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Unveiling the Impact of Integrated Nutrient Management on Soil Health and Microbial Dynamics in Mustard Cultivation

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

During the Rabi season of 2020-21, an investigation was carried out at College Farm, Agricultural College, Polasa, Jagtial, under the supervision of Professor Jayashankar Telangana State Agricultural University. The primary aim of the research was to assess the influence of integrated nutrient management on the organic carbon content, enzyme activity and microbial population in

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the mustard (*Brassica juncea* L.) crop. The experiment was conducted in soil with a sandy clay loam texture and followed a randomized block design, consisting of nine distinct treatments, each of which was replicated three times. These treatments includes: T1: 100% Recommended Dose of Fertilizer (RDF), T2: 100% RDF + FYM, T3: 100% RDF + FYM + Biofertilizer consortium, T4: 75% RDF, T5: 75% RDF + FYM, T6: 75% RDF + FYM + Biofertilizer consortium, T7: Soil Test Based NPK, T8: 75% STB NPK + FYM and T9: 75% STB NPK + FYM + Biofertilizer consortium. The results revealed that the organic carbon, dehydrogenase activity and microbial population of soil were significantly enhanced by the application of combined use of organic, inorganic fertilizers and biofertilizers. All the parameters were recorded higher with the integrated application of 75% STB NPK+ FYM + Biofertilizer consortium which was on par with 100 % RDF + FYM + Biofertilizer consortium, 75 % RDF + FYM + Biofertilizer consortium, 75 % STB NPK + FYM, 100 % RDF + FYM, 75 % RDF + FYM. The population of bacteria and fungi, organic carbon content and dehydrogenase were recorded lower in the treatments receiving sole application of inorganic fertilizers.

Keywords: Mustard; bacteria; fungi; dehydrogenase; organic carbon.

1. INTRODUCTION

In India, the average yield of mustard is low at 1,089 kg per hectare due to suboptimal nutrient utilization and improper management [1]. This is mainly attributed to cultivating rapeseed mustard in marginal rainfed lands and the inadequate use of fertilizers. Excessive reliance on chemical fertilizers can harm soil's biological activity, which plays a crucial role in nutrient transformations. Intensive farming practices, unbalanced fertilizer use and limitations on organic fertilizers not only deplete soil nutrients but also degrade soil health. Integrated Nutrient Management (INM) is a flexible approach that aims to minimize chemical fertilizer use while maximizing farmer profits. It involves a combination of chemical fertilizers, organic manures, legumes, crop residues and biological fertilizers. Oilseeds, including rapeseed mustard, hold a significant place in India's agriculture, with a production of 31.3 million tonnes over 24.65 million hectares [2]. India's oilseed market has shifted from being a net importer to a self-sufficient and net exporting country over the past 15 years.

Rapeseed mustard is a vital oilseed crop in India, accounting for a substantial portion of the country's oil production and being the third most important edible oil crop after soybean and groundnut. The global production of mustard seed and oil is around 38-42 million tonnes and 12-14 million tonnes, respectively. India is a major player in the world mustard industry, producing approximately 6.9 million tonnes of rapeseed mustard.

Due to intensive cultivation and the use of high-analysis fertilizers, Indian soils are becoming deficient in essential nutrients like nitrogen (N), phosphorus (P), potassium (K) and sulphur (S). Organic manures offer a solution to enhance soil health and crop production while improving fertilizer use efficiency. A balanced nutrient management approach that combines organic, inorganic and biological fertilizers not only supports sustainable crop production but also maintains soil health. Research involving chemical, organic and biological fertilizers as supplementary nutrient sources for mustard is crucial for the state's economy. Given the rising demand and cost of chemical fertilizers, there is a growing need to conduct field trials that integrate organic and biological fertilizers alongside chemical fertilizers. This approach aims to optimize nutrient utilization for sustainable production and soil health maintenance.

