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Effects of Effective Microorganisms Combined With Organic and Inorganic Fertilizers on the Mineral Composition and Biochemical Quality of Onion (*Allium cepa* L.) and Spinach (*Spinacia oleracea* L.)

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Abstract

Background and objectives: Effective microorganisms (EM) are promoted as a way of improving the efficiency of organic nutrient sources, but their effect on the nutritional quality of vegetables under different organic-inorganic fertilizer regimes is not well established. We tested the hypothesis that the response to EM depends on fertilizer source and rate, and compared fertilizer combinations, with and without EM, for their effects on the mineral composition and biochemical quality of onion (*Allium cepa* L.) and spinach (*Spinacia oleracea* L.).

Methods: Five pot-culture trials were conducted at Gomal University, Dera Ismail Khan, Pakistan, in 2009-10 and 2010-11, each as a completely randomized design with a split-plot arrangement (EM, applied or not, as the main factor; fertilizer treatment as the sub-factor) and three replications. The untreated control (T0) received no EM and was shared by both EM levels, so the EM effect and the EM × fertilizer interaction were tested on the fertilized treatments only. Trial I compared sole organic manure or NPK; Trials II-V combined organic manure at 100% or 50% of the recommended dose with NPK at 100% or 50%, using farmyard manure, pressmud, compost and poultry manure. Macronutrients (Na, Ca, Mg, N, P, K), micronutrients (Zn, Fe, Cu, Cr, Mn, Ni), dietary fiber, vitamin C, and crude protein (total N × 6.25) were determined in spinach leaves and onion bulbs, and data were analysed by ANOVA with LSD comparisons at $p < 0.05$.

Results: Fertilizer treatment affected (LSD, $p < 0.05$) the mineral composition and biochemical quality of onion and spinach, whereas the EM effect and EM × fertilizer interaction varied among traits and trials and are interpreted as trends. Pressmud generally gave the highest concentrations of minerals, dietary fiber, vitamin C, and crude protein, and EM generally increased them further, although the EM benefit varied among trials and traits. In spinach (Trial I, 2010-11), pressmud with EM increased N, P and K by up to 70, 29 and 23% and dietary fiber, vitamin C and crude protein by up to 71, 65 and 60%, respectively, over the untreated control. Relative increases in onion were larger (crude protein almost eleven-fold) because baseline values in unfertilized bulbs were very low. Farmyard manure, compost and poultry manure gave smaller improvements.

Conclusions: Pressmud combined with NPK and EM warrants further evaluation as a strategy for improving the nutritional quality of spinach and onion. These data do not by themselves establish synergy between EM and fertilizer or any saving of fertilizer. Increases in sodium, chromium and nickel concentrations are not necessarily nutritional benefits and require food-safety assessment. Even on a dry-weight basis, onion Cr and Ni concentrations were well below the FAO/WHO guideline values commonly cited for vegetables (2.3 and 5.0 mg kg⁻¹), whereas the dietary significance of the higher sodium requires fresh-weight, portion-based assessment.

Limitations: The results come from pot experiments with a single soil at one location and need validation under field conditions; microbial activity, soil properties, yield, and economics were not assessed. ANOVA summary statistics are not reported.

Keywords: Effective microorganisms; organic fertilizers; pressmud; macronutrients; micronutrients; dietary fiber; vitamin C; crude protein; integrated nutrient management; nutritional quality

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1. Introduction

Spinach (*Spinacia oleracea* L.) and onion (*Allium cepa* L.) are among the most widely cultivated winter vegetables in Pakistan and other subtropical countries, valued both for their culinary versatility and for their contribution to human nutrition. Spinach leaves are a rich source of minerals, dietary fiber, vitamin C, and protein, while onion bulbs supply organosulphur and flavonoid compounds together with minerals and vitamins associated with antioxidant and cardioprotective effects (Kumar et al., 2010; Jilani et al., 2004). The biochemical composition of these crops, and not merely their fresh yield, therefore determines much of their value to consumers.

Adequate and balanced macronutrient (N, P, K, Ca, Mg, Na) and micronutrient (Zn, Fe, Cu, Cr, Mn, Ni) supply is essential for normal plant metabolism and is reflected in the mineral, protein, fiber and vitamin content of the harvested produce (Tisdale et al., 1990). Conventional vegetable production relies heavily on inorganic NPK fertilizers, but their rising cost and the poor utilization of applied phosphorus in the alkaline, calcareous soils of Pakistan (Memon et al., 2011) often limit yield and quality. Organic amendments such as farmyard manure, pressmud (a sugar-mill by-product), compost and poultry manure are inexpensive, locally available alternatives or complements; beyond supplying nutrients, they improve soil organic matter, microbial activity and nutrient-buffering capacity.

Effective microorganisms (EM) is a liquid inoculant containing a mixed culture of photosynthetic bacteria, lactic acid bacteria and yeasts, first formulated by Higa (1991). When applied to soil or organic residues, EM is reported to accelerate decomposition and mineralization of organic matter, suppress

pathogens, and produce organic acids, amino acids and vitamins that can enhance nutrient solubilisation and uptake (Higa & Wididana, 1991; Hussain & Higa, 2001; Konoplya & Higa, 2001). Evidence for these benefits is, however, not uniform. Olle and Williams (2013) concluded that EM can improve the growth, yield and some quality attributes of vegetables, whereas Mayer et al. (2010) found little consistent effect on yield or soil microbial properties. Comparisons of organic and conventional nutrient sources give a similarly mixed picture for produce quality (Worthington, 2001; Dangour et al., 2009), and tissue vitamin C is sensitive to the form and balance of nitrogen supply (Lee & Kader, 2000). The outcome of combining EM with organic and inorganic sources therefore cannot be assumed and has to be tested for each crop.

