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Optimization of Organic Manure-based Technology to Enhance Soil Quality, Growth, Yield, and Fruit Quality of Ber (*Ziziphus mauritiana*) in Arid Regions

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Abstract

The present study conducted in 2022-23 to 2023-24 to evaluate the effects of organic manures on growth, yield, fruit quality of ber (Ziziphus mauritiana) cv. Gola, enzymatic activities, and microbial populations in soil under arid conditions. The combined application of vermicompost (20 kg plant^{-1}) with biofertilizers (consortium biofertilizer) emerged as the most effective, significantly enhanced fruit physical traits, with the highest fruit diameter (3.59 cm), fruit volume (24.68 ml), pulp fresh weight (23.36 g), and stone weight (1.25 g) compared to the control. The superior fruit size and pulp weight were attributed to improved nutrient availability, stimulated root growth, and enhanced microbial activity in the rhizosphere, which facilitated efficient nutrient uptake and translocation. Quality attributes, including total soluble solids (22.86%), vitamin C content (111.57 mg 100 g^{-1}), and acidity (0.33%), were also maximized under this treatment, reflecting increased availability and elevated soil enzymatic activity. Activities of dehydrogenase, alkaline phosphatase, and urease were significantly higher (10.99 µg TPF g^{-1} h^{-1}, 11.13 µg p-NP g^{-1} h^{-1}, 532.81 µg NH_3 g^{-1} h^{-1}, respectively), indicating enhanced nutrient mineralization. Soil microbial populations including bacteria, fungi, and actinomycetes progressively increased from October to December, with the highest counts observed under vermicompost + biofertilizers (consortium biofertilizer) demonstrating the synergistic effect of organic matter and beneficial microbes on soil biological health. Overall, the study highlights that the combined application of vermicompost with biofertilizers improved growth, yield, fruit quality, and soil biological activity in soil under arid conditions, the supporting sustainable fruit production.

Keywords: Ber (*Ziziphus mauritiana*), Organic manure, Vermicompost, Biofertilizers, Ber yield and quality, Arid ecology

Introduction

India ranks among the largest fruit-producing countries in the world, and within arid and semi-arid horticulture, Ber (*Ziziphus mauritiana*) occupies a distinct position owing to its remarkable adaptability to drought, salinity, and extreme temperatures. It is widely cultivated in Rajasthan, Gujarat, Madhya Pradesh, and other hot regions, where it provides both nutritional security and livelihood support to farming communities. The fruit is highly valued for its richness in vitamin C, sugars, and essential minerals, along with its ability to thrive under harsh agro-climatic conditions. Despite its resilience, ber productivity and quality in arid ecosystems are often constrained by low soil fertility, poor organic matter content, salinity, and erratic rainfall. Reliance on chemical fertilizers under such fragile environments not only limits long-term productivity but also degrades soil health, reduces microbial diversity, and adversely affects fruit quality (Sharma *et al*., 2018, 2021, Meena *et al*., 2021). Therefore, sustainable alternatives are required to maintain both soil and crop productivity.

In this context, organic manures and biofertilizers have emerged as promising nutrient management options. Organic manures such as farmyard manure, vermicompost, green manures, and crop residues improve soil structure, organic carbon, and water-holding capacity, while also stimulating beneficial microbial activity crucial for sustaining productivity in arid regions (Aulakh, *et al.,* 2010, Aulakh and Adhya, 2005). Their slow and steady nutrient release enhances nutrient use efficiency (NUE) and minimizes leaching losses in coarse-textured soils of drylands (Yadav *et al.,* 2016). Importantly, organic amendments also influence soil enzymatic activities such as dehydrogenase, urease, and phosphatase, which are vital indicators of microbial metabolism, nutrient cycling, and soil biological health. Enhanced enzymatic activity under organic management reflects greater microbial population and diversity, contributing to efficient nutrient mineralization and improved root-soil interactions (Kannan et al., 2005). From a fruit quality perspective, the application of organic manures and biofertilizers improves the biochemical composition of ber, including total soluble solids (TSS), sugars, ascorbic acid, and acidity, thereby enhancing both consumer acceptance and market value (Meena *et al.,* 2013). Moreover, with growing consumer awareness of safe food and environmental sustainability, organically produced fruits fetch premium prices in both domestic and export markets (APEDA, 2022). Beyond quality enhancement, organic nutrient management plays a significant role in mitigating abiotic stresses, as organic matter buffers soil salinity, moderates soil temperature, improves moisture retention, and enhances plant resilience to drought and heat stress (Jatav *et al*., 2025).

