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Effect of application of FYM or Micronutrient with RDF on soil's physico-chemical properties in direct seeded basmati rice at Kaithal district, Haryana, India

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ABSTRACT

A field experiment was conducted during *Kharif* in 2020 at CCS HAU, College of Agriculture, Kaul research farm to investigate the effects of FYM and micronutrients on the physico-chemical properties of direct seeded basmati rice. The study used a randomized block design with seven treatments, each with a different combination of chemical fertilizer (RDF), farmyard manure (FYM), and micronutrients ($ZnSO_4$ and $FeSO_4$). When FYM was used in conjunction with RDF, soil physico-chemical properties such as bulk density (BD), pH, and electrical conductivity (EC) exhibited no significant results, but they had significant increase in soil organic carbon (OC), NPK content and DTPA extractable micronutrients. Highest NPK content and DTPA-extractable micronutrient content in soil was observed in 75% RDF + FYM @ 15 t ha^{-1} treatment followed by 50% RDF + FYM @ 15 t ha^{-1}.

Key words: *Basmatirice, RDF, FYM*

Introduction

Rice (*Oryza sativa* L.) is the most significant cereal crop in the world. It is a good source of calories for around 40% of the global population (Virdia and Mehta, 2009). In India rice having area, yield and productivity is about 44 million hectares (Mha), of 112.9 million tonnes (Mt) and 24.32 q ha^{-1}, respectively (Anonymous, 2020a). Rice occupied roughly 1.42 Mha in Haryana, with a production of 4.88 Mt and a productivity of 34.32 q ha^{-1} (Anonymous 2020b). Punjab and Haryana are India's main basmati rice producers, accounting for more than 80% of total basmati rice.

The traditional way of rice cultivation is via transplanting, which requires a lot of water, labor and energy. The water table in the soil has been quickly declining in recent years, limiting the scope of rice production in the coming years. As a result, it is critical to seek for a superior alternative rice farming practice. Direct seeding of rice (DSR) is a viable alternative to the transplanting practice of rice production since it saves water, reduces labor requirements and reduces greenhouse gas (GHG) emissions. Direct seeding of rice is a method of developing rice crops that involves sowing seeds directly in the field rather than soil puddling and seedling preparation as in the transplanting method (Farooq *et al.*, 2011). However, direct-seeded rice (DSR) faces some limits such as decreased grain yield, nutrient inadequacy and increased weed infestations (Mahendar *et al.*, 2017).

Micronutrient deficiency is regarded as one of the major causes of rice productivity reduction (Somaratne *et al.*, 2021). Iron (Fe) deficiency is one of the most common micronutrient deficiencies worldwide, affecting around 60% of the global population (Vijayakumar *et al.,* 2020; Singh and Singh, 2018). The rapidly rising population has raised food demand, therefore, it's needed to increase rice yield without degrading its quality. One of the most significant components in meeting the expanding needs of the human population and producing sustainable agriculture is the balanced use of nutrients. The use of organic manure in conjunction with inorganic fertilizers is useful in addressing nutritional deficiencies in plants and soil. As a result, the current study focused on the influence of micronutrients and FYM on basmati rice grown under aerobic conditions.

Materials and Methods

The experiment was conducted at Research Farm, CCS HAU, College of Agriculture, Kaul, situated in humid sub-tropics at 29º 51′ N latitude, 76º 41´ E longitude at an elevation of 241 meters above mean sea level. The basmati rice variety CSR-30 was used for experiment in clay loam soil texture. The experiment was laid out in randomized block design (RBD) and replicated three times. The treatments were randomly allotted to different plots and the details of treatments of experiments are such as control (T_1), RDF (NPK) (T_2), 75% RDF + FYM @ 15 t ha^{-1} (T_3), 50% RDF + FYM @ 15 t ha^{-1} (T_4), RDF + two sprays of 0.5% $ZnSO_4$ (T_5), RDF + two sprays of 0.5% $FeSO_4$ (T_6) and RDF + two sprays of 0.5% $FeSO_4$ + two sprays of 0.5% $ZnSO_4$ (T_7). The college dairy unit provided farmyard manure (FYM). Farmyard manure chemical composition included total nitrogen content of 0.58%, total phosphorus content of 0.58%, total potassium content of 0.58%, iron content of 184 ppm, and zinc content of 4.67 ppm. These Farm yard manure @ 15 t ha^{-1} samples were incorporated in the respective field plots two weeks before sowing of the rice crop according to the treatment layout. The recommended fertilizer dose ($N_{75}P_{30}K_{30}$) was applied to rice in Haryana in accordance with the package and practises recommended by CCSHAU for direct-seeded rice. Nitrogen was applied in three split doses using urea, with half of the total nitrogen applied as a basal dose and the remaining half applied in two equal split doses at active tillering and panicle initiation. The full phosphorus and potassium doses were applied during sowing using diammonium phosphate (DAP) and murate of potash (MOP), respectively. At the tillering and panicle initiation stages, two foliar sprays of iron sulphate (0.5%) and zinc sulphate (0.5%) were applied by dissolving the required amount of iron and zinc sulphate in water with urea. Spraying of micronutrients was done in the morning around 10:00 a.m., and fertilizer was distributed until the entire plant was wet.