Recent syntheses confirm that responses to fertilizer and microbial inputs depend on the crop, nutrient source, and growing conditions. A global meta-analysis of 551 field studies found that fertilization improved the nutritional quality of food crops, that vegetables were the most responsive group, and that combined organic and inorganic sources had the greatest effect (Ishfaq et al., 2023). Meta-analyses of microbial inoculants report gains in yield and produce mineral content (Li et al., 2022), but in an analysis of 94 pot and 47 field experiments with bio-effectors, the average gain of 9.3% differed among tomato, maize, and wheat and was smaller under field than controlled conditions (Nkebiwe et al., 2024). Work on spinach has also shown that the organic carrier used to deliver a microbial inoculant influences nutrient status and yield (Safdar et al., 2022).

While the individual effects of organic manures, inorganic fertilizers, and EM on vegetable growth and yield have been

documented (Sangakkara & Weerasekera, 2001; Fawzy et al., 2012), little is known about how combinations of organic and inorganic fertilizers, applied with or without EM, jointly influence the quality traits of spinach and onion most relevant to human nutrition: macro- and micronutrient concentration, dietary fiber, vitamin C, and crude protein. The present study evaluated EM across five combination regimes of organic manures (farmyard manure, pressmud, compost, poultry manure) and inorganic NPK under the semi-arid conditions of Dera Ismail Khan, Pakistan.

The novelty of this work is that EM was evaluated within organic-inorganic combinations that include reduced (50%) rates of either component, with nutritional-quality traits rather than yield alone as response variables. We hypothesised that (i) the response to EM depends on the fertilizer source and rate (an EM $\times$ fertilizer interaction), and (ii) EM applied with organic manure allows part of the recommended organic or inorganic dose to be reduced without lowering tissue nutrient and quality traits relative to full-rate treatments. The objectives were to (1) compare fertilizer combinations, with and without EM, for the mineral composition and biochemical traits of spinach and onion; (2) determine whether EM gives a statistically significant improvement over the corresponding EM-free treatments; and (3) identify combinations that improve nutritional quality while reducing dependence on full-rate inorganic fertilizer. Optimising quality was the primary aim; reducing NPK input was a secondary aim, examined through the half-rate NPK treatments (Trials III and V).

2. Materials and Methods

Site and soil

Pot experiments were conducted at the Institute of Soil and Environmental

Sciences, Gomal University, Dera Ismail Khan, a semi-arid site (annual rainfall about 269 mm; mean minimum and maximum temperatures 16.9 and 51 °C; 41% relative humidity), in 2009–10 and 2010–11. Composite Indus riverbed soil was air-dried, sieved (2 mm), and filled at 20 kg per pot. It was sandy clay loam, alkaline (pH 8.4, E_{Ce} 0.57 dS m⁻¹), low in organic matter (0.81%) and total N (0.04%), and deficient in available P (5 mg kg⁻¹) and K (97 mg kg⁻¹) (Ryan et al., 2001).

Organic and inorganic fertilizer sources and EM

Farmyard manure (FYM) came from a local dairy farm, pressmud from Chashma Sugar Mills, and poultry manure from a local farm; compost was prepared on-station from crop residues. Urea, single superphosphate (SSP), and sulphate of potash (SOP) supplied N, P, and K. Effective microorganisms (Bio-Aab) came from the EM Foundation, Faisalabad.

The recommended dose (100% RDF) of each organic source was saturated with liquid EM, held at room temperature for 15 days, and incorporated one month before sowing/transplanting; -EM treatments received the same manure without EM. SSP and SOP were applied basally, and urea in three split doses.

Treatments and experimental design

Five separate pot trials were conducted, each a completely randomized split-plot design (EM as main factor, fertilizer treatment as sub-factor) with three replications, 12 pots per replicate and three plants per pot after thinning (Table 1). Full doses were FYM 10, pressmud 20, compost 0.7, and poultry manure 5 t ha⁻¹, and NPK at 100:40:65 (spinach) and 120:60:60 kg ha⁻¹ (onion). Trial I had six treatments (T0–T5); Trials II–V had five (T0–T4), with NPK forming part of every treatment except the control.

Untreated control (T0). T0 received no

manure, NPK, or EM and was shared by both EM levels. Because it has no +EM counterpart, the EM effect and EM × fertilizer interaction were tested on fertilized treatments only (T1–T5 in Trial I; T1–T4 in Trials II–V), and T0 was compared with the other treatments separately.

Table 1. Experimental treatments of the five trials.