2. MATERIALS AND METHODS

A field experiment was conducted at the Agricultural College's college farm in Jagtial during the rabi season of 2020, using mustard as the test crop. The experimental farm's geographical coordinates were 18° 50' 58" N latitude and 78° 56' 97" E longitude, situated at an elevation of 243.4 meters above mean sea level (MSL). Throughout the growth period of the crop, the weekly average maximum temperature ranged from 33.5°C to 30.8°C. Meanwhile, the average minimum temperature during the same period varied between 12.8°C and 18.6°C. The mean maximum and minimum temperatures for this timeframe were recorded at 31.4°C and 16.0°C, respectively. The average relative humidity stood at 66.7%. Over the crop growth period, the weekly mean evaporation rate ranged

from 1.8 mm to 4.3 mm. The variety chosen for this study was NRCHB-101. The experiment employed a Randomized Block Design (RBD) with three replications, and a total of nine treatments were applied. These treatments were as follows: T1: 100% Recommended Dose of Fertilizer (RDF), T2: 100% RDF + FYM, T3: 100% RDF + FYM + Biofertilizer consortium, T4: 75% RDF, T5: 75% RDF + FYM, T6: 75% RDF + FYM + Biofertilizer consortium, T7: Soil Test Based NPK, T8: 75% STB NPK + FYM and T9: 75% STB NPK + FYM + Biofertilizer consortium. Biofertilizer consortium includes Azotobacter + Phosphate Solubilizing Bacteria + Potassium Solubilizing Bacteria + Zinc Solubilizing Bacteria. The treatments were allotted randomly in each replication.

Analysis of soil samples revealed that the experimental soil had a sandy clay loam texture. It is low in available nitrogen, with levels measuring 196 kg ha^{-1}, whereas available phosphorus content was recorded as high at 26.6 kg ha^{-1} and available potassium content was also high at 360 kg ha^{-1}. Moreover, available sulphur content was moderately present at 26.8 kg ha^{-1}. The recommended fertilizer application for the mustard crop is 60 kg ha^{-1}, 40 kg ha^{-1} of phosphorus, and 40 kg ha^{-1} of potassium. These essential nutrients were supplied through urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively. The initial fertilization included the application of phosphorus, potassium and half of the nitrogen during the sowing stage of the crop. The remaining half of the nitrogen was administered at the flowering phase of the mustard plant, which occurred between 55 and 60 days after sowing. Prior to the sowing of the mustard crop, biofertilizers and farm yard manure (FYM) corresponding to each treatment were incorporated into the soil.

Soil samples were collected at specific growth stages: 15 days after sowing (DAS), 30 DAS, 45 DAS, 60 DAS and post-harvest. These samples were collected from a depth of 0 to 15 cm. Once collected, the soil was carefully placed into durable polythene bags and transported to the laboratory for subsequent analysis. In the controlled environment of the laboratory, the soil samples were subjected to air drying. Afterward, they were finely ground using a wooden pestle and mortar, and the resulting material was sifted through a sieve with a mesh size of 0.5 mm. for the analysis of organic carbon by wet chromic acid digestion outlined by Walkley and Black [3]. For the analysis of dehydrogenase activity fresh soil samples of about five grams was weighed into glass tubes and mixed with 5 ml TTC solution. The tubes were sealed with rubber stopper and inoculated for 24 hours at 30^0C. The control contains only 5 ml tris buffer (without TTC). After incubation 40 ml acetone was added to each tube and tubes were shaken thoroughly and further incubated at room temperature for 2 hours in dark (shaking the tubes at intervals). The suspension was then filtered and optical density of clear supernatant was measured against the blank at 546 nm (red colour). The activity of dehydrogenase is expressed in μg TPF formed per gram of dry soil per day [4]. The samples were also analysed for the assay of soil microbial load of bacteria and fungi by Serial dilution and agar plate method [5].

3. RESULTS AND DISCUSSION

Organic carbon: Organic carbon content in soil was significantly influenced by integrated nutrient management, data pertaining to organic carbon (%) as influenced by different treatments of integrated nutrient management at 15, 30, 45, 60 DAS and at harvest are presented in Table 1. Organic carbon content at 15 DAS was recorded significantly higher under 75% STB NPK + FYM + Biofertilizer consortium (0.63 %) which was on par with 100 % RDF + FYM + Biofertilizer consortium (0.62 %), 75 % RDF + FYM + Biofertilizer consortium (0.61 %), 75 % STB NPK + FYM (0.60 %), 100 % RDF + FYM (0.58 %), 75 % RDF + FYM (0.58 %). Lower organic carbon of 0.47 % was recorded with 75 % RDF (Table 1). At 30 DAS, significantly higher organic carbon of 0.60 % was recorded with the application of 75% STB NPK + FYM + Biofertilizer consortium. However, comparable organic carbon was recorded with the application of 100 % RDF + FYM + Biofertilizer consortium (0.59 %), 75 % RDF + FYM + Biofertilizer consortium (0.58 %), 75 % STB NPK + FYM (0.58 %), 100 % RDF + FYM (0.57 %), 75 % RDF + FYM (0.56 %). The lower organic carbon of 0.45 % was recorded with 75 % RDF (Table 1). Similar trend was also observed at 45 and 60 DAS. The ranges of organic carbon were 0.45 to 0.59 and 0.42 to 0.57 % at 45 and 60 DAS respectively. At harvest, the results revealed that higher organic carbon was recorded with the integrated application of 75% STB NPK+ FYM + Biofertilizer consortium (0.58 %) which was on par with 100 % RDF + FYM + Biofertilizer consortium (0.58 %), 75 % RDF + FYM + Biofertilizer consortium

