Effectiveness of organics with nutrient levels and bio-fertilizers through soil chemico-biological properties on wheat (*Triticum Aestivum* L) crop [Cv.PBW-343] in *Inseptisols*.

ABSTRACT:

The literature pertaining to research study on wheat crop are presented in an elaborative way and is reviewed in this paper, under the topic entitled "**Effectiveness of organics with nutrient levels and bio-fertilizers through soil chemico-biological properties on wheat (*Triticum Aestivum* L) crop [Cv.PBW-343] in *Inseptisols*"**, during cumulatiive study period of 2018-2019 and 2019-2020, at Research Farm, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj District of Uttar Pradesh. However, the chemical soil parameters with their cumulative mean of low soil pH (6.82), low EC (0.37 dS m^{-1}), high CEC (16.37 cmol (p^{+}) kg^{-1}), less free lime content (13.55 %), high available N (262.12 kg ha^{-1}), high available P (21.75 kg ha^{-1}), high available K (220.51 kg ha^{-1}), high available S (32.57 kg ha^{-1}), high available Fe (3.90 mg kg^{-1}), low available Mn (3.77 mg kg^{-1}), low available Cu (0.31 mg kg^{-1}) and high available Zn (1.79 mg kg^{-1}) and biological soil properties with cumulative mean of dehydrogenase enzyme activity (1.49 µg TPF g^{-1} day^{-1}), alkaline phosphatase activity (186.35 µg pNP g^{-1} hr^{-1}) and microbial biomass carbon (37.59 gm kg^{-1}) was labelled in organically amended treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobactor* + *Azospirillum* (3kg ha^{-1}) + Zn in comparison to in-organic application over control. Therefore, the combined application of FYM, *Azatobacter* spp and *Azospirilium* spp (seed inoculation) has lead to improvement in soil health potential for yield sustenance under wheat crop cultivation.

Key wards: Bio-fertilizers, FYM, INM, NPKS, enzyme activites.

1.0 INTRODUCTION:

On account of containing world energy crisis and spiraling prices of chemical fertilizer, by means of a high annual productivity of crops resulting in removal of nutrients in substantial amounts that ~~after~~ exceed replenishment through chemical fertilizer and manures ultimately leading to poor soil health. Growers have started in blanket use of inorganic chemical fertilizers, to maintain productivity. This result to crops more prone to attack of insect pest and drastic decline of the crop yield (**Dotaniya *et al.*, 2016**). Such emerging trends of indiscriminate use of fertilizer without use of organic sources of nutrients are also

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responsible ~~to~~ for deterioration of soil health. Imbalance fertilizer use has resulted in multinutrient deficiency in soils. Therefore, soils encounter a diversity of constraints because of soil quality and ultimately end up with poor functional capacity (**Singh *et al.*, 2016**). Soil microorganisms are important to agroecosystems. They are involved in key roles, such as aggregate formation, humus formation, nutrient cycling, decomposition of various compounds and other transformations in soil (Wu et al. 2011). Fertilization usually favours the accumulation of bacterial residues and increases soil microbial biomass. In addition to this, organic matter in soil improves soil structures, nutrient retention, aeration, soil moisture holding capacity and water infiltration (**Mehran *et al.*, 2011**).The use of humic acid and soil micro-organisms, particularly bacterium can assist in the potential phyto-technical increase of these crops, as well as reduce the costs of nitrogen inputs used by the same. Hence, to optimize crop productivity and maintaining a healthy ecosystem, achieved by providing the necessary conditions and the need for greater use of bio-fertilizers and organics.

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MATERIALS AND METHODS:

The experimental study on ~~topic entitled~~ "**Effectiveness of organics with nutrient levels and bio-fertilizers through soil chemico-biological properties on wheat (*Triticum Aestivum* L) crop [Cv.PBW-343] in *Inseptisols*."** was ~~studied~~ conducted during the cumulative period, beginning from *rabi* seasons 2018-2019 and 2019-2020 at Research Farm, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj District of Uttar Pradesh.

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The excavated soil sample from experimental site**,** mentioned that, the land topography range was nearly levelled with 1-3% slope, soil is of sandy loam texture with neutral to alkaline in reaction (6.82), EC was non-saline (0.30 dSm^{-1}) in nature, low organic carbon content (0.319%), low to medium available N (151 kg ha^{-1}), available P (14.80 kg ha^{-1}) and available K (240.3kg ha^{-1}).

The layout of the research field was depicted in randomized block design (RBD) with twelve treatment combinations (~~mentioned in~~ Table 1) which is replicated thrice**.** Recommended dose of NPK (100%) was applied to the wheat crop are N (~~@~~ 120 kg ha^{-1}), P_2O_5 (~~@~~ 60 kg ha^{-1}) and K_2O (~~@~~ 40 kg ha^{-1}). The sources of NPK fertilizers was nitrogen through urea (46% N), phosphorus through single super phosphate (16% P_2O_5), potash through muriate of potash (60% K_2O) and zinc through zinc sulphate (21% Zn). The bio-fertilizers i.e. *Azotobactor* and *Azospirilium* used as seed inoculant was applied ~~@~~ at 3 kg ha^{-1}

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with 5 kg of well decomposed FYM and was applied at 5cm depth in furrows, just before the seed sowing which is carried out on 13th and 14th of November month during 2018 and 2019 with row spacing of 22.5 cm and plant spacing of 5 cm. The bread wheat cv. PBW-343 variety was used for its performance in the experimental research as a test crop.

