Original Research Article

Impact of Different Fertility Levels and Liquid Biofertilizers on Biological Properties and Nutrient Content of Soil under Wheat (*Triticum aestivum* L.)Crop

Abstract

A field experiment was conducted during *Rabi* 2019 at Instructional Farm of Agronomy, Rajasthan College of Agriculture, Udaipur. The treatments comprised of four levels of four levels of fertility i.e. control, 75, 100 and 125% RDF and four levels of liquid biofertilizers i.e. control, *Azotobacter*, PSB and *Azotobacter* + PSB. Experiment was laid out in factorial randomized block design replicated thrice taking wheat var. Raj.-4238 as test crop. The Recommended dose of fertilizer (RDF) was 100:60:40 kg ha^{-1} of $N:P_2O_5:K_2O$. The results revealed significant increase in soil microbial biomass carbon and nitrogen, microbial population (bacteria, fungi and actinomycetes) as well as the dehydrogenase and alkaline phosphatase enzyme activity in post-harvest soil of wheat with increasing levels of fertility and liquid biofertilizers up to the 100% RDF and *Azotobacter* + PSB respectively. Furthermore, significant increases in sulphur and micronutrients (Zn, Cu Fe and Mn) in soil with the application of 100% RDF.

Comment [A1]: del

Key words: RDF, Biofertilizers, Fertility Levels, *Azotobacter* and PSB

1. Introduction

Wheat (*Triticum aestivum* L.) is a crucial staple food crop globally, covering approximately 17% of the total crop acreage. It contributes significantly, providing about 50% of the calories in the human diet in our country. The chemical composition of wheat grain consists of approximately 66-71.6% carbohydrates, 2.5-3.1% fats, 13-16.7% proteins and 2.5-3% crude fiber (Khan, 1984). Among the various wheat species, three Triticum species are predominantly cultivated worldwide. Globally, wheat (*Triticum* spp.) is grown over a vast area of 220 million hectares, holding the highest acreage position compared to all other crops, with an annual production of approximately 781 million tonnes. In India, it covers an area of 29.55 million hectares (about 13.43% of the global area) and yields around 101.20 million tonnes (approximately 12.96% of the world's production) with a productivity of 3424 kg ha^{-1} (Anonymous, 2019). In Rajasthan, wheat is cultivated on an area of 2.88 million hectares,

producing 9.60 million tonnes of grain with a productivity of 3334 kg ha^{-1} (Anonymous, 2019).

Nitrogen is of utmost importance in facilitating various biochemical and physiological functions within plants. It plays a crucial role in enhancing processes like photosynthesis, leading to a rich, dark-green color in plants and promoting the growth and development of stems and other vegetative parts (Leghari *et al*., 2016). Additionally, nitrogen contributes significantly to crop growth and yield improvement (Kumawat *et al*., 2021). Phosphorus is a vital nutrient element for plants, serving as an integral component of the plant system. It is indispensable for cell enlargement, cell division, energy storage, and transfer. Phosphorus is also a constituent of energy-rich compounds such as ATP and ADP, NADP, phytin, nucleic acids, and phospholipids (Abdel-Aziz *et al*., 2018). Potassium acts as an activator for enzymes that play key roles in plant growth. It is essential for various physiological processes, including stomatal activity, sugar, water, and nutrient transport, as well as the synthesis of proteins and starch (Prajapati *et al*., 2012).