Thus, organic manures and biofertilizers represent a holistic approach not only for improving growth, yield, and fruit quality but also for restoring soil fertility, enzymatic activity, and microbial populations essential for long-term sustainability. It is hypothesized that the application of different organic manures and their combinations will significantly enhance growth, yield, and fruit quality of Ber (Ziziphus mauritianaLam.) cv.Gola, enzymatic activities, and beneficial microbial populations in soil under arid conditions. Considering these aspects, the present study was undertaken to evaluate the potential of organic manure-based technology in optimizing soil quality and fruit production for sustainable horticulture in arid ecosystems.

Materials and Methods

The present investigation was conducted during 2022–23 and 2023–24 at the ICAR–Central Institute for Arid Horticulture (CIAH), Bikaner, Rajasthan, to evaluate the effect of organic manures and biofertilizers on growth, yield, fruit quality, and soil biological properties of ber (*Ziziphus mauritiana*) cv. Gola under hot arid conditions. The experimental site represents the Thar desert ecosystem, characterized by sandy soils with poor water-holding capacity, low organic matter, and extreme temperature fluctuations. Initial soil analysis revealed an alkaline reaction with pH 7.5–8.3, low organic carbon (0.015%), and available nitrogen, phosphorus, and potassium contents of 98.2, and 195 kg ha^{-1},respectively.Vermicompostused in the study contained 1.5% nitrogen, 0.5% phosphorus, and 1.65% potassium (K_2O). The experiment was laid out in a randomized block design with six treatments, namely: (1) control, (2) farmyard manure (FYM) @ 40 kg plant^{-1}, (3) vermicompost @ 20 kg plant^{-1}, (4) FYM @ 40 kg plant^{-1} + biofertilizers (consortium biofertilizer), (5) vermicompost @ 20 kg plant^{-1} + biofertilizers (consortium biofertilizer), and (6) crop residue @ 20 kg plant^{-1} + decomposer (PUSA decomposer), each replicated three times. Uniform and healthy ber plants of cv. Gola were selected, and manures along with biofertilizers were applied in basins at the onset of active growth in June month. Irrigation was mainly dependent on rainfall and supplemented during dry spell to avoid moisture stress, two to three supplementary irrigation was given to ber orchard in the month of October to December as per requirement. Observations on fruit physical attributes (fruit diameter, fruit volume, pulp fresh weight, and stone weight) and quality parameters (total soluble solids, vitamin C, and acidity) were recorded following standard procedures (AOAC, 2000). Soil biological properties were assessed by estimating microbial populations through the serial dilution plate count technique using selective media (nutrient agar for bacteria, Rose Bengal agar for fungi, and Kenknight's agar for actinomycetes) with incubation at 28 ± 2 °C for 3–5 days. Enzymatic activities were determined using standard protocols, viz. dehydrogenase activity by the TTC reduction method (Casida *et al*., 1964), alkaline phosphatase by the p-nitrophenyl phosphate method (Tabatabai and Bremner, 1969), and urease activity by estimating ammonia released from urea hydrolysis (Tabatabai and Bremner, 1972). The data pooled over two years were subjected to analysis of variance (ANOVA) as per the procedure suggested by Panse and Sukhatme (1985).

