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

ABSTRACT

Aims: To enhance soil quality, production, productivity and profit maximization with higher economic returns through integrated farming practices. Inaddition, to fulfill the needs of farmers economical point of view, academic, society and social reforms.

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

Place and duration of study: The cumulative study period of 2018-19 and 2019-20, at research farm, department of soil science and agricultural chemistry, naini agricultural institute, sam higginbottom university of agriculture, technology and sciences, which is located at $25^0$58' North latitude and 81^0 52' East longitude with an altitude of 98 meter above mean sea level and is situated 5km away on the right, bank of Yamuna river.

Methodology: Randomized block design fallowed here with 12 treatment combinations replicated 3 times**.** Recommended dose of fertilizers *i.e.* nitrogen, phosphrous and potassium, was applied @ 120:60:40 kg ha^{-1} as urea (46% N), single super phosphate (16% P_2O_5), muriate of potash (60% K_2O) and zinc sulphate (21% Zn). The *Azotobacter* spp. and *Azospirilium* spp. (seed inoculants), applied at 3 kg ha^{-1} with farm yard manure @ 5 tha^{-1}, at 5cm depth in furrows, before seed sowing was done on 13^{th} and 14^{th} of November (2018-2019) with spacing of 22.5 X 5 cm. Wheat cultivar used here is PBW-343 as a test crop.

Results: The cumulative mean of low soil pH (6.82), electrical conductivity (0.37 dS m^{-1}) and free lime content (13.55 %), the higher cation exchange capacity (16.37 cmol (p^+) kg^{-1}), higher available nitrogen, available phosphrous, available potassium and available sulphur of 262.12:21.75:220.51:32.57 kg ha^{-1}, respectively, high available iron and zinc (*i.e.* 3.90 and 1.79 mg kg^{-1}), low available manganese and copper (3.77 and 0.31 mg kg^{-1}), further the cumulative mean of dehydrogenase enzyme activity (1.49 µg triphenyl-formazan g^{-1} day^{-1}), alkaline phosphatase activity (186.35 µg para-nitrophenol g^{-1} hr^{-1}) and microbial biomass carbon (37.59 g kg^{-1}) was labelled in treatment (T_9) consisting of 75 % N + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc in comparison to in-organic application over control.

Conclusion: The combined application of farm yard manure, *Azotobacter* spp and *Azospirilium* spp along with in-organics, has lead to improvement in soil health potential, nutrient availbility and yield sustenance under wheat crop cultivation.

1.0 INTRODUCTION

Wheat is the staple food in the traditional wheat growing northwest and central India, is soft to medium hard, medium protein, white bread wheat, is one of the most important and widely cultivated staple food crops among the cereals which cultivated for its seed and as Botanically, the wheat kernel is a type of fruit called a caryopsis, belongs to family *Poaceae.* Wheat is consumed at the household level, local restaurants, and eateries in the form of handmade breads called *chapattis* or *rotis* or *parathas* (unleavened flat bread) using *atta* (whole wheat flour) estimated at around 75-80 percent of total consumption. Wheat yields in largely irrigated northern India (Punjab, Haryana, and Western Uttar Pradesh) are about 4.5 to 5.0 tons per hectare, while yields in western and central states (Gujarat, Rajasthan, Madhya Pradesh, Bihar and parts of Uttar Pradesh) are relatively lower at 1.5 to 3.0 tons per hectare. (Grain and Feed Annual, 2019).

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 exceed replenishment through chemical fertilizer and manures ultimately leading to poor soil health. Regarding lack of knowledge about the benefits of organic usages, people started using in-organic chemical fertilizers in indiscriminate way to maintain crop 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 responsible 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. 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

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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, 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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2.0 MATERIALS AND METHODS

The experiment was conducted during the cumulative period, beginning from *rabi* seasons 2018-19 and 2019-20 at research farm, department of soil science and agricultural chemistry, sam higginbottom university of agriculture, technology and sciences, which is located at 25^{0}58’ north latitude and 81^{0} 52' east longitude with an altitude of 98 meter above mean sea level and is situated 5km away on the right bank of Yamuna river, Prayagraj District of Uttar Pradesh.