Conventional agriculture has played a significant role in meeting the food demands of a growing human population. However, heavy reliance on pesticides and chemical fertilizers, particularly urea, has resulted in soil degradation and pollution. The excessive use of phosphorus and nitrogen fertilizers has led to water bodies' eutrophication, causing air and groundwater pollution (Youssef *et al*., 2014). To address these issues, harmless alternatives like biofertilizers have been introduced. Biofertilizers play a crucial role in maintaining long-term soil fertility and sustainability. They fix atmospheric nitrogen, convert insoluble phosphorus into an available form, and mobilize essential macro and micronutrients for plants, thereby enhancing their efficiency and availability (Venkatashwarlu, 2008). Moreover, biofertilizers enrich the soil environment with various macro and micronutrients through nitrogen fixation, phosphate and potassium solubilization, production of antibiotics, and degradation of organic matter (Sinha *et al*., 2014). These eco-friendly and cost-effective inputs can reduce the reliance on chemical fertilizers by 25-50% (Rana *et al*., 2012). Liquid biofertilizers are specially formulated with viable microorganisms protected by certain cell-protecting chemicals. These chemicals enhance microbial cell survival during storage and after seed application, even under adverse soil conditions such as desiccation and high temperature. Liquid biofertilizers have a high microbial population, with up to 10^9 cells per ml for 12 to 24 months, and their application dosage is significantly lower than carrier-based biofertilizers (Verma *et al*., 2018).

Soil microbial communities play a crucial role in enhancing biological soil fertility and managing productivity. These communities are carefully harvested and processed to capture their beneficial effects on soil, thereby improving the soil-microbial relationship. Soil microorganisms are involved in various essential functions such as nitrogen fixation, hormonal regulation, production of siderophores and phytohormones, resistance to phytopathogens, nutrient availability, promotion of mycorrhizal functioning, and reducing pollutant toxicity (Jacoby *et al*., 2009). Dehydrogenase, an enzyme present in all living microorganisms, plays a vital role in the oxidation of organic matter, contributing to soil health and nutrient cycling (Watts *et al*., 2010). In soils with limited phosphorus, the majority of phosphorus is organically bound. Phosphatase activity becomes a significant factor in maintaining and managing the rate of phosphorus cycling through the soil (Eichler *et al*., 2004).

2. Materials and Methods

2.1 Site, Soil and Climatic Conditions

The experiment was carried out at the Agronomy Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur. The site was situated at 24°35' N latitude, 73°42' E longitude and an altitude of 582.17 meters above sea level in the south-eastern part of Rajasthan. The region falls under Rajasthan's agro-climatic zone IVA (Sub-Humid Southern Plain and Aravalli Hills).

The composite soil sample was collected randomly before sowing of crop from the experimental field up to 15 cm depth. The composite sample was air dried under shade and passed through 2 mm sieve and then use for analysis. The soil of this area was clay loam (38.47%, silt 26.46% and clay 34.57 %). The soil having 8.25, electrical conductivity 0.82 dSm^{-1}, soil organic carbon 0.56% and available nitrogen 253.80 kg ha^{-1}, phosphorus 20.09 kg ha^{-1}, potassium 380.03 kg ha^{-1}. The soil microbial biomass carbon 159 mg kg^{-1}, soil microbial biomass nitrogen 23.76 dehyrogenase activity 8.70 µg TPF g^{-1} $24h^{-1}$ soil and alkaline phosphatase activity 41.52 µg PNP g^{-1} h^{-1} soil. $^{-1}$ The microbial population was determined by serial dilution (Allen *et al.,* 1959).

During cropping period of wheat, the corresponding mean weekly temperature fluctuations were observed during *Rabi* season in year 2019, maximum. and minimum temperature ranged between 37.3°C and 20.8°C, respectively. Mean weekly maximum and minimum relative humidity ranged between 86.7 and 16.7 per cent, respectively. Total rainfall and maximum evaporation were 42.6 and 9.9 mm was recorded during crop season.

The soil analysis confirmed that soil of experimental field was clay loam belongs to *Typic Haplustepts*, neutral alkaline in reaction, medium in available nitrogen and phosphorus and high in available potassium. Soil was low in available zinc and iron.

2.3 Experimental design

The experiment consisted of 16 treatments combinations comprising of four levels of fertility (Control, 75, 100 and 125 % RDF) and four levels of liquid biofertilizers (Control, *Azotobacter*, PSB and *Azotobacter* + PSB). Experiment was laid out in factorial randomized block design replicated thrice.