(0.57 %), 75 % STB NPK + FYM (0.56 %), 100 % RDF + FYM (0.55 %), 75 % RDF + FYM (0.51 %). Lower organic carbon of 0.44 % was recorded with 75 % RDF (Table 1).

Critical observations of the data at different stages of crop revealed that organic carbon percentage declined from 15 DAS to 60 DAS and then it has increased slightly in after harvest soil samples. The increase in organic carbon content in soil at harvest might be due to better crop growth coupled with generating root biomass and greater return of left-over surface plant residues in the soil. These results are similar to the findings of Parihar [6] and Chesti *et al*. [7]. Integrated nutrient management showed a significant influence on organic carbon content in soil. Use of inorganic fertilizers might attribute to higher contribution of biomass to the soil in the form of greater root biomass through crop residues [8].

Dehydrogenase activity: Dehydrogenase activity in soil was significantly influenced by integrated nutrient management, data pertaining to dehydrogenase activity (µg TPF g^{-1} day^{-1}) as influenced by different treatments of integrated nutrient management at 15, 30, 45, 60 DAS and at harvest are presented in Table 2. Dehydrogenase activity in soil at 15 DAS was significantly higher under 75% STB NPK + FYM + Biofertilizer consortium (3.11 µg TPF g^{-1} day^{-1}) which was on par with 100 % RDF + FYM + Biofertilizer consortium (2.98 µg TPF g^{-1} day^{-1}), 75 % RDF + FYM + Biofertilizer consortium (2.93 µg TPF g^{-1} day^{-1}), 75 % STB NPK + FYM (2.84 µg TPF g^{-1} day^{-1}), 100 % RDF + FYM (2.79 µg TPF g^{-1} day^{-1}), 75 % RDF + FYM (2.64 µg TPF g^{-1} day^{-1}). The lower dehydrogenase activity of 1.95 µg TPF g^{-1} day^{-1} was recorded with 75 % RDF (Table 2). At 30 DAS, significantly higher dehydrogenase activity of 4.10 µg TPF g^{-1} day^{-1} was recorded with application of 75% STB NPK + FYM + Biofertilizer consortium which was comparable with application of 100 % RDF + FYM + Biofertilizer consortium (4.03 µg TPF g^{-1} day^{-1}), 75 % RDF + FYM + Biofertilizer consortium (3.94 µg TPF g^{-1} day^{-1}), 75 % STB NPK + FYM (3.74 µg TPF g^{-1} day^{-1}), 100 % RDF + FYM (3.63 µg TPF g^{-1} day^{-1}), 75 % RDF + FYM (3.63 µg TPF g^{-1} day^{-1}). The lower dehydrogenase activity of 2.32 µg TPF g^{-1} day^{-1} was recorded with 75 µg TPF g^{-1} day^{-1} RDF (Table 2). Similar trend was also observed at 45 and 60 DAS. The ranges of dehydrogenase activity were 2.37 to 4.64 and 3.40 to 5.17 µg TPF g^{-1} day^{-1} at 45 and 60 DAS, respectively. At harvest, the results revealed that higher dehydrogenase activity was recorded with the integrated application of 75% STB NPK+ FYM + Biofertilizer consortium (3.90 µg TPF g^{-1} day^{-1}) which was on par with 100 % RDF + FYM + Biofertilizer consortium (3.78 µg TPF g^{-1} day^{-1}), 75 % RDF + FYM + Biofertilizer consortium (3.75 µg TPF g^{-1} day^{-1}), 75 % STB NPK + FYM (3.67 µg TPF g^{-1} day^{-1}), 100 % RDF + FYM (3.59 µg TPF g^{-1} day^{-1}), 75 % RDF + FYM (3.49 µg TPF g^{-1} day^{-1}). The lower dehydrogenase activity of 2.73 µg TPF g^{-1} day^{-1} was recorded with 75 % RDF (Table 2).