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 belongs to order *Inceptisol and* sub group *Typic Ustipsamment* with neutral to alkaline in reaction (6.82), electrical conductivity was non-saline (0.30 dSm^{-1}) in nature, low organic carbon content (0.319%), low to medium available nitrogen (151 kg ha^{-1}), available phosphrous (14.80 kg ha^{-1}) and available potassium (240.3kg ha^{-1}).

The layout of the research field was depicted in randomized block design (detailed in table 1) with twelve treatment combinations (table 2) which is replicated thrice**,** recommended dose of fertilizers *i.e.* nitrogen, phosphrous and potassium (100%) was applied in the ratio of 120:60:40 kg ha^{-1}, respectively. The sources of nitrogen was 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. Azotobacter* spp and *Azospirilium* spp used as seed inoculant, was applied at 3 kg ha^{-1} with 5 kg of well decomposed farm yard manure and was applied at 5cm depth in furrows, just before the seed sowing which is carried out on 13^{th} and 14^{th} of November month during 2018 and 2019 with row spacing of 22.5 cm and plant spacing of 5 cm.

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Wheat cultivar PBW 343, an Attila sib, is a selection made at Punjab Agricultural University, Ludhiana, Punjab, India, from a set of lines called “Veery wheat derivatives” developed at CIMMYT, Mexico, based on an initial round of spring wheat × winter wheat hybridization. After its release in the North West Plain Zone (NWPZ) of India in 1995, PBW 343 emerged as a mega cultivar.

The study hypothised that, the integrated nutrients like farm yard manure, nitrogen levels with Zn as micronutrient and bio-fertilizer *i.e.*“nitroxin” containing *Azotobactor* spp and *Azospirillum* spp was used in testing the performance of wheat cv. PBW-343 var (which is a popular, high yielding modern variety with medium to high tillering ability. It matures in 130-135 days and yields about 46-50q grain ha^{-1}), and knwoing nutrient availabilitye in soil.

After the completion of post-harvest activity in the experimental site, representative soil sample from each treated plot was collected by driving soil augur, drawn at a depth of 15cm, which represent entire soil mass and later soil was excavated to shade dry in a clean paper to avoid losses of nutrient and passed through 2mm sieve. Finally, the chemical properties of soil were analyzed.

In parallel to this, soil enzyme activities like microbial biomass carbon (MBC), dehydrogenases activity (DHA) and alkaline phosphatase activity (APA), which constitutes living microorganisms (smaller than 10 μm^3) was estimated from the fresh soil sample collected from the experimental site after crop harvest at each plot.

Thus, the outcome of the results was analysed under lab condition with standard methods employed are presented in table 3.

Table 1: Field layout details

Design	Randomized Block Design
Crop	Wheat (*Triticum aestivum* L)
Variety	PBW-343
Season	*Rabi*
Replication	3
Plot size	3m x 2m
Number of treatment combinations	12
Total number of plots	12×3 = 36
Total length of the area	39.9 m
Total width of the area	8.8m
Main irrigation channel	1m
Sub irrigation channel	0.5m
Width of bund	0.3m
Gross cultivated area	303.24 m^2
Net cultivated area	216 m^2
Seed rate	120 kg ha^{-1}

Yield	46 – 50 q ha^{-1}
Row to row distance	22.5 cm
Plant to plant	5cm
N:P: K	120:60:40 kg ha^{-1}
FYM	5 t ha^{-1}

Source: Hand Book of Agriculture by ICAR (2010)

Table 2: Experimental treatment combination of in-organic fertilizers, organic manure and bio-fertilizers

Treatments	Rabi (Wheat-*var PBW-343*)
T_1	Absolute control
T_2	75 % N
T_3	$N_{120}P_{60}K_{40}$
T_4	T_2 + FYM @ 5 t ha^{-1}
T_5	T_2 + *Azotobacter* spp + *Azospirillum* spp @ 3kg ha^{-1}
T_6	T_4 + *Azotobacter* spp + *Azospirillum* spp @ 3kg ha^{-1}
T_7	T_2 + Zn @ 25 kg ha^{-1}
T_8	T_4 + Zn @ 25 kg ha^{-1}
T_9	T_5 + Zn @ 25 kg ha^{-1}
T_{10}	50 % N + farm yard manure @ 5 t ha^{-1}
T_{11}	50 % N + *Azotobacter* spp + *Azospirillum* spp @ 3kg ha^{-1}
T_{12}	T_{10} + *Azotobacter* spp + *Azospirillum* spp @ 3kg ha^{-1} + zinc