Comment [A2]: del

2.4 Application of fertilizers

In wheat crop as per treatment required dose of nitrogen by subtracting the amount of N supplied through DAP and remaining by urea, P_2O_5 through DAP and K_2O through MOP was applied to the crop. At the time of sowing, half dose of nitrogen, full dose of phosphorus, potassium and half dose of nitrogen was applied before the sowing and remaining half dose of nitrogen was applied in two equal splits during 1st and 3rd irrigation.

2.5 Seed treatment with liquid biofertilizers

The seed treatment with liquid biofertilizers done with using a plastic bag. The bag filled with 1 kg of seeds and required amount of biofertilizers (@ 5 to 10 ml kg^{-1} seed of each biofertilizers) was added. Then bag closed and squeezed until all the seeds were evenly wetted. The bag was opened and seeds dried for 20 to 30 minutes in the shade. There are plots in which seeds are treated with *Azotobacter* and PSB alone and some plots which are treated with both.

2.6 Soil biological and chemical properties

The estimation of microbial population was done by standard serial dilution and plate count method (Scmidt and Colwell, 1967). The choroform-fumigated incubation method was used for microbial biomass carbon analysis (Vance *et al*., 1987) and chloroform fumigation method was used for microbial biomass nitrogen (Shen *et al.*, 1984). Soil acid and alkaline phosphatase activities were examined by β nitrophenol phosphate by spectrophotometry method (Tabatabai and Bremner, 1969). An Anthrone extraction method used for analysis of soil dehydrogenase activity (Casida *et al*. 1964). Micronutrients (Zn, Cu Fe and Mn) were determine using standard method given by Lindsay and Norvell (1978).

2.7 Statistical Analysis

The obtained data were statistically analyzed with the techniques of analysis of variance as described by Steel and Torrie, 1960. The comparison in the treatment mean was tested by critical difference (CD) at 5% (P=.05) level of significance.

3. Result and Discussion

3.1 Soil biological properties

3.1.1 Effect of fertility levels

The dehydrogenase enzyme activity, alkaline phosphate activity, microbial population, soil biomass carbon and soil biomass nitrogen (Table 1) significantly affected by application of fertility levels. The dehydrogenase enzyme activity, alkaline phosphate activity, microbial population, soil biomass carbon and soil biomass nitrogen significantly increased to each higher level of fertility up to 100% RDF but it remained at par with 125% RDF. Bhatt *et al.* (2017) reported that the native pools of soil organic carbon act as a substrate for enzymes which is utilized by microorganisms and their activity increases by adding inorganic nutrient source. Inorganic fertilizers have a catalytic effect in stimulating microbial growth, leading to higher microbial biomass C and N. This increase in microbial growth also contributes to elevated root biomass and root exudates, consequently providing additional carbon and energy to soil microbes, which can be attributed to the rise in dehydrogenase enzyme activity (Geetha Kumari and Shivashankar, 1991). These finding are also reported by Chand *et al.* (2010), Parewa*et al.* (2014), Bhatt *et al.* (2016) and Sial *et al*. (2019).

3.1.2 Effect of liquid biofertilizers

The dehydrogenase enzyme activity, alkaline phosphate activity, microbial population, soil biomass carbon and soil biomass nitrogen (Table 1) were significantly affected by inoculation of seed with different liquid biofertilizers. Soil microbial biomass carbon and nitrogen significantly increased might be due to microbial population increased by secretion of mucigel, sloughed off cells, exudates, roots remaining of previous crop, etc. The inoculation of biofertilizers increases the biological activities that might have enhanced the soil microbial biomass carbon and nitrogen (Behera *et al.,* 2007). Shinde and Bangar (2003) reported that an increase in the enzyme activity and microbial population in soil might be due to enhancement in porosity and availability of nutrients especially P to the plant along with better installation of inoculated micro-organism, which stimulates the indigenous microorganisms. Microbial

inoculation might have increased the population of beneficial microorganisms in soil. A similar finding was also given by Nath *et al.* (2011), Khandare *et al*. (2019) and Fitriatin*et al*. (2021).