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Generally, soil chemical properties describes a detailed information of change of a substance into completely different form, in order to know its internal quality.

Traditionally, microbiological counts in soil has its important significance during bio-transformation of mineral substance, achieving microbial population with in soil communities. In soil, biological enzyme activities are potential indicators in measuring soil quality because they are sensitive, rapid and inexpensive representatives of the potential metabolic activity of the soil (Liang, *et al.*, 2014). However, soil which was analysed under research investigation was sandy loam, as a result, the respiration rate of microorganisms decreases with decreasing in bio-availability of nutrients. Hence in order to cope up soil fertility status, soils are subjected with FYM, bio-fertilizer and N-levels in combination, the data set down from the post soil sample collection after the harvest of wheat crop during the course of experimental research 2018-2019 and 2019-2020. The outcome of the results are analysed under lab condition with standard methods employed are presented in Table 2.

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Table 1: Treatment details:

Treatments	***Rabi* (Wheat-*var PBW-343*)**
T_1	No fertilizer and no organic manure (control)
T_2	75 % recommended N dose through fertilizer
T_3	$N_{120}P_{60}K_{40}$
T_4	75 % recommended N dose through fertilizer + 5 t ha^{-1} organic manure through FYM
T_5	75 % recommended N dose through fertilizer + 3kg ha^{-1} bio-fertilizer through *Azotobacter* + *Azospirillum*
T_6	75 % recommended N dose through fertilizer +5 t ha^{-1} organic manure through FYM +3kg ha^{-1} bio-fertilizer through *Azotobacter* + *Azospirillum*
T_7	75 % recommended N dose through fertilizer + 25 kg ha^{-1} Zn through zinc sulphate
T_8	75 % recommended N dose through fertilizer + 5 t ha^{-1} organic manure through FYM + 25 kg ha^{-1} Zn through zinc sulphate.
T_9	75 % recommended N dose through fertilizer + 5 t ha^{-1} organic manure through FYM +3kg ha^{-1} bio-fertilizer through *Azotobacter* + *Azospirillum* + 25 kg ha^{-1} Zn through zinc sulphate
T_{10}	50 % recommended N dose through fertilizer + 5 t ha^{-1} organic manure

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	through FYM
T_{11}	50 % recommended N dose through fertilizer + 3kg ha^{-1} bio-fertilizer through *Azotobacter* + *Azospirillum*
T_{12}	50% recommended N dose through fertilizer + 5 t ha^{-1} organic manure through FYM + 3kg ha^{-1} bio-fertilizer through *Azotobacter* + *Azospirillum* + 25 kg ha^{-1} Zn through zinc sulphate.

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Table 2 Standard methods employed for analysing physical properties of soil:

I	**Chemical properties**	**?**	**?**	
1.	Soil pH (1:2.5)	Jackson, 1973	pH meter	
2.	Electrical conductivity (1:2.5)	Wilcox, 1950	EC bridge (Systronics digital conductivity meter–304.)	dS m^{-1}
3.	Cation exchange capacity	Black, 1965	Sodium saturation method	cmol (p^{+}) kg^{-1}
4.	Free lime	Piper, 2002	Rapid acid titration method	Percentage
5.	Organic carbon	Walkley and Black, 1947	Walkley and Black Wet oxidation method	Percentage
6.	Available nitrogen	Subbiah and Asija, 1956	Modified alkaline permanganate oxidation method	kg ha^{-1}
7.	Available phosphorus	Olsen *et al.* 1954.	Olsen's extraction followed by Spectrophotometric method	kg ha^{-1}
8.	Available potassium	Toth and Prince, 1949	Neutral normal ammonium acetate extraction fallowed by Flame photometric method	kg ha^{-1}
9.	Available Sulphur	Chesnin and Yien, 1950	Turbidimetric method	kg ha^{-1}
10.	Available Fe, Mn, Cu & Zn	Lindsay and Novell, 1978	DTPA extraction followed by Atomic Absorption Spectrophotometer	mg kg^{-1}
II	**Biological properties**			
1.	Dehydrogenase activity	Casida *et al.*, 1964	Triphenyl tetrazolium chloride method	µg TPF g^{-1} day^{-1}
2.	Alkaline phosphatase activity	Tabatabai & Bremner, 1969	p-nitrophenol phosphate method	µg pNP g^{-1} hr^{-1}
3.	Microbial Biomass Carbon	Voroney *et al.*, 1993	$CHCl_3$ fumigation extraction method	mg kg^{-1}

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Make a three line Table

RESULTS AND DISCUSSSION:

Appraisal of the data, transcribed from soil analysis, have focused that constituents like FYM, bio-fertilizers and N-levels have found effective in performing healthier results with regard to soil which have been put under research investigation.

