate (pH 8.5) as an extractant using UV based double beam spectrophotometer and measured by the Olsen method (Olsen and Watanabe, 1965). Available potassium was determined by the neutral normal ammonium acetate extraction method using a flame photometer (Jackson, 1967) [6]. Data were statistically analysed using multifactor analysis of variance (ANOVA) in RBD following Gomez and Gomez (1984) [5].

Results and Discussion

Effect of Farming Systems on Soil pH, EC and Organic Carbon of Soybean- Chickpea Cropping System

Data pertaining to soil pH, EC and organic carbon for soybean and chickpea are presented in Table 1 and 2. As observed for soybean and chickpea, differences among treatments for pH, EC and OC were non-significant in both years, reflecting the gradual nature of soil organic matter dynamics and the inherent buffering capacity of medium black soils. These non-significant differences are consistent with the short two-year duration of the study, during which measurable shifts in soil chemical equilibria are not always statistically detectable, particularly in high-buffering Vertisols (medium black soils). Nevertheless, meaningful trends were discernible. Initial soil pH before starting of experiment was 8.11 and 8.09 during 2023-24 and 2024-25, respectively. Conventional farming (F6) recorded slightly higher pH and EC values compared to organic modules for soybean and chickpea during both the year. This can be attributed to nitrification reactions associated with nitrogen-based fertilizers such as urea and ammonium nitrate, which release H^+ ions buffered by soil bases, thereby maintaining higher ionic strength and EC over time. In contrast, organic treatments showed a marginal decline in pH, attributable to the release of organic acids such as carbonic acid during decomposition of organic inputs including FYM, vermicompost, ghanjeevamrut and jeevamrut. These findings are consistent with Aziz *et al.*, (2019) [2] and Kotangale *et al.*, (2024) [9].

Initial soil EC before starting of experiment was 0.27 and 0.25 dSm^{-1} during 2023-24 and 2024-25, respectively. The organic modules recorded lower EC values relative to conventional farming after harvest of chickpea during second year. This reduction is linked to the organic acid-producing effect of compost and vermicompost application, which neutralizes salinity-related effects and improves nutrient translocation (Kotangale *et al.*, 2024) [9]. The lower EC under organic treatments may also be partially attributed to the absence of soluble mineral salt inputs such as muriate of potash and urea, which directly contribute to ionic concentration in the soil solution under conventional farming regimes.

Initial soil OC before starting of experiment (soybean) was 0.48% and 0.49% during 2023-24 and 2024-25, respectively after the harvest of chickpea during second year OC was increased over initial in all the treatments. This progressive

accumulation of organic carbon across all farming systems underscores the role of both crop residue incorporation and root biomass turnover in building soil organic matter over successive cropping cycles. Highest increased in organic carbon after harvest of chickpea was recorded in integration of organic and natural farming (F_3) 0.56%, 0.58% and 0.57 in 2023-24, 2024-25 and pooled, respectively. The F_3 treatment registered a net gain of +0.08 to +0.09% over initial OC values, representing the most pronounced improvement among all treatments. This increase in organic carbon in organic farming can be attributed to the substantial organic inputs like FYM, vermicompost and phosphate-rich organic manure, which enhance soil structure and microbial activity. The synergistic effect of diverse organic amendments in F_3 creates a positive feedback loop: enhanced microbial biomass accelerates the transformation of fresh organic matter into stable humic fractions, thereby sustaining long-term OC accretion. The variance between farming systems in SOC accumulation is fundamentally driven by the quantity, quality, and biochemical recalcitrance of organic inputs - mineral fertilizers in conventional farming supply no direct carbon substrate, whereas diverse organic amendments in F_3 contribute both labile and recalcitrant carbon pools that differentially contribute to SOC stabilization (Lal, 2020). This buildup of organic carbon in the soil is likely due to enhanced root growth and the decomposition of increased root biomass, resulting in improved soil fertility and structure (Aziz *et al.*, 2019) [2]. Followed, by organic farming registered 0.55%, 0.56% and 0.56 during 2023-24 2024-25 and pooled, respectively. Lowest increase in organic carbon was recorded under conventional farming 0.50%, 0.51% and 0.52% in 2023-24, 2024-25 and pooled, respectively reflecting the known depletion of soil organic matter under exclusive mineral fertilization.