Results and Discussion

Effect of organic manures on soil enzymatic activities

Application of organic manures significantly enhanced soil enzymatic activities such as dehydrogenase, alkaline phosphatase, and urease in ber orchards under hot arid conditions. A consistent increase in enzymatic activity was observed with higher application rates of organic inputs. Among the treatments, vermicompost + biofertilizers recorded the highest values for dehydrogenase activity (10.99 µg TPF g^{-1} dry soil h^{-1}), alkaline phosphatase activity (11.13 µg p-NP g^{-1} dry soil h^{-1}), and urease activity (532.81 µg NH_3 g^{-1} dry soil h^{-1}), which were significantly superior to the control (7.01, 7.28, and 240.10, respectively) (Table 1). These improvements can be attributed to the synergistic effect of nutrient-rich vermicompost and microbial inoculants, which enhanced soil organic carbon, stimulated microbial proliferation, and accelerated nutrient mineralization (Marinari *et al.,* 2000). Vermicompost alone also exhibited significantly higher enzymatic activities (10.12 µg TPF g^{-1} dry soil h^{-1}, 10.39 µg TPF g^{-1} dry soil h^{-1}), and 505.84 µg TPF g^{-1} dry soil h^{-1}), respectively) compared with FYM or crop residue + decomposer, indicating its superior role in enhancing soil biological activity under arid conditions. Similarly, FYM + biofertilizers outperformed FYM alone, suggesting that biofertilizers play a key role in enhancing microbial biomass and metabolic functions. Comparable results were reported by Marinari *et al.* (2000), Martens *et al.* (1992) and Senthil kumar (2000), who emphasized that integrated organic nutrient management supports microbial proliferation and accelerates soil organic matter. Thus, the vermicompost + biofertilizers treatment not only improved soil enzymatic activities but also strengthened soil fertility, ultimately leading to better growth performance of ber under arid ecosystems.

Effect of organic manures on soil microbial populations

Soil microbial populations were significantly influenced by organic manures and biofertilizers during the growth period. As shown in Table 2, bacterial, fungal, and actinomycete populations progressively increased from October to December across all treatments due to a combination of moderate temperatures, optimal moisture, and increased organic matter. After the monsoon, soils remain moist but well-aerated, creating favorable conditions for microbial growth. The ambient temperatures during this period are ideal for most microorganisms (Meng *at el*., 2023, Katrina et al.,1999) while fresh plant litter from fallen leaves and residues provides abundant nutrients, boosting microbial activity and biomass with maximum values recorded in the vermicompost + biofertilizers treatment. In this treatment, bacterial populations increased from 153 ×10t in October to 176 ×10t in December, fungal populations from 87 $\times10^{-2}$ to 101 $\times10^{-2}$, and actinomycetes from 86 $\times10^{-2}$ to 98 $\times10^{-2}$. These values were considerably higher than those under control (134 ×10t , 82 $\times10^{-2}$, and 85 $\times10^{-2}$, respectively) in December (Table 2). The superior performance of

Table 1. Effect of different organic manures on enzymes activity in soil.

Treatments	Dehydrogenase (µg TPF g^{-1} dry soil h^{-1})	Alkaline phosphatase (µg p-NP g^{-1} dry soil h^{-1})	Urease (µg NH_3^{-1} g dry soil^{-1} h)
Control	7.01	7.28	240.10
FYM	8.36	8.77	290.01
Vermicompost	10.12	10.39	505.84
FYM +Bio ertilizers	8.77	9.31	515.28
Vermicompost + Biofertilizers	10.99	11.13	532.81
Crop residue + Decomposer	7.55	7.96	303.50
LSD (p=0.05)	2.20	2.28	99.48

Table 2. Effect of different organic manures on microbial population in soil during growth period Ber (*Ziziphus mauritiana) cv. Gola.*

Treatments	Bacterial population (10^{-4})			Fungal Population (10^{-2})			Actinmycetes population (10^{-2})		
	October	November	December	October	November	December	October	November	December
Control	100	127	134	66	76	82	64	77	85
FYM	111	136	145	70	77	86	73	82	89
Vermicompost	130	165	168	82	87	94	82	86	94
FYM +Biofertilizers	119	138	150	75	82	90	76	85	93
Vermicompost + Biofertilizers	153	166	176	87	98	101	86	96	98
Crop residue + Decomposer	108	130	138	65	73	81	61	75	83
LSD (p=0.05)	19	22	23	11	13	14	11	13	14

vermicompost can be attributed to its high organic carbon, humic substances, and readily available nutrients that favour microbial multiplication (Dalal 1998; Weon *et al.,* 1999, Alvarez *et al.,* 1995). The addition of biofertilizers further enhanced microbial activity due to the synergistic introduction of beneficial microbes such as nitrogen fixers and phosphate solubilizers (Brady and Weil, 1999; Alvarez *et al.*, 1995). The observed increase in microbial populations is consistent with higher enzymatic activities, reflecting a positive relation between organic inputs, microbial proliferation, and nutrient cycling. Similar observations have been reported by (Nannipieri *et al.,* 1990).