3.2 Soil chemical properties

3.2.1 Effect of fertility levels

The available sulfur, zinc, iron, manganese and copper content in the soil after the harvest of wheat (Table 2) was significantly affected bythe increasing level of fertility. The highest available sulfur (10.18 mg ha^{-1}), zinc (0.74 mg kg^{-1}), iron (5.58mg kg^{-1}), manganese (9.82 mg kg^{-1}) and copper (2.11mg kg^{-1}) content in soil was recorded with 125% RDF. However, 125% RDF remained at par with 100% RDF. The data further revealed that the percent increase in available S, Zn, Fe, Mn and Cu status of soil were in order of 11.74, 9.80, 28.48, 10.21 and 2.67 due to the application of 125% RDF in comparison to control, respectively.The increase in available S, Zn, Fe, Mn, and Cu in the soil might be attributed to the application of inorganic fertilizers, as it improves the availability of these nutrients in the soil. The increase might be due to the increased enzymatic activity, microbial population and the organic recycling of plant nutrients which leads to greater mineralization of applied nutrients and thus increases the inherent S and micronutrient content in soil Ranjitha *et al*. (2023). Another reason could be the improvement in physio-chemical which helps in the retention of nutrient in soil and prevent nutrient losses. The application of inorganic fertilization improves the soil pH for better nutrient availability Similar results were also reported by Zhao *et al*. (2009) Gourav *et al.* (2019) and Mehta *et al.* (2022).

3.1.2 Effect of liquid biofertilizers

The inoculation of seeds with different liquid biofertilizers significantly increased the availability of sulfur in the soil. However, there was no significant impact on the concentration of micronutrients in the soil after the harvest of wheat (Table 2). The maximum available sulfur (9.49 mg ha^{-1}) was recorded with inoculation of seed with *Azotobacter* + PSB. The data further revealed that the percent increase in available S status of soil was in the order of 4.53 due to inoculation of *Azotobacter* + PSB in comparison to control.The increase in available sulfur (S) in the soil might be attributed to the application of biofertilizers, as it improves the availability of sulfur in the soil by increasing microbial activity in the soil. Similar results were also found by Subbaiah in 2019.

Comment [A3]: sulphur

Conclusion

On the basis of findings, it is concluded that 100% RDF + Azotobacter + PSB in wheat found significant in term of soil microbial biomass carbon and nitrogen, microbial population (bacteria, fungi and actinomycetes) as well as the dehydrogenase, alkaline phosphatase enzyme activity and sulphur in post-harvest soil. Moreover, micronutrient content significantly increases with the application of 100% RDF under the agro climatic condition of Sub-humid Southern Plain and Aravalli Hills of Rajasthan (Zone IVa).

References:

Abdel-Aziz, H.M.M., Hassaneen, M.N.A. and Omer, A.M. 2018. Effect of foliar application of nano chitosan NPK fertilizer on the chemical composition of wheat grains. *Egyptian Journal of Botany*, **58**(1): 87-95.

Allen, O.N. 1959. Experiments in soil bacteriology (3rd ed.). Burgess Publishing Co. Minnea Polis, Minnesota.

Anonymous, 2019. Pulses Revolution from food to nutritional security, directorate of economic & statistics, department of agriculture co-operation and farmers welfare, Government of India. Pp.-5.

Behera, U. K., Sharma, A. R. and Pandey, H. N. 2007. Sustaining productivity of wheat-soybean cropping system through integrated nutrient management practices on the vertisols of central India. *Plant and Soil*, **297**:185-199.

Bhatt, B., Chandra, R., Ram, S. and Pareek, N., 2016. Long-term effects of fertilization and manuring on productivity and soil biological properties under rice (Oryza sativa)–wheat (Triticum aestivum) sequence in Mollisols. *Archives of Agronomy and Soil Science*, *62*(8), pp.1109-1122.