Note: Basal dose of phosphorus (60 kg ha^{-1}), potassium (40 kg ha^{-1}) and zinc sulphate (25 kg ha^{-1}) was applied at the start of the experiment

Table 3: Standard methods employed for analysing soil properties

I	Chemical properties	Authors	Methods	Units
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	%
5.	Organic carbon	Walkley and Black, 1947	Walkley and Black Wet oxidation method	%
6.	Available nitrogen	Subbiah and Asija, 1956	Modified alkaline permanganate oxidation method	kg ha^{-1}
7.	Available phosphorus	Olsen *et al.*	Olsen's extraction followed by	kg ha^{-1}

		1954.	Spectrophotometric method	
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}

Note : TPF-Triphenyl-formazan, pNP-Para-nitrophenol.

Chemical properties of soil

Soil pH

The pH of soil was determined in 1:2 soil to water suspension. The buffer standard of known pH values of 4.0, 7.0 and 9.2 at 25^{0}C was maintained. By stirring the samples intermittently for 30 minutes, reading was recorded (Jackson 1973) using a systronics digital-331 pH meter.

Electrical conductivity (dS m^{-1})

Electrical conductivity of the soil was determined in the supernatant of 1:2 soil water suspension that kept for stirring constantly for 30 minutes, reading was noted down (Wilcox, 1950) by using systronics digital conductivity meter–304.

Organic carbon (g kg^{-1})

Initially 2 mm sieved soil sample was ground in agate pestle and mortar and passed through 0.5 mm sieve. Later organic carbon content of the soil was estimated by Walkley and Black (1947) wet oxidation method.

Cation exchange capacity (cmol (p+)/kg)

The cation exchange capacity of the given soil sample was estimated by saturating and leaching the soil with neutral normal sodium acetate solution and excess salts was removed by 60 per cent ethanol. The adsorbed sodium was then replaced by neutral normal ammonium acetate and the concentration of sodium in the leachate was measured by flame photometer (systronics-125) and cation exchange capacity of given soil was calculated as described by Black (1965) and expressed in (cmol (p+)/kg).

Free calcium carbonates (%)

The free calcium carbonate was determined by rapid acid titration method as described by Piper (2002).

Available nitrogen (kg ha^{-1}):

Here, modified alkaline permanganate oxidation method was used in estimating available nitrogen as outlined by Subbiah and Asija, (1956). The organic matter present in the soil was oxidized by the nascent oxygen liberated by $KMnO_4$ in the presence of NaOH and quantity of NH_3 distilled was estimated by titrating against a standard H_2SO_4.

Available phosphorus (kg ha^{-1})

Available phosphorus in soil was determined by the 0.5 M sodium bicarbonate method (Olsen's extractant) and stannous chloride, which was used for development of blue color. Soil in presence of added extractant shaking has done for 30 minutes, filtered, and treated with ammonium molybdate (complexing agent). The intensity of blue colour was read using spectrophotometer at 660 nm wavelength as described Olsen *et al.* (1954).

Available potassium (kg ha^{-1})

Determination of available potassium, accomplished with potassium extraction by using neutral normal ammonium acetate (pH 7.0) which acts as extractant and the content of potassium in the extractant was obtained as described by Toth and Prince, (1949) using flame photometer.

Available sulphur (kg ha^{-1})

Available sulphur content in the soil sample was extracted by using calcium hydrogen phosphate employing soil extractant ratio 1:10, 30 minutes shaking on a mechanical shaker, filtered it and was estimated by using turbidimetric method as described by Chesnin and Yien, (1950).

Available Zn, Fe, Mn and Cu (mg kg^{-1})

Available Zn, Cu, Fe and Mn were determined by following Lindsay and Norvell (1978) procedure using DTPA extractant. This DTPA is a mild chelating agent and as ability to chelate these micronutrients in soil solution and form soluble complex. The concentration of Zn, Cu, Fe and Mn in the filtrate was read in atomic absorption spectrophotometer.