The observations **on chemical soil properties** with respect to **soil pH**, variation among the different treatments ~~was existed~~ shows non-significan~~t~~ce. The range of soil pH was observed from 6.76-7.31, 6.87-7.40 and 6.82-7.36, respectively, during 2018-2019, 2019-2020 and on pooled basis, However, the treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, have got low soil pH i.e. 6.76, 6.87 and 6.82, when compared with chemically treated plot (T_3) consisting of 100% N i.e. 7.31, 7.40 and 7.36, over control plot (T_1), i.e. 7.06, 7.18 and 7.12, respectively, are presented in ~~the~~ **Table 3**. The results further admitted that, organically treated plots registered less soil pH values in the treatments (T_6) consisting of 75 % N +FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}), i.e. 6.79, 6.88 and 6.83 and (T_8) consisting of 75 % N + FYM @ 5 t ha^{-1} + Zn, i.e. 6.78, 6.89 and 6.83, and (T_{12}) consisting of 50 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, i.e. 6.88, 7.00 and 6.94, which are at par and followed to treatment (T_9), respectively.

The decrease in soil pH in the FYM treated plots might be attributed to the production of organic acids and release of CO_2 during organic matter decomposition in presence of microbes. The results are in agreement with findings (Kumar and Singh, *et al.*, 2010).

The data pertaining to **electrical conductivity** of soil shows that, variation among the different treatments was also existed non-significant. The range of EC was observed from 0.26-0.30, 0.34-0.44 and 0.30-0.37 dS m^{-1}, respectively, during 2018-2019, 2019-2020 and on pooled basis, are presented in ~~the~~ **Table 3**. However, the treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, have got low EC, i.e. 0.30, 0.44 and 0.37 dS m^{-1}, when compared with chemically treated plot (T_3) consisting of 100% N, i.e. 0.27, 0.39 and 0.33 dS m^{-1}, over control plot (T_1), 0.26, 0.34 and 0.30 dS m^{-1}, respectively.

However, the treatment (T_9) followed by treatment (T_6) (0.28, 0.43 and 0.36 dS m^{-1}) was at par with each other and on par with treatment (T_8) (0.28, 0.42 and 0.35 dS m^{-1},) respectively, during both the years and on pooled basis. The reason beyond lowering the EC values in organic treated plots might be due to increasing in water retaining capacity, due to

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improvement in soil aggregation thus reducing the salt concentration (Duhan and Singh, 2002).

As per results concerned, the **holding capacity of exchangeable cations** by experimental soil, differs significantly among varied treatments and soil sample analysed which gave limit range of 11.35-16.32, 11.51-16.41 and 11.43-16.37 cmol (p^+) kg^{-1}, during 2018-2019, 2019-2020 and on pooled basis. Thus, it said that the treatment enriched in combination of sources like FYM, bio-fertilizer and N-levels, have evidenced higher CEC of soil i.e. T_9 consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, noting, 16.32, 16.41 and 16.37 cmol (p^+) kg^{-1}, when compared with chemically treated plot, i.e. T_3 consisting of 100 % N alone, noting 14.74, 15.00 and 14.87 cmol (p^+) kg^{-1}, over control (T_1) i.e. 11.35, 11.51 and 11.43 cmol (p^+) kg^{-1}, respectively, are presented in ~~the~~ **Table 3**

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In addition to this, treatment (T_9) followed by treatment (T_6) (16.05, 16.16 and 16.11 cmol (p^+) kg^{-1}) both stand at par with each other and on par with treatment (T_8) (15.97, 16.10 and 16.04 cmol (p^+) kg^{-1}) respectively, during both the years and on pooled basis.

Increasing in CEC of soil might be influenced by incorporation of organic material, in which soil build-up its capacity in holding nutrients through improving clay concentration by beneficial micro-organisms. Hence, exchange of cations take place in presence of clay, adsorption of clay site retains positively charged by electrostatic forces. Thus, improved soil aggregation and structural stability and increased CEC could have achieved. The results are in proximity with findings (Das, *et al.*, 2015~~) (~~Verma, *et al.*, 2010~~) (~~Sepehya, 2011).

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Table 3 Effect of integrated nutrients on Soil pH, EC (dS m^{-1}) and CEC (cmol ($p^{+)}$ kg^{-1}) of soil in wheat (*Triticum aestivum* L.) cultivation during experimental period 2018-2019, 2019-2020 and on pooled basis.

T	Soil pH			EC (dS m^{-1})			CEC (cmol ($p^{+)}$ kg^{-1})		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1	7.06	7.18	7.12	0.26	0.34	0.30	11.35	11.51	11.43
T_2	7.11	7.24	7.17	0.26	0.37	0.31	12.64	12.76	12.70

T_3	7.31	7.40	7.36	0.27	0.39	0.33	14.74	15.00	14.87
T_4	6.88	7.02	6.95	0.28	0.39	0.34	15.42	15.53	15.47
T_5	6.97	7.11	7.04	0.29	0.38	0.33	14.28	14.51	14.39
T_6	6.79	6.88	6.83	0.28	0.43	0.36	16.05	16.16	16.11
T_7	7.17	7.31	7.24	0.26	0.40	0.33	14.23	14.29	14.26
T_8	6.78	6.89	6.83	0.28	0.42	0.35	15.97	16.10	16.04
T_9	6.76	6.87	6.82	0.30	0.44	0.37	16.32	16.41	16.37
T_{10}	6.97	7.08	7.02	0.28	0.39	0.34	15.41	15.47	15.44
T_{11}	7.01	7.13	7.07	0.27	0.37	0.32	13.47	13.80	13.64
T_{12}	6.88	7.00	6.94	0.28	0.41	0.34	15.67	15.78	15.73
F- test	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**S**	**S**	**S**
S. Ed.	0.182	0.286	0.209	0.012	0.049	0.026	1.090	1.11	5.51
C. D.	0.377	0.590	0.431	0.024	0.100	0.055	1.350	1.358	0.67