Trial	Combination regime	Treatments (T0–T5)	EM levels applied
Trial I	Sole organic manure or NPK (100% RDF)	T0 Control; T1 FYM; T2 Pressmud; T3 Compost; T4 Poultry manure; T5 NPK	T0: none; T1–T5: –EM, +EM
Trial II	Organic manure (100% RDF) + NPK (100% RDF)	T0 Control; T1 FYM+NPK; T2 Pressmud+NPK; T3 Compost+NPK; T4 Poultry manure+NPK	T0: none; T1–T4: –EM, +EM
Trial III	Organic manure (100% RDF) + NPK (50% RDF)	T0 Control; T1 FYM+½NPK; T2 Pressmud+½NPK; T3 Compost+½NPK; T4 Poultry manure+½NPK	T0: none; T1–T4: –EM, +EM
Trial IV	Organic manure (50% RDF) + NPK (100% RDF)	T0 Control; T1 ½FYM+NPK; T2 ½Pressmud+NPK; T3 ½Compost+NPK; T4 ½Poultry manure+NPK	T0: none; T1–T4: –EM, +EM
Trial V	Organic manure (50% RDF) + NPK (50% RDF)	T0 Control; T1 ½FYM+½NPK; T2 ½Pressmud+½NPK; T3 ½Compost+½NPK; T4 ½Poultry manure+½NPK	T0: none; T1–T4: –EM, +EM

T0 = untreated control, shared by both EM levels; RDF = recommended dose; ½ = 50% of RDF.

EM and manures. The EM stock (Bio-

Aab) had pH 3.5 and 1.0×10^7 cfu mL⁻¹ for each microbial group and was applied at 50 mL per kg of manure; –EM manures received an equal volume of sterilised water. Manure composition and per-pot rates (converted from field recommendations for 20 kg soil) are in Table 2.

Table 2. Application rates and nutrient composition of the organic materials and EM.

Material	Rate (t ha ⁻¹)	Rate (g pot ⁻¹)	N (%)	P (%)	K (%)	O C (%)	C: N	p H	EC (d S m ⁻¹)
Farmyard manure	10	100	1.2	0.6	1.1	24.0	20:1	7.8	3.2
Pressmud	20	200	1.8	1.5	0.8	36.0	20:1	6.5	4.5
Compost	0.7	7	1.5	0.8	1.2	22.5	15:1	7.4	2.1
Poultry manure	5	50	2.9	1.9	1.6	33.6	12:1	7.2	5.8
EM (Bio-Aab)	–	20 mL	0.1	0.02	0.05	1.2	12:1	3.5	4.2

Crop husbandry

Spinach was direct-seeded (10 g pot⁻¹) on 4 November 2009, and leaves were harvested at market maturity. Onion (local cultivar ‘Shah Alam’) seedlings were nursery-raised, and five seedlings were transplanted per pot on 13 January 2010. Pots were irrigated to maintain soil moisture close to field capacity, and standard plant-protection measures were followed uniformly across treatments. In 2010-11, spinach was sown on 6 November and harvested 45 days after sowing, and onion seedlings were transplanted in mid-December and harvested at maturity, about 130 days after sowing.

Biochemical analysis

Spinach leaves and onion bulbs from each pot were washed with deionized

water, and a composite sample per replicate was oven-dried at 65 °C to constant weight for mineral, fibre and protein analysis; vitamin C was determined on fresh tissue. Each determination was carried out in duplicate per replicate, with reagent blanks in each batch, instruments calibrated with standard solutions, and a certified reference sample included in each digestion batch. The pH of an aqueous plant-tissue extract was determined following [Ryan et al. \(2001\)](#).

Vitamin C: determined titrimetrically using the 2,6-dichlorophenolindophenol dye method ([AOAC, 1990](#)). A 2 g sample was extracted in a 1:1 HCl-HPO₃ mixture, filtered, and a 10 mL aliquot titrated against a standard dye solution; ascorbic acid (mg 100 g⁻¹) was calculated from the titre, dye factor and the volumes used.

Total nitrogen and crude protein: total N was determined by the micro-Kjeldahl digestion-distillation-titration method ([Bremner & Mulvaney, 1982](#)), and crude protein was calculated as total N × 6.25 ([AOAC, 1990](#)). Because the 6.25 factor assumes that all nitrogen is protein, it can overestimate true protein in vegetables containing non-protein nitrogen such as nitrate ([Mariotti et al., 2008](#)); the values are therefore reported as crude protein.

Macronutrients: samples were dry-ashed (550 °C) and extracted in 2 N HNO₃; P was measured spectrophotometrically, Na and K by flame photometry, and Ca and Mg by EDTA titration ([AOAC, 1990](#)).

Micronutrients: samples were dry-ashed (500 °C), dissolved in 1:1 HNO₃, and Zn, Fe, Cu, Cr, Mn, and Ni were determined by atomic absorption spectrophotometry ([AOAC, 1990](#)).

Dietary fiber: total dietary fiber was determined by the enzymatic-gravimetric method ([AOAC, 1990](#)); samples were gelatinized with heat-stable α-amylase and digested with protease and

amyloglucosidase, and the soluble and insoluble fractions were precipitated, dried at 105 °C, and summed.

Statistical analysis

Data for each trial were analysed by split-plot ANOVA in Statistica 9, with means compared by LSD at $p < 0.05$ where F was significant ([Steel et al., 1997](#)). Seasons were analysed separately. Following Gomez and [Gomez \(1984\)](#), EM was tested against the replicate × EM error, and fertilizer and EM × fertilizer against the sub-plot error. Because T0 received no EM, ANOVA covered fertilized treatments only. Full ANOVA tables are not reported; significant effects refer to F-tests and LSD at $p < 0.05$.