Biological properties of soil

Soil dehydrogenase activity (µg TPF g^{-1} day^{-1})

Soil dehydrogenase activity was assayed with the method of Casida *et al.*, (1964). In this method, 5 grams of soil was taken in a stoppered test tube, 2.5ml of distilled water, 1ml of 3 per cent triphenyl tetrazolium chloride solution and 0.5 ml of 1 per cent glucose was added and incubated at 37ºC for 24 hours. After incubation, 10 ml of methanol was added to each vial and was shaken thoroughly for one minute. The supernatant was filtered through Whatman No. 50 filter paper and the soil was washed repeatedly with methanol till the filtrate was free from red color and the pooled filtrate was diluted to 100 ml. The production of triphenyl formazan (TPF) was measured at wave length of 485 nm in spectrophotometer or colorimeter using methanol as blank.

Soil alkaline phosphatase activity (µg pNP g^{-1} hr^{-1})

Alkaline phosphatase activity of soil samples was assayed with the method of Tabatabai and Bremner (1969). The reaction mixture comprising of one gram of soil, 0.2 ml of toluene, 4 ml of MUB (Modified Universal Buffer) of pH 11 and 1 ml of p-nitro phenyl phosphate solution (made with same buffer) was added in a 50 ml Erlenmeyer flask containing soil sample and. The flask was swirled for a few seconds to mix the contents and then placed in an incubator at 37±2°C. After 1 hour of incubation, one ml of 0.5 M $CaCl_2$ and 4 ml of 0.5 M NaOH was added to the soil suspension and was filtered through a Whatman no.1 filter paper. The intensity of yellow color was measured at 420 nm using spectrophotometer against the reagent blank.

Microbial biomass carbon (mg kg^{-1})

Soil microbial biomass carbon was determined using the $CHCl_3$ fumigation extraction method (Voroney *et al.,* 1993). To take 10 gram of soil which was subjected to oven dry weight of soil was used in duplicates and K_2SO_4- extractable C was determined using dichromate digestion. Microbial biomass carbon was calculated using the equation

$$\text{Biomass C} = EC/0.54.$$

Where,

EC = (organic C in K_2SO_4 from fumigated soil) - (organic C in K_2SO_4 from Un-fumigated soil).

Statistical analysis:

The data averaged into respective parameter requisite was recorded and subjected to suitable transformation by "Analysis of variance technique". After analysis, data was accommodated in the table as per the needs of objectives for interpretation of results. For testing the hypothesis, the following ANOVA table was used. The significant and non-significant treatment effect was judged with the help of 'F' (variance ratio) table. If the calculated value exceeds the table value, the effect was considered to be significant. The standard procedures in agriculture statistics given by (Gomez, 1984), was consulted throughout. The interpretation of data will be done by using the critical difference value calculated at 0.05 probability level. The level of significance will be expressed at 0.05 probabilities.

The following is the skeleton of analysis of variance table 3 used in the present study as given below.

Table 3: Skeleton of ANOVA table

Source of variation	Df	SS	MSS	F Cal	F Tab at 5%
Due to replications	(r-1)	RSS	RSS / (r-1)	MSS(r) / EMS	F(r-1) / (r-1) (t-1)
Due to treatments	(t-1)	TrSS	TrSS / (t-1)	MSS(t) / EMS	F(t-1) / (r-1) (t-1)
Due to error	(r-1) (t-1)	ESS	ESS / (r-1) (t-1)		
Total	(rt-1)	TSS			

Where,

Standard Error Deviation (S.E.d):

S.E.(d)= V(2XMSSE)/r

Co-efficient of variation (CV):

CV (%) = σ/X̄ x 100

Critical difference (CD):

CD = S.E.(d) × 't' error degree of freedom at 5% level of significance

X̄ = Mean

σ = Standard deviation

r = Number of replications

df = Degree of freedom

SS = Sum of squares

RSS	=	Sum of squares due to replication
TrSS	=	Sum of squares due to treatment
TSS	=	Total sum of squares
ESS	=	Error sum of squares
MSS(r)	=	Mean sum of squares due to replication
MSS(t)	=	Mean sum of squares due to treatment
EMSS	=	Error mean sum of squares
S.E.(d)	=	Standard error deviation