Bhatt, M.K., Labanya, R., Joshi, H.C., Pareek, N., Chandra, R. and Raverkar, K.P. 2017. Long-term effects of inorganic fertilizers and FYM on soil chemical properties and yield of wheat under rice-wheat cropping system. *Himalayan Ecology*, **25**:28-35.

Casida, I.E., Klein, D.A. and Santore, T. 1964. Measurement of dehydrogenase activity by incubating the soil with TTC method. *Soil Science*, **98**:373.

Chand, S., Somani, L.L. and Bhandari, S.C. 2010. Effect of fertilizer, farmyard manure (FYM) and biofertilizers on the population of Azotobacter and PSB in the soil. *Journal of the Indian Society of Soil Science*, **58**(4):460-463.

Eichler B, Caus M, Schnug E, Köppen D. 2004. Soil acid and alkaline phosphatase activities in regulation to crop species and fungal treatment. LandbauforschungVölkenrode; **54**(1):1-5.

Fitriatin, B.N., Amanda, A.P., Kamaluddin, N.N., Khumairah, F.H., Sofyan, E.T., Yuniarti, A. and Turmuktini, T., 2021. Some soil biological and chemical properties as affected by biofertilizers and organic ameliorants application on paddy rice. *Eurasian Journal of Soil Science*, *10*(2), pp.105-110.

Gourav, S.N.K., Sharma, R.P. and Sharma, G.D., 2019. Long term effect of fertilizers and amendments on the properties of an acid Alfisol and uptake of primary nutrients and sulfur in maize-wheat rotation in North Western Himalayas. *Journal of Plant Nutrition*, *42*(15), pp.1770-1788.

Jacoby, R., Peukert, M., Succurro, A., Koprivova, A., Kopriva, S. 2017. The Role of Soil Microorganisms in Plant Mineral Nutrition Current Knowledge and Future Directions. *Front Plant Science*; **8**(19):1617.

Khan, M.A. 1984. Nutritional attributes of wheat. *Progressive Farming*, **4**:23-26.

Khandare, R.N., Chandra, R., Pareek, N. and Raverkar, K.P., 2019. Carrier-based and liquid bioinoculants of Azotobacter and PSB saved chemical fertilizers in wheat (Triticum aestivum L.) and enhanced soil biological properties in Mollisols. *Journal of Plant Nutrition*, *43*(1), pp.36-50.

Kumawat, H., Singh, D.P., Jat, G., Choudhary, R., Singh, P.B., Dhayal, S. and Khardia, N., 2021. Effect of fertility levels and liquid biofertilizers on growth and yield of wheat (*Triticum aestivum* L.). The Pharma Innovation Journal, 10(9), pp.1365-1369.

Leghari, S.J., Wahocho, N.A., Laghari, G.M., Laghari, A.H, Bhabhan, G.M, Talpur, K.H., Bhutto, T.A., Wahocho, S.A. and Lashari, A.A. 2016. Role of nitrogen for plant growth and development: A review. *Advances in Environmental Biology*, **10**(9):209-218.

Lindsay, W.L. and Norvell, W.A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal*, **42**:421-442.

Mehta, G., Jat, G., Meena, S.C., Jain, D., Singh, P.B., Khardia, N., Chahar, P. and Dhayal, S. 2022. Soil Properties as Influenced by Fertility Levels and Micronutrient Application in Chickpea (*Cicer arietinum* L.). *Frontiers in Crop Improvement*, **10**: 1466-1470.

Nath, D. J., Ozah, B., Baruah, R. and Borah, D. K. 2011. Effect of integrated nutrient management on soil enzymes, microbial biomass carbon and bacterial population

under rice (*Oriza sativa*) and wheat (*Triticum aestivum)* sequence. *Indian Journal of Agricultural Sciences*, **81**(12**)**:11143-1148.