Table 1. Effect of integrated nutrient management on soil organic carbon content (%) during crop growth period

Treatment	15 DAS	30 DAS	45 DAS	60 DAS	A.H
100% RDF	0.49	0.46	0.45	0.45	0.46
100% RDF+ FYM	0.58	0.57	0.55	0.54	0.55
100% RDF+ FYM+ BC	0.62	0.59	0.59	0.57	0.58
75 % RDF	0.47	0.45	0.45	0.42	0.44
75 % RDF + FYM	0.58	0.56	0.53	0.53	0.55
75 % RDF + FYM+ BC	0.61	0.58	0.57	0.56	0.57
STB NPK	0.49	0.46	0.45	0.45	0.46
75% STB NPK+FYM	0.60	0.58	0.56	0.55	0.56
75% STB NPK+FYM + BC	0.63	0.60	0.59	0.57	0.58
Mean	0.57	0.54	0.53	0.52	0.53
Sem±	0.03	0.03	0.04	0.03	0.03
CD (P=5)	0.08	0.08	0.11	0.08	0.09
CV	8.25	8.22	11.9	8.69	9.48

BC= Biofertilizer consortium, RDF= Recommended dose of fertilizer, STB NPK= Soil test based NPK

Table 2. Effect of integrated nutrient management on dehydrogenase activity in soil (µg TPF g^{-1} day^{-1}) during crop growth period

Treatment	15 DAS	30 DAS	45 DAS	60 DAS	A.H
100% RDF	2.09	2.44	2.51	3.44	2.86
100% RDF+ FYM	2.79	3.63	4.30	4.66	3.59
100% RDF+ FYM+ BC	2.98	4.03	4.54	4.89	3.78
75 % RDF	1.95	2.32	2.37	3.40	2.73
75 % RDF + FYM	2.64	3.63	4.24	4.60	3.49
75 % RDF + FYM+ BC	2.93	3.94	4.41	4.88	3.75
STB NPK	2.14	2.63	2.76	3.57	3.00
75% STB NPK+FYM	2.84	3.74	4.33	4.72	3.67
75% STB NPK+FYM + BC	3.11	4.10	4.64	5.17	3.90
Mean	2.61	3.39	3.79	4.37	3.42
Sem±	0.12	0.16	0.19	0.21	0.17
CD (P=5)	0.37	0.49	0.58	0.63	0.51
CV	8.18	8.35	8.72	8.26	8.46

BC= Biofertilizer consortium, RDF= Recommended dose of fertilizer, STB NPK= Soil test based NPK

The application of organic manures along with inorganic fertilizers increased the dehydrogenase activity [9]. The increase in dehydrogenase activity in INM treatments could be attributed to the formation of humic acids, which increased the activity of microorganisms in soil, resulting in an increase in dehydrogenase activity in soil [10]. The addition of farmyard manure, crop residues, biofertilizers, and chemical fertilizers increased the activity of dehydrogenase enzyme as FYM and crop residues were the major carbon sources that provided energy for soil microorganisms and increased the number of pores, which are important in the soil-water-plant relationship and maintained good soil structure accompanied by better dehydrogenase activity [11]. Lower dehydrogenase activity at later stages compared to earlier stages could be attributed to a decrease in moisture availability [12].