3. Results and discussion

Across all trials and both seasons, the untreated control (T0) had the lowest concentrations of all macro- and micronutrients and the lowest dietary fiber, vitamin C, and crude protein in both crops. The seasons followed similar trends, and 2010–11 values were more stable and better separated by LSD, so these are shown in Figures 1–6; corresponding patterns occurred in 2009–10. Because ANOVA tables are not reported, +EM versus -EM differences and EM × fertilizer patterns are descriptive trends rather than formally demonstrated effects.

3.1 Macronutrient concentrations

Macronutrient concentrations are shown in Figures 1 and 2. Pressmud (T2) generally gave the highest concentrations in both crops, followed by poultry manure and FYM; compost and sole NPK (Trial I) were intermediate. In spinach Trial I (2010–11), pressmud with EM increased Ca by 79%, Mg by 78%, N by 70%, Na by 42%, P by 29%, and K by 23% over the control. Onion responses were proportionally larger because of very low baseline concentrations, with N, Ca, and K more than doubling.

EM application increased macronutrient concentration over the corresponding EM-free treatment in almost every combination, and this increment was generally largest when pressmud was combined with a full or half dose of NPK (Trials II and III), where N, P and K concentrations of both crops reached their highest recorded values. This pattern is consistent with a complementary effect between readily available inorganic nutrients and EM-stimulated mineralization of organic N, P and K in pressmud, which may avoid the temporary nitrogen immobilization often associated with decomposition of high C: N organic residues (Tisdale et al., 1990). Pressmud is rich in moisture, sugars, and readily decomposable organic matter that favour establishment of the EM consortium (Namita & Sharma, 2010). These findings agree with Fawzy et al. (2012), who reported higher N, P and K in onion after EM and related bio-stimulant applications, and with Adewole and Ilesanmi (2011), who observed comparable increases in tissue nutrients after combined organic-inorganic-microbial amendment of okra.

Annexure (A)

Annexure (B)

3.2 Micronutrient concentrations

Micronutrients are shown in Figures 3 (spinach) and 4 (onion). The control had the lowest values in all trials, and pressmud with EM the highest, although Cr and Ni responded less consistently. In spinach Trial I (2010–11), pressmud with EM raised Zn by 232%, Fe by 95%, and Mn by 97% over the control, and Cu several-fold from a very low baseline. Onion gains were proportionally larger for Cu and Zn, whereas Cr and Ni responses were smaller and often not significant.

As with the macronutrients, EM co-application increased micronutrient concentration over the corresponding EM-

free treatment in most combinations, an effect commonly attributed to EM-derived organic acids that lower rhizosphere pH and increase the solubility and availability of micronutrient cations in alkaline, calcareous soils (Alam et al., 2010; Gorski & Kleiber, 2010). Similar EM-induced improvements in micronutrient uptake by onion have been reported by Fawzy et al. (2012). Rhizosphere pH and organic-acid production were not measured here, so this explanation remains speculative.

Nutritional suitability and food safety. Not every increase is desirable. Higher sodium (up to 42% in spinach under pressmud with EM) runs counter to advice to moderate sodium intake; Cr and Ni are not required for vegetable quality, and organic wastes can carry trace metals (Alloway, 2013). The FAO/WHO guideline values commonly applied to vegetables are 2.3 mg kg⁻¹ for Cr and 5.0 mg kg⁻¹ for Ni (compiled by Kolawole et al., 2022); to our knowledge, neither Codex Alimentarius nor Pakistani standards set maximum levels for these in onion or spinach. Moisture was not measured, but fresh-weight concentrations in onion (about 90% moisture) would be roughly ten times lower. Even on a dry-weight basis, the highest Cr (about 0.39 mg kg⁻¹ d.w., ½pressmud + ½NPK + EM, Trial V) and Ni (about 0.26 mg kg⁻¹, Trial IV) were about one-sixth and one-twentieth of the guideline values, against 0.01–0.02 mg Cr and 0.03–0.04 mg Ni kg⁻¹ in the control. These increases were small in absolute terms and did not approach the guideline values, although repeated and field-scale trials should continue to monitor trace metals. Sodium has no permissible limit as a contaminant; its relevance is dietary, because WHO advises adults to consume less than 2 g of sodium per day (WHO, 2012), and depends on fresh-weight concentrations and portion sizes not

determined here. We therefore treat higher Na, Cr, and Ni as changes needing food-safety assessment, not quality improvements; the quality gains reported are confined to dietary fiber, vitamin C, crude protein, and the essential nutrients (N, P, K, Ca, Mg, Zn, Fe, Cu, Mn).

Annexure (C)

Annexure (D)

3.3 Dietary fiber, vitamin C and crude protein content

Dietary fiber, vitamin C and crude protein are shown in Figures 5 and 6. The control had the lowest values, and pressmud was generally the most effective amendment, but the EM benefit was not uniform: in onion, it was small or absent for dietary fiber in Trial III and crude protein in Trials III and IV, and in spinach, it varied with trial and treatment. In spinach Trial I (2010–11), pressmud with EM increased dietary fiber by 71%, vitamin C by 65%, and crude protein by 60% over the control; in onion, crude protein rose almost eleven-fold and vitamin C and fiber by more than 100% from very low baselines. Peak values, generally under pressmud + NPK + EM (Trials II, III and V), were 2.9–3.0 (fiber), 36–40 (vitamin C) and 3.2 (crude protein) mg 100 g⁻¹ d.w. in spinach, and 14.5 (vitamin C) and 16.2 (crude protein) in onion.