3.0 RESULTS AND DISCUSSSION

Appraisal of the data, transcribed from soil analysis, have focused that constituents like farm yard manure, bio-fertilizers and nitrogen 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 shows non-significant. The range of soil pH was observed from 6.76-7.31, 6.87-7.40 and 6.82-7.36, respectively, during 2018-19, 2019-20 and on pooled basis, However, the treatment (T_9) consisting of 75 % nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, 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% nitrogen *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 table 3. The results further admitted that, organically treated plots registered less soil pH values in the treatments (T_6) consisting of 75 % nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}), *i.e.* 6.79, 6.88 and 6.83 and (T_8) consisting of 75 % nitrogen + farm yard manure @ 5 t ha^{-1} + zinc, *i.e.* 6.78, 6.89 and 6.83, and (T_{12}) consisting of 50 % nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, 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 farm yard manure treated plots might be attributed to the production of organic acids and release of carbon dioxide during organic matter decomposition in presence of microbes. Similar findings reported by (Kumar and Singh, *et al.*, 2010) (Upadhyay and Vishwakarma 2014) (Ram *et al*. 2016) (Gawde *et al.* 2017) (Bhatt *et al.* 2017) (Bharti and Raj 2017) (Brar *et al.* 2015) (Patel *et al.* 2018).

The data pertaining to electrical conductivity of soil shows that, variation among the different treatments was also existed non-significant. The range of electrical conductivity

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was observed from 0.26-0.30, 0.34-0.44 and 0.30-0.37 dS m^{-1}, respectively, during 2018-19, 2019-20 and on pooled basis, are presented in table 3. However, the treatment (T_9) consisting of 75 % nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, have got low electrical conductivity, *i.e.* 0.30, 0.44 and 0.37 dS m^{-1}, when compared with chemically treated plot (T_3) consisting of 100% nitrogen, *i.e.* 0.27, 0.39 and 0.33 dS m^{-1}, over control plot (T_1), *i.e.* 0.26, 0.34 and 0.30 dS m^{-1}, respectively.

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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 electrical conductivity values in organic treated plots might be due to increasing in water retaining capacity, due to improvement in soil aggregation thus reducing the salt concentration (Duhan and Singh, 2002) (Bahadur *et al.* 2013) (Upadhyay and Vishwakarma 2014) (Ram *et al*. 2016) (Gawde *et al.* 2017) (Bhatt *et al.* 2017) (Bharti and Raj 2017) (Brar *et al.* 2015) (Patel *et al.* 2018).

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 2018-19, 2019-20 and on pooled basis. Thus, it said that the treatment enriched in combination of sources like farm yard manure, bio-fertilizers and nitrogen levels, have evidenced higher cation exchange capacity of soil, *i.e.* T_9 consisting of 75 % nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, 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 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 cation exchnage capacity 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 cation exchange capacity could have achieved. The results are in proximity with findings (Das, *et al.*, 2015 Verma, *et al.*, 2010 Sepehya, 2011) (Bahadur *et al.* 2013) (Upadhyay and Vishwakarma

2014) (Ram *et al*. 2016) (Gawde *et al.* 2017) (Bhatt *et al.* 2017) (Bharti and Raj 2017) (Brar *et al.* 2015) (Patel *et al.* 2018).

Table 3: Effect of integrated nutrients on soil pH, electrical conductivity (dS m^{-1}) and cation exchange capacity (cmol (p^{+}) kg^{-1}) of soil during wheat cultivation

T	Soil pH			EC (dS m^{-1})			CEC (cmol (p^{+}) kg^{-1})		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**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, NS-Non-significant, S-Significant, EC Electrical conductivity, CEC-Cation exchange capacity.

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. In particularly, treatment (T_9) consisting of 75 % nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, *i.e.* 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% nirogen alone, *i.e.* 18.17, 18.08 and 18.13%, which was high, over control (T_1), *i.e.* 21.98, 22.60 and 22.29 %, respectively.

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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.