Effect of Farming Systems on Available NPK of Soybean and Chickpea at Harvest

Data on available soil N, P and K at harvest of soybean and chickpea are presented in Table 1 and 2. Significant treatment differences were recorded for all three macronutrients. Available nitrogen increased from the initial status of 213 $kg\ ha^{-1}$ (2023-24) and 220 $kg\ ha^{-1}$ (2024-25) across nearly all treatments. The increase in available N across treatments confirms that all farming systems, through their respective nutrient inputs and biological processes, positively contributed to the soil N pool relative to the unfertilized control. Conventional farming (F_6) recorded the significantly highest increase in available nitrogen at harvest of soybean over the initial level, registered 223, 249 and 236 $kg\ ha^{-1}$ during 2023-24 2024-25 and pooled, respectively reflecting rapid mineralization driven by the narrow C:N ratio associated with synthetic fertilizer application (Das *et al.*, 2019). The net gain of conventional farming over the initial N status (approximately +10 $kg\ ha^{-1}$ in 2023-24 and +29 $kg\ ha^{-1}$ in 2024-25) reflects an accelerating trend likely linked to cumulative mineralization priming driven by repeated synthetic N additions. However, conventional farming was statistically at par with integration of organic and natural farming and with the organic farming during both years. Among the organic modules, integration of organic and natural farming recorded the highest increase in available nitrogen over the initial level, registering 221, 245 and 233 $kg\ ha^{-1}$ during 2023-24 2024-25 and pooled, respectively. The highest decrease in available nitrogen over the initial level was recorded in the control (F_7), registered 178, 188, and 183 $kg\ ha^{-1}$ during 2023-24, 2024-25 and pooled,

respectively. The superiority of F_3 is attributed to the combined use of compost, vermicompost, jeevamrut and which stimulate nitrogen mineralization and biological nitrogen fixation (Kotangale *et al.*, 2024; Potkile *et al.*, 2017) ^[9, 18]. Furthermore, the leguminous nature of chickpea in the second season likely contributed additional biologically fixed nitrogen, partially explaining the higher available N status recorded at post-chickpea harvest across all treatments.

After harvest of chickpea during second year available nitrogen was increased over initial (soybean) in most of the treatment. The highest increase in available nitrogen was recorded in conventional farming, with available nitrogen of 243, 263 and 253 kg ha⁻¹ during, respectively. Among the organic modules, the highest increase in available nitrogen over the initial status occurred in the integrated organic and natural farming treatment (F_3), with available nitrogen of 238, 256 and 247 kg ha⁻¹ during 2023-24, 2024-25 and pooled, respectively which was statistically at par with conventional farming (F_6). The comparable performance of F_3 to conventional farming in sustaining soil N availability after two cropping cycles, without any synthetic fertilizer input, is a notable finding that underscores the agronomic viability of integrated organic-natural farming as a transitional or alternative strategy. In contrast, the control treatment showed a decrease in available nitrogen relative to the initial status (178, 193 and 185 kg ha⁻¹ during 2023-24, 2024-25 and pooled, respectively). (Charith, 2025) ^[3]. The progressive depletion of soil N under the unfertilized control is consistent with continuous N removal through crop uptake, which, in the absence of exogenous inputs or nitrogen fixation, inevitably exhausts the available soil N pool. This finding reinforces the necessity of nutrient inputs-whether organic or inorganic-for maintaining soil fertility under cropping systems.

Available phosphorus increased from initial values of 13.30 kg ha⁻¹ and 17.10 kg ha⁻¹ in 2023-24 and 2024-25, respectively. Conventional farming again recorded the highest increase in available P_2O_5 after soybean harvest (20.58, 24.06 and 22.32 kg ha⁻¹), followed by the integration of organic and natural farming (19.75, 22.02 and 20.88 kg ha⁻¹) during 2023-24, 2024-25 and pooled, respectively which was statistically at par with F_6 . The notable enhancement in phosphorus availability under F_3 is linked to the application of PROM, which stimulates phosphate-solubilizing bacteria (PSB) and to the organic matter's ability to form stable complexes with Ca^{2+} and Mg^{2+} , thereby reducing phosphorus fixation in the alkaline soil (Kotangale *et al.*, 2024; Potkile *et al.*, 2017) ^[9, 18]. The net gain in available P under F_3 over the initial status was approximately 6.45-8.72 kg ha⁻¹ across years-representing a substantial improvement achieved without soluble synthetic phosphatic fertilizers, indicating the effectiveness of bio-mediated P solubilization in alkaline Vertisols.

Conventional farming recorded the highest increase in available P_2O_5 after chickpea harvest compared to initial values (23.00 kg ha⁻¹ in 2023-24, 26.41 in 2024-25 and 24.71 kg ha⁻¹ pooled, respectively). Among the different organic modules, the integration of organic and natural farming (F_3) recorded the highest increase in available P_2O_5 over the initial status (21.49, 23.61 and 22.55 kg ha⁻¹ during 2023-24, 2024-25 and pooled, respectively) which was statistically at par with F_6 during 2023-24. Less improvement was observed over initial (soybean) in control recorded pooled 12.86 kg ha⁻¹ after the harvest of chickpea. (Charith, 2025) ^[3]. The relatively low P status in the

control treatment, persisting over two seasons, reflects the progressive depletion of available P due to crop removal and fixation in the alkaline soil matrix without any compensatory input. Notably, chickpea's ability to exude citric and malic acids from its roots contributes to rhizosphere P mobilization and may partly explain the modest P retention observed even in low-input treatments across years.