Bacterial population: Bacterial population in soil was significantly influenced by integrated nutrient management, data pertaining to bacterial population (cfu x 10^6 g^{-1} soil) as influenced by different treatments of integrated nutrient management at 15, 30, 45, 60 DAS and at harvest are presented in Table 3. Bacterial population at 15 DAS was recorded significantly higher under 75% STB NPK + FYM + Biofertilizer consortium (6.51 cfu x 10^6 g^{-1} soil) which was on par with 100 % RDF + FYM + Biofertilizer consortium (6.43 cfu x 10^6 g^{-1} soil), 75 % RDF + FYM + Biofertilizer consortium (6.41 cfu x 10^6 g^{-1} soil), 75 % STB NPK + FYM (6.26 cfu x 10^6 g^{-1} soil), 100 % RDF + FYM (6.19 cfu x 10^6 g^{-1} soil), 75 % RDF + FYM (6.11 cfu x 10^6 g^{-1} soil). Lower bacterial population of 4.43 cfu x 10^6 g^{-1} soil was recorded with 75 % RDF (Table 3). At 30 DAS, significantly higher bacterial population of 6.98 cfu x 10^6 g^{-1} soil was recorded with application of 75% STB NPK + FYM + Biofertilizer consortium which was comparable with application of 100 % RDF + FYM + Biofertilizer consortium (6.85 cfu x 10^6 g^{-1} soil), 75 % RDF + FYM + Biofertilizer consortium (6.83 cfu x 10^6 g^{-1} soil), 75 % STB NPK + FYM (6.60 cfu x 10^6 g^{-1} soil), 100 % RDF + FYM (6.45 cfu x 10^6 g^{-1} soil), 75 % RDF + FYM (6.37 cfu x 10^6 g^{-1} soil). Lower bacterial population of 4.53 cfu x 10^6 g^{-1} soil was recorded with 75 % RDF (Table 3). Similar trend was also observed at 45 and 60 DAS. The bacterial population varied from 4.73 to 7.57 and 5.53 to 7.91 cfu x 10^6 g^{-1} soil at 45 and 60 DAS, respectively. At harvest, the results revealed that higher bacterial population was recorded with the integrated application of 75% STB NPK+ FYM + Biofertilizer consortium (7.47 cfu x 10^6 g^{-1} soil) which was on par with 100 % RDF + FYM + Biofertilizer consortium (7.37 cfu x 10^6 g^{-1} soil), 75 % RDF + FYM + Biofertilizer consortium (7.27 cfu x 10^6 g^{-1} soil), 75 % STB NPK + FYM (7.18 cfu x 10^6 g^{-1} soil), 100 % RDF + FYM (7.08 cfu x 10^6 g^{-1} soil), 75 % RDF + FYM (6.97 cfu x 10^6 g^{-1} soil). Lower bacterial population of 5.25 cfu x 10^6 g^{-1} soil was recorded with 75 % RDF (Table 3).

Fungal population: Fungal population at 15 DAS was recorded significantly higher under 75% STB NPK + FYM + Biofertilizer consortium (4.09 cfu x 10^3 g^{-1} soil) which was on par with 100 % RDF + FYM + Biofertilizer consortium (3.96 cfu x 10^3 g^{-1} soil), 75 % RDF + FYM + Biofertilizer consortium (3.88 cfu x 10^3 g^{-1} soil), 75 % STB NPK + FYM (3.75 cfu x 10^3 g^{-1} soil),

100 % RDF + FYM (3.70 cfu x 10^3 g $^{-1}$ soil), 75 % RDF + FYM (3.60 cfu x 10^3 g $^{-1}$ soil). The lower fungal population of 2.53 cfu x 10^3 g $^{-1}$ soil was recorded with 75 % RDF (Table 4). Similar trend was also observed at 30 and 45 DAS. The fungal population varied from 2.77 to 4.34 and 2.98 to 4.60 cfu x 10^3 g $^{-1}$ soil at 30 and 45 DAS, respectively. At 60 DAS, significantly higher fungal population of 4.85 cfu x 10^3 g $^{-1}$ soil was recorded with application of 75% STB NPK + FYM + Biofertilizer consortium which was comparable with application of 100 % RDF + FYM + Biofertilizer consortium (4.78 cfu x 10^3 g $^{-1}$ soil), 75 % RDF + FYM + Biofertilizer consortium (4.77 cfu x 10^3 g $^{-1}$ soil), 75 % STB NPK + FYM (4.68 cfu x 10^3 g $^{-1}$ soil), 100 % RDF + FYM (4.65 cfu x 10^3 g $^{-1}$ soil), 75 % RDF + FYM (4.56 cfu x 10^3 g $^{-1}$ soil). The lower fungal population of 3.36 cfu x 10^3 g $^{-1}$ soil was recorded with 75 % RDF (Table 4). At harvest, the results revealed that higher fungal population was recorded with the integrated application of 75% STB NPK+ FYM + Biofertilizer consortium (4.57 cfu x 10^3 g $^{-1}$ soil) which was on par with 100 % RDF + FYM + Biofertilizer consortium (4.48 cfu x 10^3 g $^{-1}$ soil), 75 % RDF + FYM + Biofertilizer consortium (4.47 cfu x 10^3 g $^{-1}$ soil), 75 % STB NPK + FYM (4.33 cfu x 10^3 g $^{-1}$ soil), 100 % RDF + FYM (4.26 cfu x 10^3 g $^{-1}$ soil), 75 % RDF + FYM (4.16 cfu x 10^3 g $^{-1}$ soil). The lower fungal population of 2.93 cfu x 10^3 g $^{-1}$ soil was recorded with 75 % RDF (Table 4).