Effect of organic manures on fruit growth and quality of Ber fruit

The findings of the present investigation demonstrated that the application of organic manures exerted a significant influence on the growth, yield, and fruit quality of ber (*Ziziphus mauritiana*) cv. Gola. Among the various nutrient management treatments, the combined application of vermicompost (20 kg plant^{-1}) along with biofertilizers proved most effective, recording the highest values for both physical and biochemical fruit attributes. This treatment resulted in the maximum fruit diameter (3.59 cm), fruit volume (24.68 ml), pulp fresh weight (23.36 g), and stone fresh weight (1.25 g) (Table 3), all of which were significantly superior compared to the control and other treatments. The improvement in fruit size and weight under vermicompost + biofertilizers may be attributed to better nutrient availability, enhanced microbial and enzymatic activity, which collectively supported superior assimilate partitioning towards fruit development. These results clearly indicate that the integrated use of organic manures and biofertilizers not only enhances soil fertility but also improves the physical and nutritional quality of ber fruits, thereby offering a sustainable approach for productivity enhancement under arid horticultural systems. These findings align with studies by Bhadauria and Tripathi (2023a) in mango. The

Table 3. Effect of different organic manures on fruit physical attributes of Ber (*Ziziphus mauritiana) cv. Gola.*

Treatments	Average diameter (cm)	Average volume (ml)	Average Pulp fress weight (g)	Average stone fresh weight (g)	Total soluble salt (%)	Vitamin C (mg 100 g^{-1})	Acidity (%)
Control	2.78	19.16	18.32	1.08	19.16	102.51	0.19
FYM	2.99	21.53	20.21	1.18	21.22	107.89	0.24
Vermicompost	3.41	23.36	22.73	1.20	22.25	108.81	0.28
FYM + Biofertilizers	3.20	22.05	21.79	1.21	21.74	110.54	0.30
Vermicompost + Biofertilizers	3.59	24.68	23.36	1.25	22.86	111.57	0.33
Crop residue + Decomposer	2.92	20.74	19.58	1.13	19.67	106.34	0.21
LSD (p=0.05)	0.49	2.25	1.40	0.12	1.54	7.74	0.04

improvement in fruit size and pulp weight may be explained from the fact that the different sources of nutrients enhance the nutrient availability by enhancing the capability of plants for better uptake of nutrients from rhizosphere. These results are in conformity with the findings as reported by Korwar *et al*. (2006); Singh *et al*., (2012); Athani *et al. (*2014); and Singh *et al.* (2010). Fruit quality parameters were also positively influenced by organic nutrition. The highest TSS (22.86%), vitamin C (111.57 mg 100 g^{-1}), and acidity (0.33%) were observed in vermicompost + biofertilizers, followed by FYM + biofertilizers. The increase in TSS and vitamin C content under organic manure treatments may be due to improved macro and micronutrient availability, coupled with enhanced soil enzymatic activities, leading to better synthesis and accumulation of sugars and ascorbic acid. This enhancement in biochemical properties may be due to improved carbohydrate metabolism and nutrient translocation resulting from the synergistic action of vermicompost and biofertilizers. These results align with studies by Verma *et al.* (2019) in dragon fruit, Tripathi *et al.* (2017) in strawberry and Singh and Tripathi (2020b) in papaya. These findings are in agreement with the result of Athani *et al.* (2009) in guava and Yadav *et al*. (2010) in strawberry, Jatav *et al*. (2025) *et al.* in Bael.