Available potassium before the start of the experiment was 330 and 342 kg ha⁻¹ during 2023-24 and 2024-25, respectively. Conventional farming recorded the highest increase in available K_2O after soybean harvest (356, 366 and 361 kg ha⁻¹) over the initial status during 2023-24, 2024-25 and pooled, respectively. Among the different organic modules, the highest increase in available potassium was recorded in the integration of organic and natural farming treatment (351, 357 and 354 kg ha⁻¹ during 2023-24, 2024-25 and pooled, respectively), which was again statistically at par with F_6 . The positive impact of vermicompost and neem cake under F_3 on available K is attributed to their role in reducing K fixation through organic matter-clay interactions and in supplementing the exchangeable K pool through slow but sustained release during decomposition (Kotangale *et al.*, 2024; Potkile *et al.*, 2017) ^[9, 18]. The net gain of +21-26 kg ha⁻¹ over initial K status under F_3 is particularly noteworthy, given that the treatment received no muriate of potash, demonstrating that organic inputs alone can sustain K availability at levels comparable to conventional fertilization in medium black Vertisols rich in K-bearing primary minerals.

The highest increase in available potassium after chickpea harvest over the initial status (soybean) was recorded under conventional farming (364, 370 and 367 kg ha⁻¹) during 2023-24, 2024-25 and pooled, respectively with integration of organic and natural farming (F_3) following closely (354, 359 and 357 kg ha⁻¹) during 2023-24, 2024-25 and pooled, respectively, remaining statistically at par with F_6 . The accumulation of available K under F_3 is attributed to ghanjeevamrut and fermented organic manures, which enhance microbial-mediated K release and reduce nutrient leaching through improved soil physical properties (Charitha, 2025) ^[3]. Available potassium was decreased over initial (soybean) after harvest of chickpea during second year in control treatment. This K depletion in the control is consistent with the net negative K balance expected under continuous cropping without external K inputs, as crop removal progressively exhausts the exchangeable and non-exchangeable K fractions. The trend across all nutrient parameters-N, P and K-consistently points to the superior capacity of F_3 (integrated organic and natural farming) to maintain soil nutrient stocks at levels statistically comparable to conventional farming, while relying entirely on biological and organic nutrient management mechanisms. This finding has important implications for transitioning to sustainable agriculture in semi-arid, black soil-dominated agricultural regions, where maintaining soil fertility without synthetic chemical inputs remains a key challenge.

Conclusion

The results of this two-year experiment clearly demonstrate that the integration of organic and natural farming (F_3) represents the most effective among alternative farming systems for maintaining and improving soil health under the soybean-chickpea cropping sequence in Vidarbha. Although soil pH, electrical conductivity and organic carbon did not differ significantly due to the inherent buffering capacity of medium black soils, distinct and meaningful pedological trends emerged.

Conventional farming (F₆) consistently maintained higher pH and EC levels, a phenomenon linked to the higher ionic strength and proton-releasing nitrification processes of mineral nitrogenous fertilizers. Conversely, organic modules facilitated a marginal reduction in alkalinity through the evolution of organic acids (e.g., carbonic acid) during the decomposition of FYM and vermicompost. The integration of organic and natural farming (F₃) emerged as the most robust alternative to conventional practices for soil health restoration. Treatment F₃ recorded the highest accumulation of soil organic carbon (0.57% pooled), significantly outperforming conventional systems where exclusive mineral fertilization led to the lowest OC gains. Significant differences were recorded for available soil nitrogen, phosphorus and potassium, with conventional farming recording the highest values; however, the integrated organic-natural module was statistically at par with conventional farming for all three macronutrients in both crops. These findings highlight that a judicious combination of FYM, vermicompost, PROM, ghanjeevamrut and jeevamrut can sustain soil nutrient supply comparable to synthetic fertilizers while offering the additional benefits of organic matter enrichment and improved soil biological activity. The integrated module therefore holds considerable promise as a sustainable and economically viable alternative to conventional input-intensive farming, supporting long-term soil health and agricultural resilience in the Vidarbha region.

Disclaimer (Artificial intelligence)

Author(s) hereby declare 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.