The consistently positive response of vitamin C to organic amendment, particularly pressmud with EM, is in line with the close link between potassium and carbohydrate supply and ascorbic acid biosynthesis; where N was supplied predominantly as inorganic fertilizer without adequate potassium and organic carbon, as under sole NPK in Trial I, the vitamin C response was smaller, consistent with reports that excess inorganic N relative to carbon and K can depress ascorbic acid accumulation (Lee & Kader, 2000). The rise in dietary fiber under organic and EM treatments is consistent

with greater photosynthate production associated with EM-enhanced chlorophyll synthesis and plant vigour (Xu et al., 2000), while the parallel increase in crude protein matches the higher tissue N recorded under the same treatments (Konoplya & Higa, 2001; Sangakkara & Weerasekera, 2001).

Annexure (E)

Annexure (F)

3.4 Comparison with recent research and practical implications

The highest mineral, fiber, vitamin C, and crude protein values in our trials were obtained when pressmud was combined with NPK (Trials II, III and V). This agrees in direction with a global meta-analysis of 551 field studies in which combined inorganic and organic nutrient sources had the greatest effect on the nutritional quality of food crops, and vegetables were the most responsive group (Ishfaq et al., 2023). Because we measured concentrations and not yield or uptake, however, part of the differences may reflect dry-matter accumulation, and our data do not show how the treatments affect nutrient uptake per plant.

The size of the EM effect varied among trials, traits, and crops, consistent with recent syntheses showing that responses to microbial inoculants are not uniform. A meta-analysis of 97 studies found that microbial inoculants increased crop yield and produce mineral content, mainly through stress alleviation and improved nutrient availability (Li et al., 2022), whereas bio-effector gains averaged 9.3% with large differences among crops and the smallest gains under field conditions (Nkebiwe et al., 2024). The EM responses reported here should therefore be regarded as specific to the EM product (Bio-Aab), crops, soil and trial conditions used.

Recent spinach work has used organic materials as carriers for microbial

inoculants, with carrier type influencing growth, nutrient status and yield (Safdar et al., 2022). Here, manures were saturated with EM, so the organic material served as both nutrient source and EM substrate; with no sterilized-EM or carrier-only control and no microbial counts, the contribution of the organisms cannot be separated from that of the substrate and its nutrients.

Why field validation is needed. Pots restrict root volume, use a single sieved soil and exclude field heterogeneity and competition with native microorganisms, and may overstate field responses (Nkebiwe et al., 2024). Our results are preliminary and should be tested in multi-season, multi-location field trials recording yield, uptake, soil and microbial properties and cost before recommendations are made.

3.5 Limitations of the study

The findings come from pot experiments using a single riverbed soil at one location, one onion cultivar, and two seasons that were analysed separately, and they cannot be extrapolated directly to field conditions. Nutrient and quality-trait concentrations were measured, but fresh yield, total nutrient uptake, possible dilution effects, microbial activity, and soil chemical properties were not, nor was economics assessed. The unfertilized control received no EM, so the EM effect could be assessed only within fertilized treatments. The design also lacked a sterilized-EM or carrier-only control and microbial measurements. The ANOVA summary statistics (F-values and mean squares) are not reported, so the EM and EM $\times$ fertilizer effects cannot be verified by the reader and are interpreted cautiously as trends.

4. Conclusion

In these pot experiments, pressmud with NPK and EM generally gave the

highest macronutrient, micronutrient, dietary fiber, vitamin C, and crude protein values in spinach and onion, and EM generally raised these traits above EM-free treatments, although the benefit varied with crop, trait, and trial. Other manures gave smaller gains, and sole NPK an intermediate response. Higher Na, Cr, and Ni are not nutritional benefits and require food-safety assessment, although onion Cr and Ni were well below commonly cited FAO/WHO guideline values (2.3 and 5.0 mg kg⁻¹) even on a dry-weight basis. Pressmud-based integrated fertilization warrants further evaluation, but because the study was pot-based and yield, microbial processes, soil properties, and economics were not assessed, the data do not establish EM–fertilizer synergy, field-scale benefit, or fertilizer savings.

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Data availability and ethics statements

The data supporting the findings are presented in the figures and tables of this article. Ethical approval was not required because the study involved no human or animal subjects.