Soil sample analysis

The surface soil samples were taken before rice sowing from five random places in the experimental field whereas soil samples were taken from three places from each plot after harvesting of the rice crop. The soil samples were first dried, mixed, and passed through 2 mm sieve before being investigated to determine the physico-chemical properties of the soil. The experimental soil had the texture of clay loam and was examined using the international Pipette Method (Piper, 1966). The core method, glass electrode pH meter (Jackson, 1973), conductivity bridge meter (Jackson 1973), and Walkley and Black rapid titration (1934) was used to assess the bulk density, pH, EC, and organic carbon of soil, respectively. Available N, P and K were calculated by alkaline permanganate method (Subbiah and Asija, 1956), olsen's Method and 1 N NH_4OAC methods with the help of flame photometer, respectively. DTPA-extractable micronutrients (mg kg^{-1}) were calculated by using Atomic absorption spectrophotometer. Microbial biomass carbon was determined by chloroform fumigation method as described by Vance *et al*. (1987). Dehydrogenase activity was determined by formation of tri-phenyl formazan (TPF) from triphenyltetrazolium (Casida *et al*., 1964). Urease activity was determined using method as described by Tabatabai and Bremner, 1972) and steam distillation method was used to determine NH_4-N (Keeney and Nelson, 1982). Alkaline phosphatase activity was assessed by the method as described by Tabatabai and Bremner, 1969.

Data analysis

The crop data underwent statistical analysis utilizing both EXCEL and the OPSTAT statistical software package (Sheoran *et al*., 1998), which was developed by the Department of Statistics at CCS Haryana Agricultural University to get an ANOVA test ($p = 0.05$).

Results

Physico-chemical properties of soil

Bulk density

According to the findings in Table 4 and Fig 2, the treatment of micronutrients and FYM had no significant influence on soil bulk density. Lowest bulk density was observed in treatment T_4 (50% RDF + FYM @ 15 t ha^{-1}) and T_3 (75% RDF + FYM @ 15 t ha^{-1}). Decrease in bulk density with the application of FYM because it increases soil porosity and soil aeration (Sankaramoorthy *et al.*, 2017) also FYM has lower bulk density than soil thus, resulting in lower bulk density of soil. Mujdeci *et al.* (2020), Bhatt *et al.* (2019), Pratap *et al.* (2016) and Antil *et al.* (2011) all found similar findings.

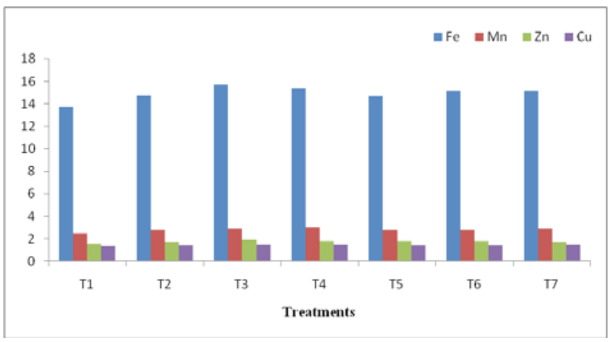

Fig. 1. Effect of micronutrients (Zn and Fe) and FYM on DTPA-extractable micronutrients (Fe, Mn, Zn and Cu) concentration in soil (mg kg^{-1})

pH

The result revealed that there is no significant influence on soil pH with the application of different treatment as compare to control (Table 4 and Fig. 2). The highest soil pH (8.57) was obtained in treatment T_1 (control), while the lowest (8.42) was obtained in treatment T_4 (50% RDF + FYM @ 15 t ha^{-1}). While FYM application resulted in a modest drop in soil pH. The modest drop in its value could be attributed to the release of organic acids and organic compounds in soil, which are the by products of FYM (organic matter) decomposition. Soil pH was reduced by the presence of organic compounds and acids. These findings were corroborated by Karthika (2019), Mahmood *et al.* (2017), and Malik and Singh (2016).