Effect of organic manures and biofertilizers on yield of ber

Fruit yield of ber was significantly influenced by the application of organic manures and biofertilizers (Fig. 1). The lowest yield (25.4 kg $tree^{-1}$) was observed in the control, whereas the highest yield (38.3 kg $tree^{-1}$) was recorded under vermicompost + biofertilizers, representing a 50.8% increase over the control. This was followed by vermicompost (33.8 kg $tree^{-1}$), crop residue + decomposer (31.4 kg $tree^{-1}$), and vermicompost alone (29.7 kg $tree^{-1}$) all of which outperformed the control. The percentage yield response of ber varied notably among the treatments. Compared to the control, the highest increase (50.79%) was observed under the combined application of vermicompost and biofertilizers. This was followed by vermicompost alone (33.07%), FYM with biofertilizers (23.62%), and crop residue with decomposer (23.62%). FYM alone resulted in a comparatively lower increase of 16.93% over the control, highlighting the enhanced effectiveness of integrated organic nutrient management in improving ber yield under arid conditions The superior performance of vermicompost + biofertilizers may be attributed to the combined benefits of nutrient-rich vermicompost, which supplies humic substances, readily available N, P, K, and micronutrients, along with biofertilizers that enhance nitrogen fixation and phosphorus solubilisation (Bhalerao *et al.,* 2009). These synergistic effects improved soil structure, water-holding capacity, microbial activity, and nutrient uptake, leading to better fruit set, retention, and ultimately higher yield. The enhanced fruit set and retention can also be linked to a continuous supply

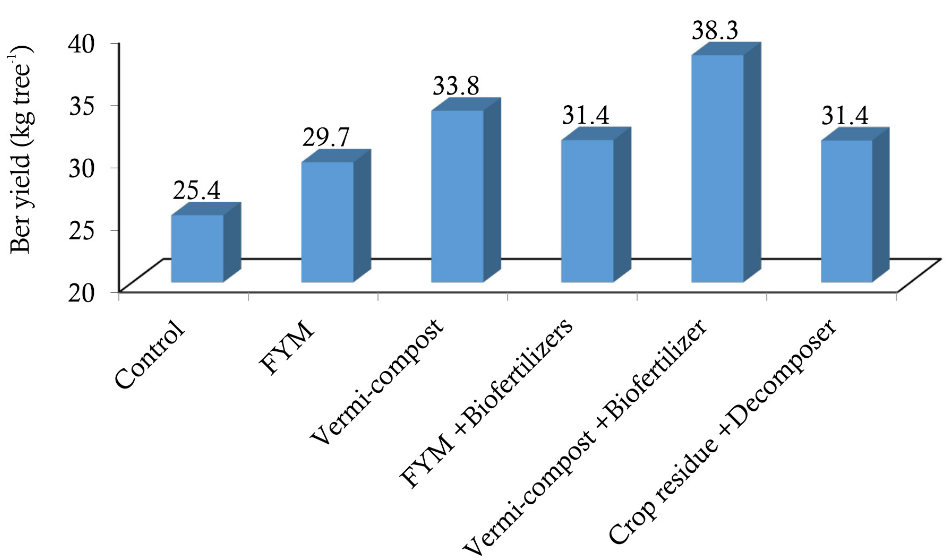

Fig. 1 Effect of different organic manures on Yield of Ber (*Ziziphus mauritiana) cv. Gola*

of essential nutrients from the start of the experiment through harvesting, ensuring a steady flow of photosynthates to developing fruits during critical stages. The synergistic interaction of organic manures and microbial inoculants not only promoted vegetative growth but also enhanced reproductive efficiency (Sharma *et al.,* 2021). These findings are in close conformity with earlier reports of Goswami *et al.,* (2012) in guava and Singh *et al.,* (2010) in ber, who also highlighted the role of organic nutrient sources in improving fruit set and yield. Similarly, Kumar *et al.,* (2014) and Singh *et al.,* (2017) and Bohane (2016) observed that vermicompost and biofertilizers improved productivity in ber and other fruit crops by enhancing NUE and microbial biomass (Meena *et al.,* 2025b). More recently, Meena *et al.,* (2025b) and Sharma, (2013) emphasized that organic nutrient management ensures long-term soil fertility, yield sustainability, and resilience of arid horticultural systems.

Conclusion

The study revealed that organic manures significantly enhanced growth, yield, fruit quality, soil enzyme activity, and microbial population in ber under arid conditions. Among treatments, vermi-compost + biofertilizers proved most effective, recording maximum fruit yield, pulp weight, TSS, vitamin C, and soil microbial activity, followed by FYM + biofertilizers. These results confirm that organic nutrient management enhances soil biological health by improving microbial populations and enzymatic activities, thereby contributing to long-term soil sustainability in ber cultivation under arid and semi-arid conditions.