Note: CD at 0.05 level of significance (probability), T-Treatments, S-significant

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The presence of **free lime content** in soil sample, which was ranged from 13.25-23.27, 13.86-24.11 and 13.55-23.69 %, respectively, during the study period 2018-2019, 2019-2020 and on pooled basis, respectively. In particularly, treatment falling under (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, noting, 13.25, 13.86 and 13.55 %, showed significantly lesser percentage of free lime present in soil, compared with chemically treated plot (T_3) consisting of 100% N alone, noting, 18.17, 18.08 and 18.13 %, which was high, over control (T_1), i.e. 21.98, 22.60 and 22.29 %, respectively.

Further, treatment (T_9) followed by treatment (T_6) (14.69, 14.21 and 14.46 %) and treatment (T_8) (14.62, 15.33 and 14.98 %) both stand statistically similar and at par with treatment (T_9), are presented in **Table 4.**

The organically treated plot including bio-fertilizer and N-levels, marked significantly higher **organic carbon content** and it varied from 0.31-0.96, 0.37-1.02 and 0.34-0.99 %, respectively, during 2018-2019, 2019-2020 and on pooled basis. In particular, with respect to various treatments, highest percentage of organic carbon labelled in the treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, noting 0.96, 1.02 and 0.99 %, in comparison with chemical treatment (T_3) consisting of 100% N alone, noting 0.66, 0.74 and 0.70 %, which was very low, over control (T_1) i.e. 0.31, 0.37 and

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0.34 %, respectively. Furthermore, the treatment (T_9) followed by treatment (T_6) (0.90, 0.96 and 0.93 %) in which both statistically at par with each other and on par with the treatment (T_8) (0.79, 0.91 and 0.85 %) and treatment (T_{12}) (0.82, 0.89 and 0.85 %), respectively, in which both are found statistically similar, during both the years and on pooled basis, are presented in **Table 4.**

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Besides adding organic carbon, the added organic sources to the treatment plot itself influenced the soil root growth system, resulting in addition of greater root biomass and root exudates to the soil and also observed that It might be due to build up effect of organic matter in surface soil, over all led to ultimately increasing in soil organic carbon. (Mohammed *et al.*, 2014) (Eldardiry, *et al.*, 2013).

The observational studies after analysing soil samples from respective field, it was noticed that, integral effect of organics and inorganics found highest **available N** source in experimental site. The available N among the treatments ranged from 214.07-261.99, 217.21-262.25 and 217.07-262.12 kg ha^{-1}, respectively. In clarity, treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, noting, 261.99, 262.25 and 262.12 kg ha^{-1}, evidenced significantly highest available N in soil, in comparison with chemical treatment (T_3) consisting of 100% N alone, noting, 242.08, 242.37 and 242.22 kg ha^{-1}, both stand statistically at par with each other over control (T_1) i.e. 216.93, 217.21 and 217.07 kg ha^{-1}. Furthermore, treatment (T_9) stand statistically on par with the treatment (T_6) (234.74, 235.00 and 234.87 kg ha^{-1}), respectively, during both the years and on pooled basis, are presented in **Table 4**.

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Increasing in available N observed under organically treated plot, which might be due to mineralization effect of organic sources (Tabassum, *et al.*, 2010). It might be also due to the favourable soil conditions provided by FYM addition might have helped in mineralization of additional soil N leading to build-up of higher available N and improved soil fertility (Santhy, *et al.*, 1998) (Sarin, *et al.*, 1991) (Kumar, 2014) (Davari, *et al.*, 2012) (Essan and Lattief , 2014).

Table 4 Effect of integrated nutrients on free lime (%), OC (%) and available N (kg ha^{-1}) of soil in wheat (*Triticum aestivum* L.) cultivation during experimental period 2018-2019, 2019-2020 and on pooled basis.

T	Free lime (%)			OC (%)			Available N (kg ha^{-1})		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1	21.98	22.60	22.29	0.31	0.37	0.34	216.93	217.21	217.07
T_2	23.27	24.11	23.69	0.39	0.47	0.43	224.26	224.53	224.39

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T_3	18.17	18.08	18.13	0.66	0.74	0.70	242.08	242.37	242.22
T_4	15.72	16.39	16.06	0.75	0.82	0.78	227.45	229.74	228.60
T_5	17.82	19.29	18.56	0.54	0.64	0.59	226.76	230.44	228.60
T_6	14.69	14.21	14.46	0.90	0.96	0.93	234.74	235.00	234.87
T_7	18.75	18.45	18.60	0.51	0.59	0.55	227.45	229.70	228.58
T_8	14.62	15.33	14.98	0.79	0.91	0.85	231.46	232.00	231.73
T_9	13.25	13.86	13.55	0.96	1.02	0.99	261.99	262.25	262.12
T_{10}	17.88	17.69	17.79	0.70	0.81	0.75	217.98	218.23	218.10
T_{11}	19.27	21.05	20.16	0.48	0.57	0.52	217.02	221.26	219.14
T_{12}	14.78	15.38	15.08	0.82	0.89	0.85	214.07	226.34	220.21
F- test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S. Ed.	3.82	1.93	1.51	0.109	0.113	0.110	3.630	3.703	3.659
C. D.	4.688	2.378	1.839	0.225	0.233	0.227	7.493	7.643	7.553