Electrical conductivity

Highest EC (0.17dSm^{-1}) was observed in treatment

Table 2. Treatment details

Treatments	Nutrients levels
T_1	Control
T_2	RDF (NPK)
T_3	75% RDF + FYM @15 t ha^{-1}
T_4	50% RDF + FYM @ 15 t ha^{-1}
T_5	RDF + two sprays of 0.5% $ZnSO_4$
T_6	RDF + two sprays of 0.5% $FeSO_4$
T_7	RDF + two sprays of 0.5% $FeSO_4$ + two sprays of 0.5% $ZnSO_4$

*RDF- recommended dose of fertilizers

Table 1. Initial soil physico-chemical properties

Soil property	Values	Method used
Textural Class	Clay Loam Sand- 47.4%, Silt -25.4%, Clay-27.2%	International Pipette Method (Piper, 1966)
Bulk density (Mg m^{-3})	1.34	Core method
Ph	8.66	Glass electrode pH meter (Jackson, 1973)
EC (dS m^{-1}, 1:2 at 25°C)	0.11	Conductivity bridge meter (Jackson, 1973)
Organic carbon (%)	0.54	Walkley and Black rapid titration (1934)
Available nitrogen (kg ha^{-1})	105	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus (kg ha^{-1})	21.47	Olsen´s Method (Olsen *et al.*, 1954)
Available potassium (kg ha^{-1})	360	1 N NH_4OAC methods with the help of flame photometer
DTPA-extractable micronutrients (mg kg^{-1})		
Zn	1.8	
Fe	14.75	Atomic absorption spectrophotometer (Lindsay and Norvell, 1978)
Cu	1.34	
Mn	2.95	

The details of experiment are given below:

T4 (50% RDF + FYM @ 15 t ha^{-1}) and lowest (0.14dSm^{-1}) in treatment T_1 (control) as shown in Table 4 and Fig. 2. The combined application of micronutrients and FYM in combination with RDF had no effect on soil EC value (Scotti *et al.*, 2016 and Deekshitha *et al.*, 2021).

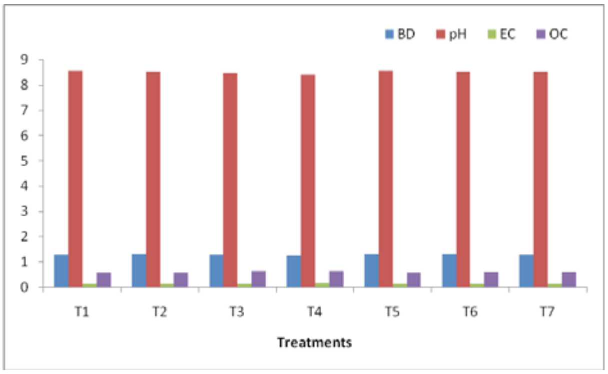

Fig. 2. Effect of micronutrients (Zn and Fe) and FYM on Bulk density (BDMg m^{-3}), pH, EC (dSm^{-1}) and Organic carbon (OC %)

Organic Carbon (OC)

The organic carbon content of the soil ranged from 0.58 to 0.66% in various treatments (Table 4 and Fig. 2). Highest organic carbon was observed in treatment T_4(50% RDF + FYM @ 15 t ha^{-1}) which was at par with T_3(75% RDF + FYM @ 15 t ha^{-1}) and lowest (0.58%) was found in control (T_1). Furthermore, Treatments T_5 (RDF + two sprays of 0.5% $ZnSO_4$), T_6 (RDF + two sprays of 0.5% $FeSO_4$) and T_7 (RDF + two sprays of 0.5% $FeSO_4$ + two sprays of 0.5% $ZnSO_4$) are also at par with each other in terms of organic carbon. This could be related to the fact that organic matter contains a high percentage of soil OC, approximately 58%. There isinverse relationship between BD and OC. As a result, soil has a lower bulk density has higher organic matter content (Abdelbaki 2018). Nishant *et al.* (2021) and Bhattacharyya *et al.* (2007) found similar results in wheat.