Parewa, H.P., Yadav, J. and Rakshit, A. 2014. Effect of fertilizer levels, FYM and bioinoculants on soil properties in inceptisol of Varanasi, Uttar Pradesh, India. *International Journal of Agriculture, Environment and Biotechnology*, **7**(3):517.

Prajapati, K. and Modi, H.A. 2012. The importance of potassium in plant growth–a review. *Indian Journal of Plant Sciences*, **1**(2-3):177-186.

Rana, A., Joshi, M., Prasanna, R., Shivay, Y.S. and Nain, L. 2012. Biofortification of wheat through inoculation of plant growth promoting *Rhizobacteria* and cyanobacteria. *European Journal of Soil Biology*, **50**:118-126.

Ranjitha Bai, H., Gowda, R., Gowda, M., Naika, R. and BR, G.K.A., 2023. Effect of levels of mulberry shoots biochar, Farm yard manure and NPK fertilizer on soil properties under tree mulberry garden.

Santos, V.B., Araujo, S.F., Leite, L.F., Nunes, L.A. and Melo, J.W. 2012. Soil microbial biomass and organic matter fractions during transition from conventional to organic farming systems. Geoderma, **170**:227–231.

Scmidt, E.L. and Colwell, A.C. 1967. A practical manual of soil microbiology laboratory methods. Soil Bull, 7, FAO, Rome.

Sharma, G.D., Thakur, R., Somraj, Kauraw, D.L. and Kulhare, P.S. 2013. Impact of integrated nutrient management on yield, nutrient uptake, protein content of wheat (*Triticum aestivum*) and soil fertility in a typic haplustert. *The Bioscan*, **8**(4):1159-1164.

Shen, S. M., Pruden, G. and Jenkinson, D. S. 1984. Mineralization and immobilization of nitrogen in fumigated soil and the measurement of microbial biomass nitrogen. *Soil Biology and Biochemistry*, **16**:437-444.

Shinde, D.B. and Banger, N.D. 2003. Studies on dual inoculation of nitrogenous and phosphatic bacterial cultures in sugarcane. *Journal of Maharashtra Agricultural University*, **28**:190-192.

Sial, T.A., Liu, J., Zhao, Y., Khan, M.N., Lan, Z., Zhang, J., Kumbhar, F., Akhtar, K. and Rajpar, I. 2019. Co-application of milk tea waste and NPK fertilizers to improve sandy soil biochemical properties and wheat growth. *Molecules*, **24**(3): p.423.

Sinha, R.K., Valani, D., Chauhan, K. and Agarwal, S. 2014. Embarking on a second green revolution for sustainable agriculture by vermiculture biotechnology using earthworms: reviving the dreams of Sir Charles Darwin. *International Journal of Agricultural Health Safty*, **1**:50–64.

Steel, R.G.D., Torrie, J.H. 1960. Principles and procedures of statistics with special reference to the *biological sciences*, McGraw Hill, New York. 187-287.

Subbaiah, P. V. 2019. Effect of organic and inorganic sources of nutrients and biofertilizers on soil available nutrients, growth and production of maize–onion cropping system. *Journal of Pharmacognosy and Phytochemistry*, **8**(4): 583-587.

Tabatabai, M.A. and Bremner, J.M. 1969. Use of nitrophenyl phosphate assay of soil phosphatase activity. *Soil Biologyand Biochemistry*, **1**:301-307.

Vance, C.P. 1997. Enhanced agricultural sustainability through biological nitrogen fixation. In biological fixation of nitrogen for ecology and sustainable agriculture. *Springer*, pp. 179-186.

Venkatashwarlu, B., 2008. Role of bio-fertilizers in organic farming: Organic farming in rain fed agriculture: Central Institute for Dry Land Agriculture. Hyderabad. Pakistan, pp.85-95.

Verma, N. P., Kuldeep, Y. K. and Yadav, N. 2018. Study of liquid biofertilizers as an innovative agronomic input for sustainable agriculture. *International Journal of Pure and Applied Bioscience*, **6**(1):190-194.