Note: CD at 0.05 level of significance (probability), T-Treatments, S-significant, OC-Organic carbon

On the basis of research studies during the course of two years, it has come with output that, the organically treated plot including bio-fertilizer and N-levels, marked significantly highest **available P** in soil and it varied from 16.41-21.52, 16.88-21.98 and 16.75-21.75 kg ha^{-1}, respectively, during 2018-2019, 2019-2020 and on pooled basis, are presented in **Table 5.** However, treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, noting, 21.52, 21.98 and 21.75 kg ha^{-1}, evidenced significantly highest available P in soil, in comparison with chemical treatment (T_3) consisting of 100% N alone, noting, 19.41, 20.49 and 19.77 kg ha^{-1}, both stand statistically at par with each other, over control (T_1) i.e. 16.63, 16.88 and 16.75 kg ha^{-1}, respectively. Furthermore, treatment (T_9) stand slightly on par with the treatment (T_6) (19.51, 20.00 and 19.76 kg ha^{-1}) and treatment (T_8) (19.50, 20.01 and 19.76 kg ha^{-1}) respectively, which are identically same, during both the years and on pooled basis.

The highest available P in FYM treated plot resulted, might be due to effective solubilization of native P in the soil through the release of various organic acids by FYM. On another side it may also influenced by release of carbon dioxide (CO_2), which plays a dominant role in enhancing the P availability, during the decomposition of organic matter which forms carbonic acids, solubilizing certain primary minerals (Singh and Wanjari 2007).

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The organically treated plot having higher clay content, having higher persistence in soil including bio-fertilizer and N-levels, marked significantly highest **available K** in soil and it varied from 136.29-217.29, 136.76-223.73 and 136.52-220.51 kg ha^{-1}, respectively, during 2018-2019, 2019-2020 and on pooled basis, are presented in **Table 5**. Among various treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, noting, 217.29, 223.73 and 220.51 kg ha^{-1}, evidenced significantly highest available P in soil, in comparison with chemical treatment (T_3) consisting of 100% N alone, noting, 216.55, 217.02 and 216.79 kg ha^{-1}, both stand statistically at par with each other, over control (T_1), i.e. 136.29, 136.76 and 136.52 kg ha^{-1}, respectively. Furthermore, treatment (T_9) stand slightly on par with treatment (T_4) (205.35, 205.81 and 205.58 kg ha^{-1}) treatment (T_6) (205.35, 205.83 and 205.59 kg ha^{-1}) and treatment (T_8) (204.35, 206.82 and 205.59 kg ha^{-1}) respectively, in which all three are identically same, during both the years and on pooled basis.

The higher amount of available K in the FYM treated plot might have resulted, due to the fact that FYM, on its application pronounced increased CEC in soil, which is mainly capable of holding large amount of exchangeable K. Further, it helped in releasing exchangeable K from non-exchangeable pool.

It could also ascribe due to the reduction in K-fixation and release of K from reserved non-exchange site, which is held between inter lattice layer of clay or due to the interaction of organic matter with clay besides the direct addition of K to available pool of the soil. The results are in agreement with findings (Kher and Minhas 1991).

On the basis of research studies during the course of two years, the outcome of the result says that, the organically treated plot including bio-fertilizer and N-levels, marked significantly highest **available S** in soil and it varied from 19.61-32.44, 19.86-32.71 and 19.73-32.57 kg ha^{-1}, respectively, during 2018-2019, 2019-2020 and on pooled basis, are presented in **Table 5**. However, treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, noting, 32.44, 32.71 and 32.57 kg ha^{-1}, evidenced significantly highest available S in soil, in comparison with chemical treatment (T_3) consisting of 100% N alone, noting, 29.78, 30.01 and 29.89 kg ha^{-1}, both stand statistically at par with each other, over control (T_1) i.e. 19.61, 19.86 and 19.73 kg ha^{-1}, respectively.

Furthermore, treatment (T_9) stand statistically on par with the treatment (T_6) (28.17, 28.43 and 28.30 kg ha^{-1}) and treatment (T_8) (27.28, 27.52 and 27.40 kg ha^{-1}) respectively,

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during both the years and on pooled basis. Primarily, the increase in available S was due to use of single superphosphate (SSP) as a source of P, which contains appreciable amount of S. In addition to this, the highest available sulphur in organic treatment might be attributed to mineralization of available NPKS nutrients from FYM, another reason might be that, the suitable soil conditions under organic sources might have promoted for mineralization of nutrients and leading to build-up higher NPKS. Similar results are in conformity with authors. (Agarwal, *et al.*, 2010) (Ravankar, *et al.*, 2005).

Table 5 Effect of integrated nutrients on available PKS in wheat (*Triticum aestivum* L.) cultivation during experimental period 2018-2019, 2019-2020 and on pooled basis.