Available N, P, and K content in soil

Available N, P and K content in soil ranged from 105.24 to 159.76 kg ha^{-1}, 20.05 to 33.6 kg ha^{-1}, and 353.78 kg ha^{-1} to 393.37 kg ha^{-1}, respectively (Table 5 and Fig. 3). The maximum available N, P and K was found in treatment T_3 (75% RDF + FYM at 15 t ha^{-1}) which was at par with treatment T_4 (50% RDF + FYM at 15 t ha^{-1}) and lowest was found in treatment T_1 (control). The use of FYM and RDF together in a treatment slightly enhanced soil accessible N content, which could be attributed to an increase in mineralization of fixed nitrogen. Farmyard manure is also a rich source of nitrogen, supplying nitrogen directly to the soil and so increasing soil readily available N content in soil. Meena *et al.* (2018) discovered that when FYM @ 10 t ha^{-1} was treated alongside NPK, the N content in the soil increased by 51.7%. Available P content in soil was observed highest under treatment T_3, which might be due to

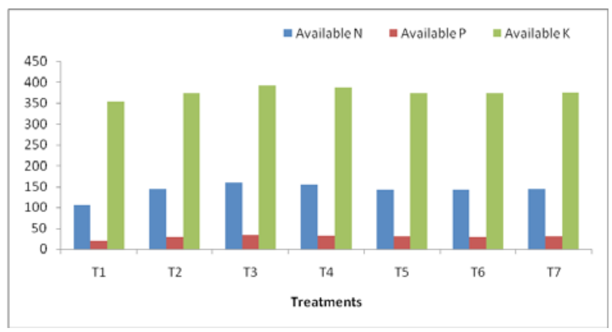

Fig. 3. Effect of micronutrients (Zn and Fe) and FYM on available NPK content in soil (kg ha^{-1})

Table 3. Effect of micronutrients (Zn and Fe) and FYM on DTPA-extractable micronutrients (Fe, Mn, Zn and Cu) concentration in soil

Treatments	DTPA-extractable micronutrients in soil (mg kg^{-1})			
	Fe	Mn	Zn	Cu
Control (T_1)	13.69	2.51	1.54	1.35
RDF (NPK) (T_2)	14.68	2.81	1.71	1.41
75% RDF + FYM @ 15 t ha^{-1}(T_3)	15.69	2.93	1.92	1.52
50% RDF + FYM @ 15 t ha^{-1}(T_4)	15.34	3.03	1.82	1.48
RDF + two spray of 0.5% $ZnSO_4$(T_5)	14.67	2.78	1.78	1.43
RDF + two spray of 0.5% $FeSO_4$(T_6)	15.17	2.77	1.77	1.42
RDF + two spray of 0.5% $FeSO_4$ + two spray of 0.5% $ZnSO_4$(T_7)	15.12	2.90	1.76	1.46
CD (p= 0.05)	1.14	0.29	0.12	NS
SEm±	0.37	0.09	0.05	0.03

solubilization of native P content present in soil by the organic acid produced released. These results were confirmed by the finding of experiment performed by Hakeem *et al.* (2010) and Karthika, 2019. Similarly higher available K content was observed using RDF and FYM. These findings were validated by the findings of Gour *et al.* (2015), Hakeem *et al.* (2010), and Upadhyay *et al.* (2011) experiments. Micronutrients spray and RDF applied together failed to give significant impact over RDF alone, which might be due to no interaction of foliar spray of micronutrients with soil (Karthika, 2019).

DTPA extractable micronutrients in soil

DTPA-extractable Fe, Zn, Cu and Mn

The results presented in Table 3 and Fig 1 show that DTPA-extractable Fe increased markedly in all treatments when compared to the control. DTPA-extractable Fe, Mn, Zn and Cu in soil ranged from 13.69 to 15.69 mg kg^{-1}, 2.51 to 3.03 mg kg^{-1}, 1.54 to 1.92 mg kg^{-1} and 1.35 to 1.52 mg kg^{-1}, respectively in various treatments. The combined use of RDF and FYM resulted in the highest value of DTPA-extractable Fe, Zn, Cu and Mn in treatment T_3 (75% RDF + FYM @ 15 t ha^{-1}) and the lowest value was found under control (T_1). The addition of micronutrients and FYM to RDF resulted in significantly greater soil DTPA extractable Fe, Zn, Cu and Mn content. That could be because FYM is a good source of micronutrients.