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References

Alvarez MB, Gagne S and Antoun H (1995) Effect of compost on rhizosphere microflora of tomato and on the incidence of plant growth promoting rhizobacteria. *Applied and Environmental Microbiology* **61**: 194–199.

AOAC (2000) Official Methods of Analysis. 17th Edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA. Methods 925.10, 65.17, 974.24, 992.16

Athani SI, Ustad AI, Prabhuraj HS, Swamy GSK, Patil PB and Kotikal YK (2009) Influence of vermicompost on growth, fruit yield and quality of guava cv. Sardar. *Acta Horticulturae* **735**: 381–385.

Bhadauria AS and Tripathi VK (2023a) Effect of bio-enhancers and bio-fertilizers on growth and quality of mango cv. Amrapali under sub-tropical plains of central Uttar Pradesh, India. *International Journal of Plant and Soil Science* **35(19)**: 1260–1267.

Bhalerao VP, Patil NM, Badgujar CD and Patil DR (2009) Studies on integrated nutrient management for tissue cultured Grand Naine banana. *Indian Journal of Agricultural Research* **43(2)**: 107–112.

Bohane L, Tiwari R and Gautam KK (2016) Integrated nutrient management in ber (Zizyphus mauritiana Lamk.) cv. Gola under Malwa Plateau conditions of Madhya Pradesh. *Indian Journal of Horticulture* **73(1)**: 128–132.

Brady NC and Weil RP (1999) Soil organic matter. In: The nature and properties of soils (Eds.) Brady NC and Weil RP, pp. 446–490. Upper Saddle River, New Jersey.

Casida L, Klein D and Santoro T (1964) Soil dehydrogenase activity. *Soil Science* **98**: 371-376.

Dalal RC (1998) Soil microbial biomass – what do the numbers really mean? *Australian Journal of Experimental Agriculture* **38**: 649–665.

Edwards KJ, Gihring TM and Banfield JF (1999) Seasonal variations in microbial populations and environmental conditions in an extreme acid mine drainage environment. *Applied and Environmental Microbiology* **65(8)**: 3627–3632.

Goswami AK, Lal S and Misra KK (2012) Integrated nutrient management improves growth and leaf nutrient status of guava cv. Pant Prabhat. *Indian Journal of Horticulture* **69**: 168–172.

Jatav MK, Meena A, Balai RC, Meena RK, Meena SR, Maheshwari SK and Singh AK (2025) Mitigating fruit cracking in bael (Aegle marmelos Corr.) fruits through organic and inorganic nutrient application and mulching in hot arid regions. *Agricultural Mechanization in Asia Africa and Latin America* **54(2)**: 15195–15204.

Kannan P, Saravanan A, Krishnakumar S and Natarajan SK (2005) Biological properties of soil as influenced by different organic manures. *Research Journal of Agriculture and Biological Sciences* **1(2)**: 181–183.

Korwar GR, Pratibha G, Ravi V and Palanikumar D (2006) Influence of organic and inorganic fertilizers on growth and yield of aonla (Emblica officinalis Gaertn.) in semi-arid tropics. *Indian Journal of Agricultural Sciences* **76**: 457–461.

Marinari S, Masciandaro G, Ceccanti B and Grego S (2000) Influence of organic and mineral fertilizer on soil biological and physical properties. *Bioresource Technology* **71**: 9–17.

Martens DA, Johanson JB and Frankenberger WT (1992) Production and persistence of soil enzymes with repeated addition of organic residues. *Soil Science* **153**: 53–61.

Meena A, Jatav MK, Appa Rao VV and Balai RC (2025) Optimizing spinach production in arid regions by integrating soil and foliar applications of micronutrients with organic fertilizers under saline irrigation. *Journal of Agriculture and Ecology* **20**: 70–76 doi: 10.58628/JAE-2520-108.

Meena A, Jatav MK, Balai RC and Appa Rao VV (2025b) Potassium fractions and their dynamics for increasing yield in a sustainable fruit-based cropping system in arid region. *Agricultural Mechanization in Asia Africa and Latin America* **56(5)**: 20601–20612.