Table 3. Effect of integrated nutrient management on bacterial count (cfu x 10^6 g^{-1} soil)) during crop growth period

Treatment	15 DAS	30 DAS	45 DAS	60 DAS	A.H
100% RDF	4.55	4.67	4.96	5.67	5.35
100% RDF+ FYM	6.19	6.45	7.19	7.39	7.08
100% RDF+ FYM+ BC	6.43	6.85	7.44	7.77	7.37
75 % RDF	4.43	4.53	4.73	5.53	5.25
75 % RDF + FYM	6.11	6.37	7.05	7.25	6.97
75 % RDF + FYM+ BC	6.41	6.83	7.38	7.61	7.27
STB NPK	4.68	4.86	5.16	5.82	5.46
75% STB NPK+FYM	6.26	6.60	7.23	7.44	7.18
75% STB NPK+FYM + BC	6.51	6.98	7.57	7.91	7.47
Mean	5.73	6.01	6.52	6.93	6.60
Sem±	0.27	0.28	0.31	0.32	0.32
CD (P=5)	0.82	0.86	0.95	0.98	0.96
CV	8.20	8.19	8.32	8.06	8.33

BC= Biofertilizer consortium, RDF= Recommended dose of fertilizer, STB NPK= Soil test based NPK

Table 4. Effect of integrated nutrient management on fungi count (cfu x 10^3 g^{-1} soil) during crop growth period

Treatment	15 DAS	30 DAS	45 DAS	60 DAS	A.H
100% RDF	2.60	2.84	3.09	3.44	3.06
100% RDF+ FYM	3.70	4.10	4.34	4.65	4.26
100% RDF+ FYM+ BC	3.96	4.27	4.54	4.78	4.48
75 % RDF	2.53	2.77	2.98	3.36	2.93
75 % RDF + FYM	3.60	4.04	4.25	4.56	4.16
75 % RDF + FYM+ BC	3.88	4.25	4.51	4.77	4.47
STB NPK	2.70	2.90	3.14	3.51	3.13
75% STB NPK+FYM	3.75	4.16	4.39	4.68	4.33
75% STB NPK+FYM + BC	4.09	4.34	4.60	4.85	4.57
Mean	3.42	3.74	3.98	4.29	3.93
Sem±	0.16	0.18	0.19	0.21	0.19
CD (P=5)	0.49	0.55	0.57	0.63	0.57
CV	8.23	8.47	8.18	8.42	8.35

BC= Biofertilizer consortium, RDF= Recommended dose of fertilizer, STB NPK= Soil test based NPK

Effect of integrated nutrient management showed a significant effect on microbial population. Organic inputs generally enhanced the development of microbial population and increased the global activity of soil [13]. Microbial community increases under organic manure application which is mainly attributed to higher organic carbon, especially the biologically active phase of carbon, which is an energy source for the proliferation of microorganisms in the soil. These findings are in accordance with Chopra *et al*. [14]. Integration of inorganics, FYM and biofertilizers increased the bacterial count, it may be due to the fact that organic manure introduces a high amount of beneficial microflora and phytohormones in the soil which increases the organic matter content and air water relationships in the soil. These results are in agreement with the findings of Kaur *et al*. [15]. Moreover, it is observed that treatments receiving biofertilizer inoculation contains more bacterial count than treatments without biofertilizer inoculation. Addition of biofertilizers increased total bacterial population by supporting their growth which can be attributed to extracellular polysaccharides and other microbial processes [16]. A lower microbial population was observed at harvest as a result of organic matter decomposition and reduced nutrient availability [17].

4. CONCLUSIONS

In summary, the integrated nutrient management approach employed in this study demonstrated its potential to enhance soil organic carbon content, dehydrogenase activity, and microbial populations, both bacterial and fungal. These outcomes signify the importance of balanced nutrient management practices in improving soil health and promoting sustainable agricultural systems. The positive influence of organic inputs and biofertilizers on soil microbial communities underscores their significance in fostering nutrient cycling, organic matter decomposition and overall soil ecosystem functions. However, it is notable that microbial populations, particularly bacterial and fungal counts, decreased slightly at the harvest stage, possibly due to the effects of organic matter decomposition and decreased nutrient availability. Overall, this study provides valuable insights into the benefits of integrated nutrient management in enhancing soil quality and microbial dynamics, contributing to the development of more resilient and productive agricultural systems.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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