Watts, D.B., Torbert, H.A., Feng, Y. and Prior, S.A. 2010. Soil microbial community dynamics as influenced by composted dairy manure, soil properties, and landscape position. *Soil Science*; 175:474–486.

Youssef, M.M.A. and Eissa, M.F.M. 2014. Biofertilizers and their role in management of plant parasitic nematodes. A review, *Journal of Biotechnology* Pharmceutical Research, **5**:1-6.

Zhao, Y., Wang, P., Ligianlong, Chen, Y., Ying, X. and Liu, S. 2009. The effects of two organic manures on soil properties and crop yields on a temperate calcareous soil under a wheat- maize cropping system. European J. Agronomy, 31: 36-42.

Table 1: Effect of fertility levels and liquid biofertilizers on biological properties of soil after crop harvest

Treatments	Microbial population			Soil microbial biomass		Enzyme activities	
	Bacterial (10^7cfu g^{-1} of soil)	Fungal (10^5cfu g^{-1} of soil)	Actinomycetes (10^6cfu g^{-1} of soil)	Carbon (mg kg^{-1})	Nitrogen (mg kg^{-1})	Dehydrogenase activity (µg TPF g^{-1} 24 h^{-1})	Alkaline phosphate activity (µg PNP g^{-1} ha^{-1})
Fertility levels (RDF)							
Control (F_0)	63.64	23.39	34.88	165.82	25.14	9.95	15.86
75 % RDF (F_1)	69.09	24.44	38.29	176.47	26.33	11.58	18.15
100 % RDF (F_2)	73.62	25.42	40.66	185.70	27.88	13.53	20.21
125 % RDF (F_3)	75.29	25.81	40.86	188.98	28.65	13.77	20.61
SEm±	1.08	0.29	0.37	1.61	0.31	0.23	0.22
C.D. (P = 0.05)	3.12	0.84	1.08	4.65	0.90	0.68	0.64
Liquid biofertilizers							
No inoculation (B_0)	63.41	22.44	34.83	169.92	24.90	9.92	15.70
Azotobacter (B_1)	71.67	25.08	39.28	179.58	27.37	12.60	18.83
PSB (B_2)	70.68	24.68	38.96	178.00	26.54	12.41	18.69
Azo + PSB (B_3)	75.88	27.33	41.61	189.48	29.18	13.91	21.61
SEm±	1.08	0.29	0.37	1.61	0.31	0.23	0.22
C.D. (P = 0.05)	3.12	0.84	1.08	4.65	0.90	0.68	0.64

Table 2: Effect of fertility levels and liquid biofertilizers on Sulphur and micronutrient availability in soil after crop harvest

Treatments	Sulphur (mg ha^{-1})	Zinc (mg ha^{-1})	Iron (mg ha^{-1})	Manganese (mg ha^{-1})	Copper (mg ha^{-1})
Fertility levels (RDF)					
Control (F_0)	9.11	0.67	4.35	8.91	2.05
75 % RDF (F_1)	9.84	0.70	5.04	9.35	2.08
100 % RDF (F_2)	10.16	0.73	5.57	9.76	2.10
125 % RDF (F_3)	10.18	0.73	5.58	9.82	2.11
SEm±	0.10	0.01	0.02	0.13	0.01
C.D. (P = 0.05)	0.30	0.02	0.06	0.38	0.02
Liquid biofertilizers					
No inoculation (B_0)	9.49	0.68	5.02	9.16	2.06
Azotobacter (B_1)	9.72	0.69	4.67	9.32	2.07
PSB (B_2)	9.79	0.69	4.65	9.21	2.08
Azo + PSB (B_3)	9.92	0.69	5.05	9.36	2.08
SEm±	0.10	0.01	0.02	0.13	0.01
C.D. (P = 0.05)	0.30	NS	NS	NS	NS