T	Available P (kg ha^{-1})			Available K (kg ha^{-1})			Available S (kg ha^{-1})		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1	16.63	16.88	16.75	136.29	136.76	136.52	19.61	19.86	19.73
T_2	18.12	18.42	18.27	188.55	189.05	188.80	22.46	22.68	22.57
T_3	19.41	20.49	19.77	216.55	217.02	216.79	29.78	30.01	29.89
T_4	19.52	19.99	19.75	205.35	205.81	205.58	25.35	25.60	25.48
T_5	18.02	18.51	18.26	192.29	192.77	192.53	24.38	24.61	24.50
T_6	19.51	20.00	19.76	205.35	205.83	205.59	28.17	28.43	28.30
T_7	19.65	19.84	19.74	196.02	196.47	196.24	23.49	23.70	23.59
T_8	19.50	20.01	19.76	204.35	206.82	205.59	27.28	27.52	27.40
T_9	21.52	21.98	21.75	217.29	223.73	220.51	32.44	32.71	32.57
T_{10}	18.02	18.46	18.24	179.22	179.72	179.47	19.89	20.13	20.01
T_{11}	16.41	17.11	16.76	162.42	162.90	162.66	20.88	21.10	20.99
T_{12}	19.30	20.13	19.74	181.09	181.54	181.31	21.55	21.80	21.67
F- test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S. Ed.	1.161	1.185	1.167	13.269	13.704	13.414	0.725	0.951	0.837
C. D.	2.397	2.446	2.409	27.388	28.285	27.687	1.496	1.962	1.728

Note: CD at 0.05 level of significance (probability), T-Treatments, S-significant

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Outcome of the result says that, the organically treated plot including bio-fertilizer and N-levels, marked significantly **highest available Fe** in soil and it varied from 3.12-3.84, 3.21-3.95 and 3.17-3.90 mg kg^{-1}, respectively, during 2018-2019, 2019-2020 and on pooled basis. However, the treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, have noted highest available Fe, i.e. 3.84, 3.95 and 3.90 mg kg^{-}

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^{1}, when compared with chemically treated plot (T_3) consisting of 100% N, i.e. 3.32, 3.58 and 3.45 mg kg^{-1}, over control plot (T_1), i.e. 3.12, 3.21 and 3.17 mg kg^{-1}, respectively. The results further revealed that, the treatment (T_9) followed by treatment (T_6) (3.72, 3.84 and 3.78 mg kg^{-1}) and treatment (T_8) (3.72, 3.81 and 3.77 mg kg^{-1}) and stand statistically at par with each, respectively, during both the years and on pooled basis, are presented in **Table 6**.

The data pertaining to Mn availability in soil shows that, significant variation existed among the different treatments. The range of **available Mn** was ranged from 4.30-6.20, 4.39-6.32 and 4.35-6.24 mg kg^{-1}, respectively, during 2018-2019, 2019-2020 and on pooled basis, are presented in **Table 6** In contrast, treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, noting, 3.72, 3.81 and 3.77 mg kg^{-1}, evidenced significantly lowest available Mn in soil, in comparison with chemical treatment (T_3) consisting of 100% N alone, noting, 6.20, 6.28 and 6.24 mg kg^{-1}, over control (T_1), i.e. 4.89, 4.98 and 4.94 mg kg^{-1}, respectively.

Furthermore, treatment (T_9) followed by treatment (T_6) (4.30, 4.39 and 4.35 mg kg^{-1}) stand statistically at par with each other, on par with treatment (T_8) (4.50, 4.58 and 4.54 mg kg^{-1}, respectively), during both the years and on pooled basis.

The data pertaining to Cu availability in soil shows that, significant variation existed among the different treatments. The range of **available Cu** was observed from 0.28-0.98, 0.33-1.01 and 0.31-0.99 mg kg^{-1}, respectively, during 2018-2019, 2019-2020 and on pooled basis. In contrast, from various treatments, (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, noting, 0.28, 0.33 and 0.31 mg kg^{-1}, evidenced significantly lowest available Cu in soil, in comparison with chemical treatment (T_3) consisting of 100% N alone, noting, 0.98, 1.01 and 0.99 mg kg^{-1}, over control (T_1), i.e. 0.58, 0.62 and 0.60 mg kg^{-1}, respectively. Furthermore, treatment (T_9) followed by treatment (T_6) (0.52, 0.56 and 0.54 mg kg^{-1}) and treatment (T_8) (0.53, 0.55 and 0.54 mg kg^{-1}) both stand statistically similar and at par to treatment (T_9), are presented in **Table 6**

The reason for low Cu availability in soil, mainly depends on the functional groups of the soil reactive particles and their sorption capacity, which is a result of diverse factors. (McBride, 1994). However, soil belongs to organically treated plot having neutral to alkaline in reaction, may generally have lower Cu availability which is related to the presence of carbonates that favour Cu precipitation and adsorption (Bradl, 2004). In addition, organic matter restricts Cu availability, because of its high affinity sites and a binding energy capable of making strong complex with the copper metal. Hence its availability is very less. (Croue, *et al.*, 2003).

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Outcome of the result from the two years says that, the organically treated plot including bio-fertilizer and N-levels, marked significantly highest **available Zn** in soil and it varied from 1.13-1.78, 1.19-1.80 and 1.16-1.79 mg kg^{-1}, respectively, during 2018-2019, 2019-2020 and on pooled basis. However, the treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, have noted highest available Zn, i.e. 1.78, 1.79 and 1.79 mg kg^{-1}, when compared with chemically treated plot (T_3) consisting of 100% N, i.e. 1.42, 1.53 and 1.47 mg kg^{-1}, over control plot (T_1), i.e. 1.13, 1.19 and 1.16 mg kg^{-1}, respectively.