On the other hand, T_5 (RDF + two sprays of 0.5% $ZnSO_4$), T_6 (RDF + two sprays of 0.5% $FeSO_4$), and T_7 (RDF + two sprays of 0.5% $ZnSO_4$ + two sprays of 0.5% $ZnSO_4$), were comparable to each other and to T_2 (RDF). This is due to the fact that foliar sprayed micronutrients had no contact with soil and so had no effect on the properties of the soil. Karthika (2019) and Bharose *et al.* (2017) found similar results. In comparison to the control, the DTPA extractable Cu content in soil was non-significantly greater in treatments that included micronutrients and FYM in addition to RDF. This could be because FYM addition reduces Cu content availability.

Biological properties

Microbial biomass carbon: The range of microbial biomass carbon in soil varied from 315.14 to 356.28 ìg g^{-1} soil across various treatments (Table 6 and Fig.

Table 4. Effect of micronutrients (Zn and Fe) and FYM on physico-chemical properties

Treatments	Bulk Density (Mg m^{-3})	pH	EC (dSm^{-1})	Organic Carbon (%)
Control (T_1)	1.31	8.57	0.14	0.58
RDF (NPK) (T_2)	1.32	8.52	0.15	0.59
75% RDF + FYM @ 15 t ha^{-1}(T_3)	1.29	8.48	0.16	0.65
50% RDF + FYM @ 15 t ha^{-1}(T_4)	1.27	8.42	0.17	0.66
RDF + two spray of 0.5% $ZnSO_4$(T_5)	1.33	8.56	0.15	0.60
RDF + two spray of 0.5% $FeSO_4$(T_6)	1.32	8.54	0.15	0.61
RDF + two spray of 0.5% $FeSO_4$ + two spray of 0.5% $ZnSO_4$(T_7)	1.31	8.52	0.15	0.61
CD (p= 0.05)	NS	NS	NS	0.05
SEm±	0.02	0.035	0.008	0.017

Table 5. Effect of micronutrients (Zn and Fe) and FYM on available NPK content

Treatments	Available nutrients (kg ha^{-1})		
	N	P	K
Control (T_1)	105	20.1	354
RDF (NPK) (T_2)	145	28.9	374
75% RDF + FYM @ 15 t ha^{-1}(T_3)	160	33.6	393
50% RDF + FYM @ 15 t ha^{-1}(T_4)	154	32.3	388
RDF + two spray of 0.5% $ZnSO_4$(T_5)	143	30.2	374
RDF + two spray of 0.5% $FeSO_4$(T_6)	143	29.5	374
RDF + two spray of 0.5% $FeSO_4$ + two spray of 0.5% $ZnSO_4$(T_7)	145	30.2	376
CD (p= 0.05)	9.44	4.7	13
SEm±	3.03	1.46	47

4). But significantly higher MBC was observed in 75% RDF + FYM @ 15 t ha^{-1} (T_3) treatment as compared to control (T_1). This is due to presence of organic manures and it serves as a medium for soil microbes, leading to an augmentation in their population within the soil. The application of manure can be attributed to enhanced crop growth, an increase in root biomass and the secretion of root exudates, which likely attract microorganisms which ultimately increase microbial biomass carbon (Shahid, 2013).

Urease: The range of urease activity in soil varied from 94.65 to 105.89 µg NH_4^+ g^{-1} soil hr^{1}across various treatments (Table 6 and Fig. 4). But significantly higher urease activity (10.589 & 104.56µg NH_4^+ g^{-1} soil hr^{1}) was observed in 75% RDF + FYM @ 15 t ha^{-1} (T3) and 50% RDF + FYM @ 15 t ha^{-1} (T_4) treatments, respectively as compared to control (T_1). The increase in urease activity by the integrated application of FYM with chemical fertilizer can be ascribed to the boost in microbial biomass carbon and their population as reported by Kashyap and Khokhar (2017).