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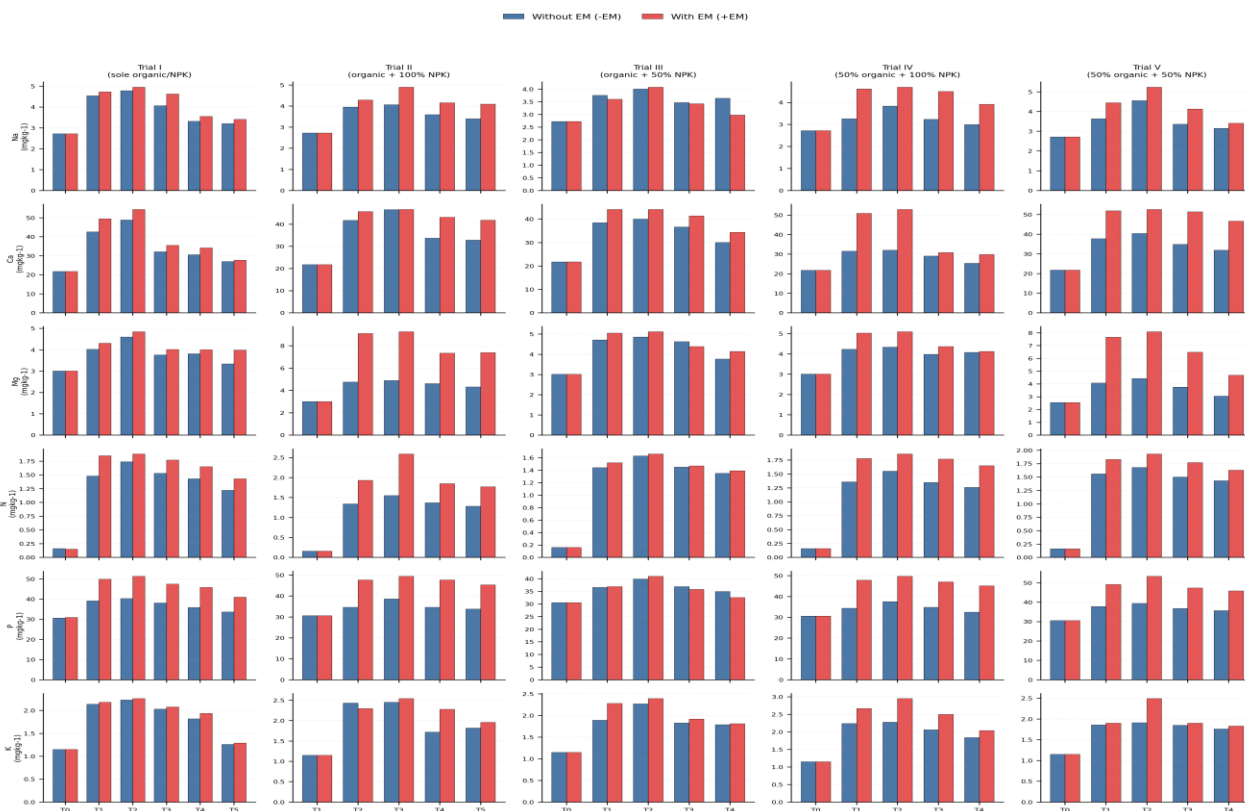
Annexure (A)**Figure 1. Macronutrient (Na, Ca, Mg, N, P, K) concentrations in spinach leaves under five organic-inorganic fertilizer combination trials, with and without EM (2010-11)****Figure 1. Macronutrient concentrations (mg kg⁻¹ dry weight) in spinach leaves, with (+EM) and without (-EM) effective microorganisms, 2010-11.****Annexure (B)****Figure 2. Macronutrient (Na, Ca, Mg, N, P, K) concentrations in onion bulb under five organic-inorganic fertilizer combination trials, with and without EM (2010-11)**

Figure 2. Macronutrient concentrations (mg kg^{-1} dry weight) in onion bulb, with (+EM) and without (-EM) effective microorganisms, 2010-11.

Annexure (C)

Figure 3. Micronutrient (Zn, Fe, Cu, Mn) concentrations in spinach leaves under five organic-inorganic fertilizer combination trials, with and without EM (2010-11)

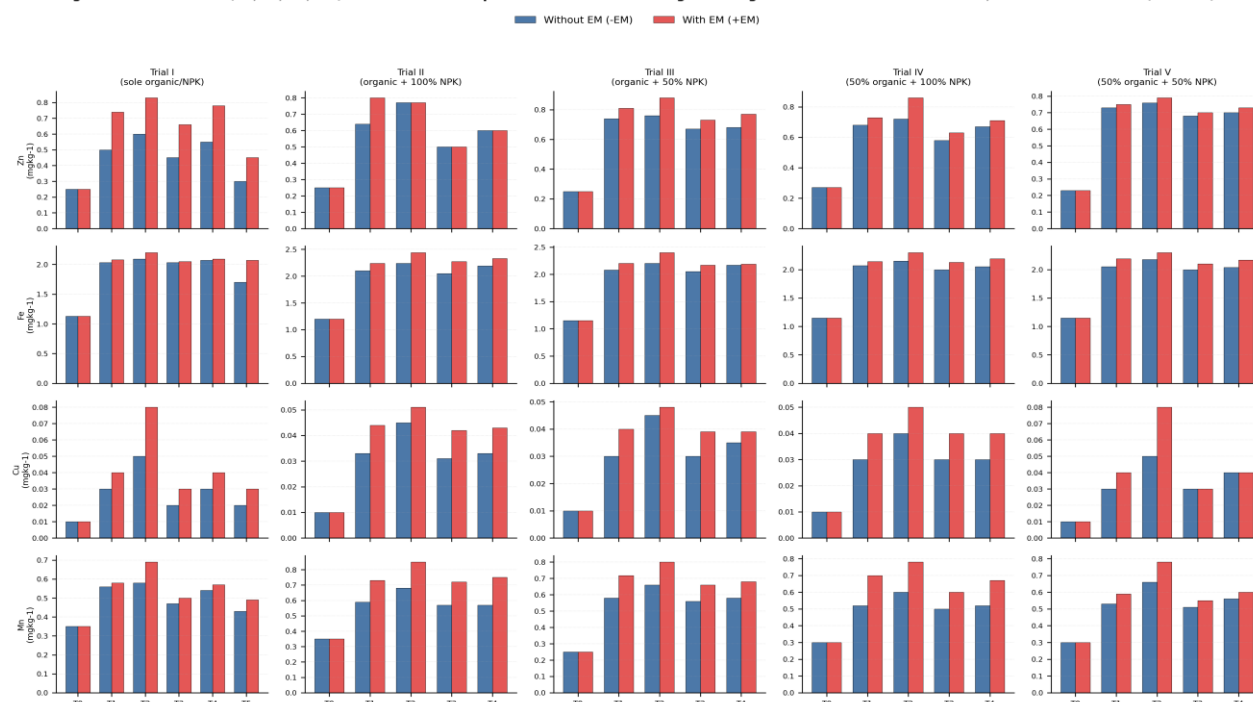


Figure 3. Micronutrient concentrations (mg kg^{-1} dry weight) in spinach leaves, with (+EM) and without (-EM) effective microorganisms, 2010-11.