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However, the treatment (T_9) followed by treatment (T_6), i.e. 1.77, 1.79 and 1.78 mg kg^{-1}, both stand statistically at par with each other, on par with treatment (T_8), i.e. 1.75, 1.78 and 1.76 mg kg^{-1}, respectively, during both the years and on pooled basis, are presented in **Table 6.**

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The consequence of overall analysis of chemical parameters influenced well with respect to positive effect of amendment used as bio-fertilizer and FYM, might be attributed to increment in macro and micronutrients availability at the rhizosphere and also due to growing tissues and organs acquisition with higher amounts of nitrogen supported by N_2-fixing *Azospirillum* and *Azotobacter* on wheat plants. These results are in agreement with reporters (Madhu, *et al.,* 1993) (Amara, *et al.,* 1995), (Patel, *et al.,* 1996), (Panwar, *et al.,* 2000) (El-Bakry, *et al.,* 2001).

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Table 6 Effect of integrated nutrients available soil micro-nutrients in wheat (*Triticum aestivum* L.) cultivation during experimental period 2018-2019, 2019-2020 and on pooled basis.

T	Available micro-nutrients (mg kg^{-1}) in soil.											
	Available Fe			Available Mn			Available Cu			Available Zn		
	1st	2nd	Pooled	1st year	2nd	Pooled	1st year	2nd	Pooled	1st	2nd	Pooled

	year	year			year			year		year	year	
T_1	3.12	3.21	3.17	4.89	4.98	4.94	0.58	0.62	0.60	1.13	1.19	1.16
T_2	3.31	3.39	3.35	6.10	6.32	6.22	0.87	0.93	0.90	1.33	1.41	1.37
T_3	3.32	3.58	3.45	6.20	6.28	6.24	0.98	1.01	0.99	1.42	1.53	1.47
T_4	3.56	3.64	3.60	4.56	4.66	4.61	0.57	0.59	0.58	1.59	1.62	1.61
T_5	3.54	3.59	3.57	6.08	6.15	6.12	0.88	0.91	0.90	1.42	1.61	1.52
T_6	3.72	3.84	3.78	4.30	4.39	4.35	0.52	0.56	0.54	1.77	1.79	1.78
T_7	3.23	3.54	3.38	5.72	5.79	5.75	0.77	0.79	0.78	1.51	1.53	1.52
T_8	3.72	3.81	3.77	4.50	4.58	4.54	0.53	0.55	0.54	1.75	1.78	1.76
T_9	3.84	3.95	3.90	3.72	3.81	3.77	0.28	0.33	0.31	1.78	1.79	1.79
T_{10}	3.60	3.68	3.64	4.82	4.94	4.88	0.77	0.80	0.79	1.52	1.56	1.54
T_{11}	3.46	3.53	3.50	5.71	5.83	5.77	0.70	0.74	0.72	1.48	1.52	1.50
T_{12}	3.67	3.73	3.70	4.64	4.87	4.76	0.56	0.62	0.59	1.70	1.72	1.71
Ftest	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
SEd	0.030	0.086	0.054	0.71	0.65	0.43	0.31	0.27	0.14	0.20	0.17	0.18
C.D.	0.062	0.178	0.112	0.54	0.80	0.535	0.23	0.24	0.17	0.25	0.22	0.23

Note: CD at 0.05 level of significance (probability), T-Treatments, S-significant, NS-Non significant

The observations on **biological soil properties** with respect to enzyme activities shows that, significantly higher **dehydrogenase enzyme activity** was marked in the organically treated plot including bio-fertilizer and N-levels and it varied from 0.84-1.42, 1.00-1.57 and 0.92-1.49 µg TPF g^{-1} day^{-1}, respectively. The highest percentage of enzyme activity labelled in the treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobactor* + *Azospirillum* (3kg ha^{-1}) + Zn, noting, 1.42, 1.57 and 1.49 µg TPF g^{-1} day^{-1}, in comparison with chemical treatment (T_3) consisting of 100% N alone, noting, 1.24, 1.26 and 1.25 µg TPF g^{-1} day^{-1}, which was low, over control (T_1), i.e. 0.84, 1.00 and 0.92 µg TPF g^{-1} day^{-1}, respectively.

Furthermore, the treatment (T_9) followed by the treatment (T_6), i.e. 1.37, 1.52 and 1.44 µg TPF g^{-1} day^{-1}, in which both was statistically at par with each other, on par with the treatment (T_8), i.e. 1.30, 1.46 and 1.38 µg TPF g^{-1} day^{-1}, respectively, during both the years and on pooled basis, are presented in **Table 7.**

Among, different treatment combination, usage of both *Azotobacter* spp. and *Azospirillum spp*. as seed inoculant, during experimentation, might have found most effective and efficient, resulted in receiving maximum values of plant growth parameter, yield attributing characteristics, grain yield, soil microbial biomass carbon (SMBC) and

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dehydrogenase activities at all the growth stages of wheat crop. The work was in conformity with findings (Singh, *et al.*, 2015)