Dehydrogenase activity

The range of urease activity in soil varied from 47.28 to 72.22 µg TPF g^{-1} soil 24 hr^{-1} across various treatments (Table 6 and Fig. 4). Significantly increased in dehydrogenase activity was observed in all the treatments as compared to control. But highest dehydrogenase activity (72.22 µg TPF g^{-1} soil 24 hr^{-1}) was observed in treatment T_3 (75% RDF + FYM @ 15 t ha^{-1}) which was at par with (69.75 µg TPF g^{-1} soil 24 hr^{-1}) treatment T_4 (50% RDF + FYM @ 15 t ha^{-1}). The application of FYM integrated with chemical fertilizer in the soil led to a noticeable increase in dehydrogenase activity. This increase can be attributed to the rise in soil organic carbon, which subsequently enhanced microbial biomass and enzyme activities (Kashyap and Khokhar, 2017).

Alkaline phosphatase activity

The range of alkaline phosphatase activity in soil varied from 416.30 to 458.56 µg PNP g^{-1} soil hr^{-1} across various treatments (Table 6 and Fig. 4). Significantly increased in alkaline phosphatase activity was observed in all the treatments as compared to control. But highest alkaline phosphatase activity (458.56 µg PNP g^{-1} soil hr^{-1}) was observed in treatment T3 (75% RDF + FYM @ 15 t ha^{-1}) which was at par with (456.49 µg PNP g^{-1} soil hr^{-1}) treatment T4 (50% RDF + FYM @ 15 t ha^{-1}). The application of

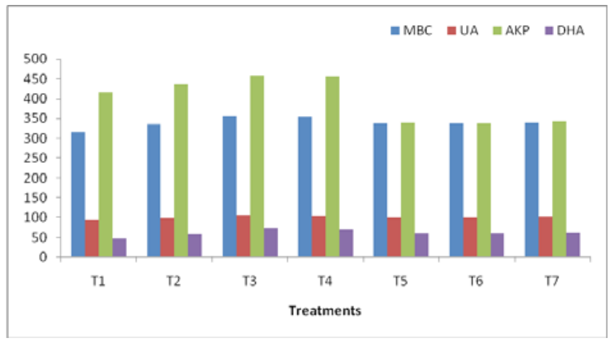

Fig. 4. Effect of micronutrients (Zn and Fe) and FYM on Microbial biomass carbon (MBC µg g^{-1} soil), urease activity (UA µg NH_4^+ g^{-1} soil hr^{1}), alkaline phosphatase activity (AKP µg PNP g^{-1} soil hr^{-1}) and dehydrogenase enzyme activity (DHAµg TPF g^{-1} soil 24 hr^{-1})

Table 6. Effect of micronutrients (Zn and Fe) and FYM on MBC and enzyme activities

Treatments	MBC (µg g^{-1} soil)	Enzyme activities		
		Urease (µg NH_4^+ g^{-1} soil hr^{1})	Alkaline phosphatase (µg PNP g^{-1} soil hr^{-1})	Dehydrogenase (µg TPF g^{-1} soil 24 hr^{-1})
Control (T_1)	315.14	94.65	416.3	47.28
RDF (NPK) (T_2)	335.75	98.25	435.32	58.56
75% RDF + FYM @ 15 t ha^{-1}(T_3)	356.28	105.89	458.56	72.22
50% RDF + FYM @ 15 t ha^{-1}(T_4)	354.893	104.56	456.49	69.75
RDF + two spray of 0.5% $ZnSO_4$(T_5)	338.18	100.02	339.33	60.33
RDF + two spray of 0.5% $FeSO_4$(T_6)	337.32	99.57	337.56	59.75
RDF + two spray of 0.5% $FeSO_4$ + two spray of 0.5% $ZnSO_4$(T_7)	339.57	101.38	342.89	61.89
CD (p= 0.05)	15.024	2.809	15.479	2.782
SEm±	4.823	0.902	4.968	0.893

FYM integrated with chemical fertilizer in the soil led to a noticeable increase in alkaline phosphatase activity. These results are also sported by Kashyap and Khokhar (2017).

Conclusion

Soil physico-chemical parameters such as bulk density (BD), pH and electrical conductivity (EC) showed no significant effect when FYM was used in conjunction with RDF. The application of micronutrients and FYM in combination with RDF had considerable impact on soil OC, NPK content available micronutrients in soil. Increase in microbial biomass carbon and enzyme activity with the application of FYM.

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