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References

- Anonymous. The world of organic agriculture. FIBL-IFOAM report. 2023. Available from: <https://www.fibl.org/en/shop-en/1254-organic-world-2023>
- Aziz MA, Mushtaq T, Ahmad M, Dar EA, Mahdi SS, Qureshi IA. Effect of integrated nutrient management on soil physical properties using soybean (*Glycine max* L.) as indicator crop under temperate conditions. *Chemistry and Science Reviews and Letters*. 2019;8(29):123–128.
- Charith R. Influence of farming modules on soil health under chickpea-soybean system [PhD thesis]. Akola: Dr. PDKV; 2025.
- Das S, Kumar N, Das R, Kaustav A. Long term impact of nutrient management options on yield and nutrient uptake of soybean and soil properties under soybean-wheat cropping system in the Indian Himalayas. *Indian Journal of Agricultural Sciences*. 2019;89(3):406–414.
- Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: John Wiley and Sons; 1984.
- Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall Publication Pvt Ltd; 1967. p. 452.
- Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India Pvt Ltd; 1973.
- Jukanti AK, Gaur PM, Gowda CLL, Chibbar RN. Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.): a review. *British Journal of Nutrition*. 2012;108(S1):S11–S26.
- Kotangale L, Phalke DK, Deshmukh S, Jagtap P, Bacchav S. Evaluating chemical and biological properties of soil as influenced by various farming practices in soybean. *International Journal of Advanced Biochemistry Research*. 2024;8(12):180–184. doi:10.33545/26174693.2024.v8.i12c.3097
- Lal R. Regenerative agriculture for food and climate. *Journal of Soil and Water Conservation*. 2020;75(4):79A–81A. doi:10.2489/JSWC.2020.0620A
- Mathivanan R, Edwin SC, Amutha R, Vishwanathan K. Panchagavya effects on growth and yield attributes of crops. *International Poultry Science*. 2006;5(12):1144–1150.
- Natarajan K. Panchagavya: a manual. Kodumudi, Tamil Nadu: Rural Community Action Center (RCAC); 2008.
- Olsen SR, Watanabe FS. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Washington DC: United States Department of Agriculture; 1965. Circular 939.
- Palekar S. The philosophy of spiritual farming. 2nd ed. Amravati, Maharashtra, India: Zero Budget Natural Farming Research, Development and Extension Movement; 2005.
- Palekar S. The principles of spiritual farming. Vol II. 2nd ed. Amravati, Maharashtra, India: Zero Budget Natural Farming Research, Development and Extension Movement; 2006.
- Palekar S. Zero budget natural farming: five layers Palekar's model (Part I). Amravati, Maharashtra, India: Zero Budget Natural Farming Research, Development and Extension Movement; 2006.
- Paslawar AN, Mhashakhatri S, Shingrup PV, Chirde PN, Darekar NK. Productivity dynamics of blackgram with intercropping of minor millets on BBF under organic cultivation. *Legume Research*. 2023. doi:10.18805/LR-5031
- Potkile SN, Bhale VM, Deshmukh JP, Choudhary AA, Shingrup PV. Nutrient management through organic sources in soybean-wheat cropping sequence under irrigated condition. *International Journal of Pure and Applied Bioscience*. 2017;5(5):1035–1041. doi:10.18782/2320-7051.5258
- Rashid M, Khalid I, Sanghvi G, Shankar A, Saeed F, Afzaal M, et al. Soybean synergies: a comprehensive review on novel extraction techniques and their role in unlocking health potential. *Food Science and Nutrition*. 2025;13(10):e70983. doi:10.1002/fsn3.70983
- Rosset PM, Martinez-Torres ME. Rural social movements and agroecology: context, theory and process. *Ecology and Society*. 2012;17(3).
- Sharma S, Ravisankar N, Jain N, Sarangi S. Natural farming: current status, research and case studies. *Indian Journal of Agronomy*. 2023;68(Special Issue):S1–S15.
- Shukla AK, Singh RR, Mishra T, Tripathi KM, Shukla S, Singh S. Evaluation of biodynamic compost and biodynamic compost wash on growth and yield of rice. *International Journal of Plant and Soil Science*. 2023;35(21):892–902.

23. Sial AK, Shankar T, Praharaj S, Sahoo U, Maitra S. Intensive farming: its effect on the environment. Indian Journal of Natural Sciences. 2021;12(69).
24. Smith J, Yeluripati J, Smith P, Nayak DR. Potential yield challenges to scale-up of zero budget natural farming. Nature Sustainability. 2020;3:247–252.
25. Subbiah BV, Asija GV. A rapid procedure for determination of available nitrogen in soils. Current Science. 1956;25:256–260.
26. Yadav JK, Sharma M, Yadav R, Yadav SK. Effect of different organic manures on growth and yield of chickpea (*Cicer arietinum* L.). Journal of Pharmacognosy and Phytochemistry. 2017;6(5):1857–1860.