Similarly, **alkaline phosphatase activity** it varied from 148.44-185.97, 152.27-186.73 and 152.05-186.35 µg pNP g^{-1} hr^{-1}, respectively, during 2018-2019, 2019-2020 and on pooled basis. The highest percentage of phosphatase activity labelled in organically amended treatment (T_9) consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, noting, 185.97, 186.73 and 186.35 µg pNP g^{-1} hr^{-1}, in comparison with chemical treatment (T_3) consisting of 100% N alone, noting, 164.53, 165.25 and 164.89 µg pNP g^{-1} hr^{-1}, which was very low, over control (T_1), i.e. 151.81, 152.27 and 152.05 µg pNP g^{-1} hr^{-1}, respectively. Furthermore, the treatment (T_9) followed by and statistically at par with treatment (T_6) i.e. 183.20, 185.78 and 184.49 µg pNP g^{-1} hr^{-1}, during both the years and on pooled basis, are presented in **Table 7.**

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The **MBC** in treated soil sample varied from 29.40-37.37, 30.66-37.87 and 30.42-37.59 gm kg^{-1}, respectively, during 2018-2019, 2019-2020 and on pooled basis and the highest percentage of MBC labelled in the treatment T_9 consisting of 75 % N + FYM @ 5 t ha^{-1} + *Azotobacter* + *Azospirillum* (3kg ha^{-1}) + Zn, noting, 37.37, 37.81 and 37.59 gm kg^{-1}, in comparison with chemical treatment (T_3) consisting of 100% N alone, noting, 34.86, 35.35 and 35.11 gm kg^{-1}, which was very low, over control (T_1), i.e. 30.19, 30.66 and 30.42 gm kg^{-1}, respectively, are presented in **Table 7.**

Furthermore, the treatment (T_9) followed by treatment (T_6) i.e. 36.96, 37.43 and 37.20, (in which both are statistically at par with each other), on par with the treatment (T_4) i.e. 36.24, 36.70 and 36.47 gm kg^{-1} and treatment (T_8) i.e. 36.24, 36.71 and 36.48 gm kg^{-1}, in which both are found statistically similar, respectively, during both the years and on pooled basis.

From the studies, higher microbial biomass carbon was observed in organic treated plot, which might be the result of cumulative effect of the amendments used and also left-over crop residues on the field after harvest during the previous seasons. Crop residues can have a large effect on soil microbial biomass and activity, which, in turn, affect the ability of soil to supply nutrients to plants through soil organic matter turnover. MBC have positively correlated with organic carbon content in soil. The work is in conformity with findings, (Beck, *et al.*, 1997) (Leiros, *et al.*, 2000).

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Table 7 Effect of integrated nutrients on soil enzyme activities in wheat (*Triticum aestivum* L.) cultivation during experimental period 2018-2019, 2019-2020 and on pooled basis.

T	DHA (µg TPF g^{-1} day^{-1})			APA (µg pNP g^{-1} hr^{-1})			MBC (gm kg^{-1})		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1	0.84	1.00	0.92	151.81	152.27	152.05	30.19	30.66	30.42
T_2	0.90	1.04	0.97	148.44	170.97	159.71	30.37	32.86	31.61
T_3	1.24	1.26	1.25	164.53	165.25	164.89	34.86	35.35	35.11
T_4	1.20	1.35	1.27	180.98	181.46	181.22	36.24	36.70	36.47
T_5	1.12	1.27	1.20	160.74	161.21	160.98	33.58	34.03	33.80
T_6	1.37	1.52	1.44	183.20	185.78	184.49	36.96	37.43	37.20
T_7	0.99	1.16	1.08	160.23	160.92	160.57	32.27	32.75	32.51
T_8	1.30	1.46	1.38	179.33	183.81	181.57	36.24	36.71	36.48
T_9	1.42	1.57	1.49	185.97	186.73	186.35	37.37	37.81	37.59
T_{10}	1.18	1.36	1.27	175.62	176.26	175.94	34.37	34.87	34.62
T_{11}	0.93	1.06	0.99	153.42	161.94	157.68	29.40	33.85	31.63
T_{12}	1.25	1.36	1.31	180.18	182.78	181.48	35.76	36.24	36.00
F- test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S. Ed.	0.175	0.172	0.172	9.10	6.34	4.61	1.029	0.933	0.975
C. D.	0.360	0.355	0.355	11.294	10.312	5.66	2.124	1.927	2.013

Note: CD at 0.05 level of significance (probability), T-Treatments, S-significant, DHA-Dehydrogenase activity, APA-Alkaline phosphatase activity, MBC-Microbial biomass carbon

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CONCLUSION:

The overall ~~picture~~ result, during two years (2018-2019 and 2019-2020) of research investigation, delivered to wheat growers that, for optimum requirement of farmers livelihood, the best alternative way to sound success in agriculture production is by effective utilization of higher organic resource during cultivation practices in combination with inorganics at lesser amount, in order to sustain soil health and economic productivity. However, Integrated treatments found better in organic ones in terms of soil dehydrogenase, phosphatase and urease and available nutrient status (NPKS), organic carbon and cation exchange capacity. Biofertilizers like *Azatobacter* spp and *Azospirilium* spp (seed inoculation) and farmyard manure has proved potential organic inputs for yield sustenance under wheat crop cultivation.

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