Annexure (D)

Figure 4. Micronutrient (Zn, Fe, Cu, Cr, Mn, Ni) concentrations in onion bulb under five organic-inorganic fertilizer combination trials, with and without EM (2010-11)

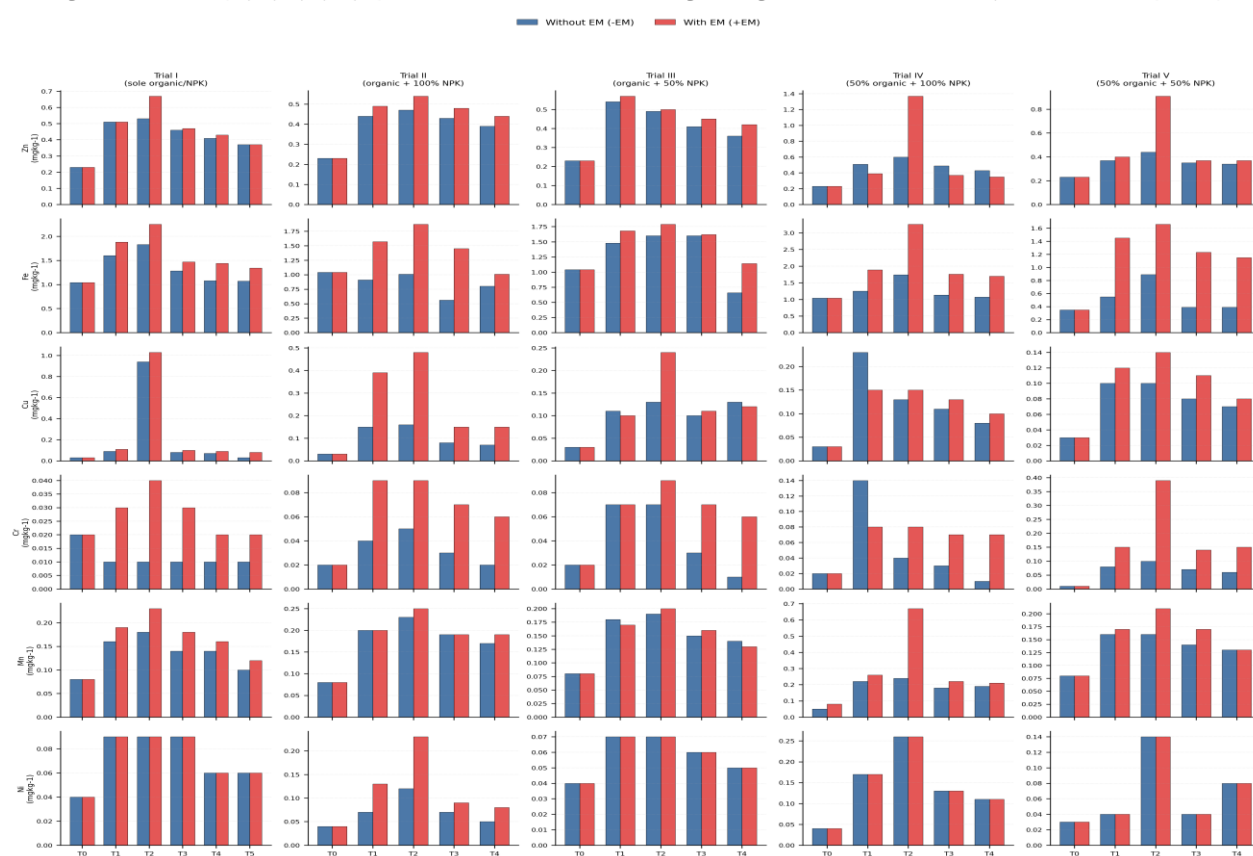


Figure 4. Micronutrient concentrations (mg kg^{-1} dry weight) in onion bulb, with (+EM) and without (-EM) effective microorganisms, 2010–11.