Meena A, Jatav MK, Balai RC, Meena SR and Appa Rao VV (2025a) Optimizing amendments for saline water to enhance productivity and biochemical proficiency of kachri (Cucumis callosus) in a hot arid agroecosystem. *Agricultural Mechanization in Asia Africa and Latin America* **54(1)**: 15195–15204.

Meena A, Jatav MK, Saroj PL, Balai RC, Sharma BD and Meena SR (2021) Evaluation of soil fertility, correlation and nutrient indexing of available macro and micro nutrients in arid vegetable growing pockets of Rajasthan. *Frontiers in Crop Improvement* **9**: 809–814.

Meng W, Sun M, Zhao Y, Shi Y, Sun S, Wang S, Zhou Y and Chen L (2023) Seasonal changes of soil microbiota and its association with environmental factors in coal mining subsidence area. *MB Express* **13**: 147 doi: 10.1186/s13568-023-01653-5.

Nannipieri P, Greco S and Ceccanti B (1990) Ecological significance of the biological activity in soil. In: Soil Biochemistry (Eds.) Bollag JM and Stotzky G, pp. 293–355. Marcel Dekker, New York.

Panse VG and Sukhatme PV (1985) Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research Publication, 87-89.

Senthilkumar S (2000) Integrated plant nutrient supply system in hybrid rice. M.Sc. (Ag.) Thesis, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad.

Sharma A, Wali VK, Bakshi P and Jasrotia A (2013) Effect of integrated nutrient management strategies on nutrient status, yield and quality of guava. *Indian Journal of Horticulture* **70(3)**: 333–339.

Sharma BD, Jatav MK, Balai RC and Meena A (2021) Integrated nutrient management for horticultural crops in arid region. In: *Dryland Horticulture*. CRC Press, pp. 33.

Sharma BD, Meena A, Jatav MK and Balai RC (2018) Integrated nutrient management for horticultural crops in arid region. CIAH/Tech./Pub. No. 77, ICAR-Central Institute for Arid Horticulture, Bikaner, Rajasthan, pp. 42.

Singh A and Tripathi VK (2020b) Influence of integrated nutrient management on growth, yield and quality parameters of papaya (Carica papaya L.). *Journal of Pharmacognosy and Phytochemistry* **9(5)**: 2022–2026.

Singh AK, Singh S and Appa Rao VV (2012) Influence of organic and inorganic nutrient sources on soil properties and quality of aonla in hot semi-arid ecosystem. *Indian Journal of Horticulture* **69**: 50–54.

Singh HD, Lal DG and Singh SK (2010) Effect of nitrogen, phosphorus and zinc fertilization on soil nutrient status and yield of ber (*Zizyphus mauritiana* Lamk.) cv. Gola in arid and semi-arid regions. *Environmental and Ecology* **28**: 328–331.

Tabatabai MA and Bremner JM (1969) Use of p-nitrophenol phosphate for the assay of soil phosphatase activity. *Soil Biology Biochemistry* **1**: 301-307.

Tabatabi MA and Bremner JM (1972) Assay of urease activity in soils. *Soil Biology and Biochemistry* **4**: 479-487.

Tripathi VK, Jain A, Kumar S, Dubey V and Kumar A (2017) Efficacy of bio-fertilizers and mulching on growth, yield and quality of strawberry (Fragaria × ananassa) cv. Chandler. *Indian Journal of Agricultural Sciences* **87(9)**: 1179–1183.

Verma RS, Lata R, Ram RB, Kumar S, Verma SS and Prakash S (2019) Effect of organic, inorganic and bio-fertilizers on physico-chemical attributes of dragon fruit (Hylocereus undatus L.) under Lucknow conditions. *Indian Journal of Pure Applied Biosciences* **7(6)**: 67–70.

Weon HY, Kwon JS, Suh JS and Choi WY (1999) Soil microbial flora and chemical properties as influenced by the application of pig manure compost. *Korean Journal of Soil Science and Fertilizer* **32**: 76–83.

Yadav SK, Prasad R and Khokhar UU (2010) Optimization of integrated nutrient supply system for strawberry cv. Chandler in H.P. (India). *Scientia Horticulturae* **124**: 62–66.

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