Annexure (E)

Figure 5. Dietary fiber, vitamin C and crude protein content of spinach leaves under five organic-inorganic fertilizer combination trials, with and without EM (2010-11)

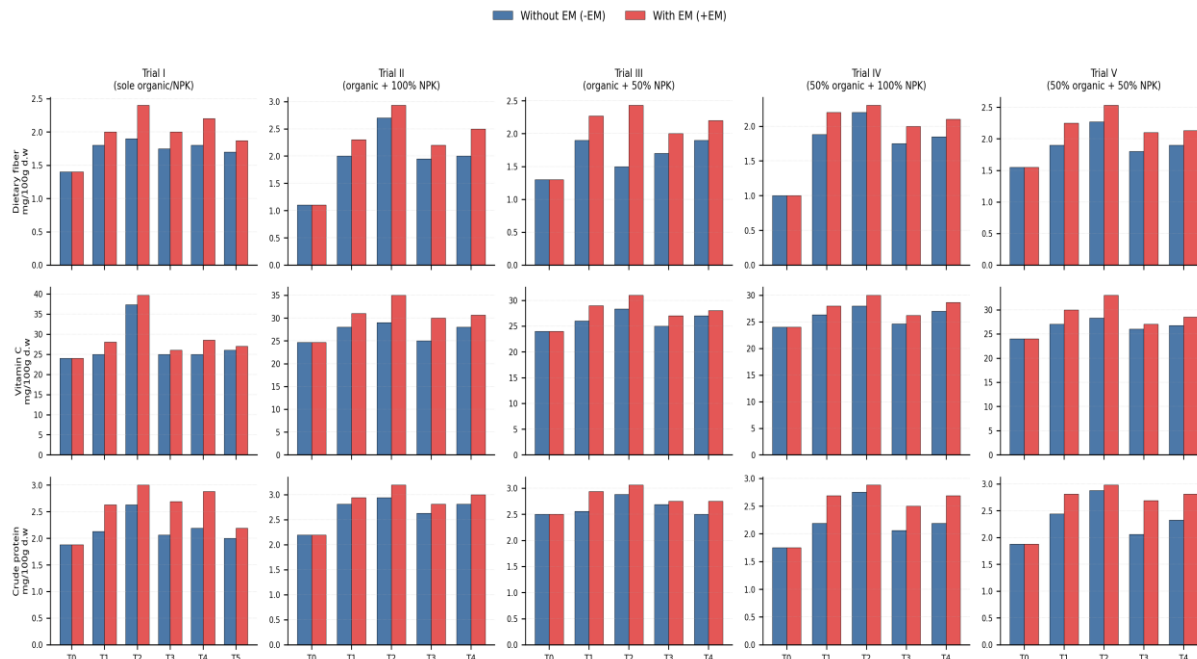


Figure 5. Dietary fiber, vitamin C and crude protein (mg 100 g^{-1} dry weight) of spinach leaves, with (+EM) and without (-EM) effective microorganisms, 2010–11.

Annexure (F)

Figure 6. Dietary fiber, vitamin C and crude protein content of onion bulb under five organic-inorganic fertilizer combination trials, with and without EM (2010-11)

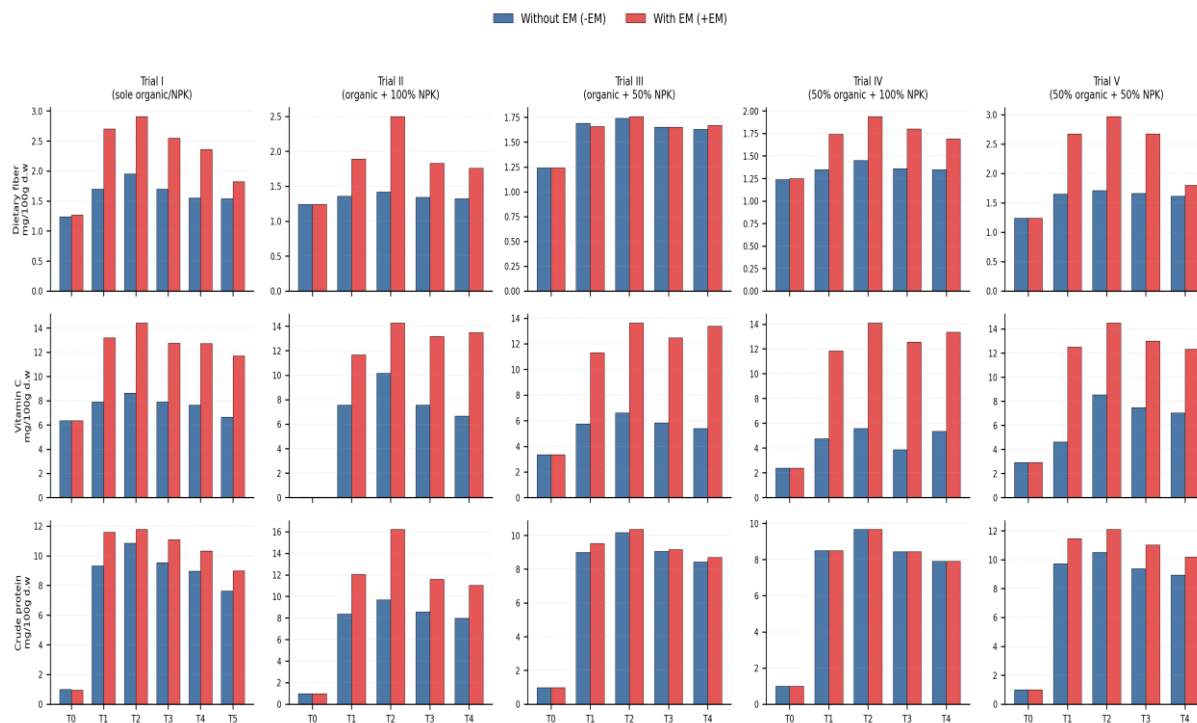


Figure 6. Dietary fiber, vitamin C and crude protein (mg 100 g^{-1} dry weight) of onion bulb, with (+EM) and without (-EM) effective microorganisms, 2010–11.