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The lesser values are observed in integrated treatments, it might be due to production of organic acids, which is a potential source in leading to dissolution effect, during organic matter decomposition in soil. The findings are well supported by authors (Sangwan and Singh, 1993) (Dang and Verma, 1996) (Satyavathy, 1998) (Bahadur *et al.* 2013) (Upadhyay and Vishwakarma 2014) (Ram *et al*. 2016) (Gawde *et al.* 2017) (Bhatt *et al.* 2017) (Bharti and Raj 2017) (Brar *et al.* 2015) (Patel *et al.* 2018).

The organically treated plot including bio-fertilizers and nitrogen-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. In particular, with respect to various treatments, highest percentage of organic carbon labelled in the treatment (T_9) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, *i.e.* 0.96, 1.02 and 0.99 %, in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, *i.e.* 0.66, 0.74 and 0.70 %, which was very low, over control (T_1) *i.e.* 0.31, 0.37 and 0.34 %, respectively. In 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) (Bahadur *et al.* 2013) (Tadesse *et al.* 2013) (Yaduvanshi *et al.* 2013) (Parewa *et al*. 2014) (Singh *et al*. 2014a) (Upadhyay and Vishwakarma 2014) (Ram *et al*. 2016) (Gawde *et al.* 2017) (Bhatt *et al.* 2017) (Bharti and Raj 2017) (Brar *et al.* 2015) (Patel *et al.* 2018).

The observational studies after analysing soil samples from respective field, it was noticed that, integral effect of organics and inorganics found highest available nitrogen source in experimental site. The available nitrogen 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% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, *i.e.* 261.99, 262.25 and 262.12 kg ha^{-1}, evidenced significantly highest available nitrogen in soil, in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, *i.e.* 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 nitrogen 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 farm yard manure addition might have helped in mineralization process in building-up higher available nitrogen and improved soil fertility (Santhy, *et al.*, 1998) (Sarin, *et al.*, 1991) (Kumar, 2014) (Davari, *et al.*, 2012) (Essan and Lattief , 2014) (Bahadur *et al.* 2013) (Tadesse *et al.* 2013) (Yaduvanshi *et al.* 2013) (Parewa *et al*. 2014) (Singh *et al*. 2014a) (Upadhyay and Vishwakarma 2014) (Ram *et al*. 2016) (Gawde *et al.* 2017) (Bhatt *et al.* 2017) (Bharti and Raj 2017) (Brar *et al.* 2015) (Patel *et al.* 2018).

Table 4: Effect of integrated nutrients on free lime content (%), organic carbon (%) and available nitrogen (kg ha^{-1}) in soil during wheat cultivation

T	Free lime content (%)			Organic carbon (%)			Available nitrogen (kg ha^{-1})		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**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
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.

On the basis of research studies during the course of two years, it has come with output that, the organically treated plot including bio-fertilizers and nitrogen levels, marked significantly highest available phosphrous in soil and it varied from 16.41-21.52, 16.88-21.98

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and 16.75-21.75 kg ha^{-1}, respectively, are presented in table 5. However, treatment (T_9) consisting of 75 % nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, *i.e.* 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% nitrogen alone, *i.e.* 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. Further, 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.

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The highest available phosphorus in farm yard manure treated plot resulted, which might be due to effective solubilization of native phosphorus in the soil through the release of various organic acids by farm yard manure. On another side it may also influenced by release of carbon dioxide, which plays a dominant role in enhancing the phosphorus availability, during the decomposition of organic matter which forms carbonic acids, solubilizing certain primary minerals (Singh and Wanjari 2007) (Bahadur *et al.* 2013) (Tadesse *et al.* 2013) (Yaduvanshi *et al.* 2013) (Parewa *et al.* 2014) (Singh *et al.* 2014a) (Upadhyay and Vishwakarma 2014) (Ram *et al.* 2016) (Gawde *et al.* 2017) (Bhatt *et al.* 2017) (Bharti and Raj 2017) (Brar *et al.* 2015) (Patel *et al.* 2018).

The organically treated plot having higher clay content, having higher persistence in soil including bio-fertilizers and nitrogen levels, marked significantly highest available potassium in soil and it varied from 136.29-217.29, 136.76-223.73 and 136.52-220.51 kg ha^{-1}, respectively, are presented in table 5. Among various treatment (T_9) consisting of 75 % nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, *i.e.* 217.29, 223.73 and 220.51 kg ha^{-1}, evidenced significantly highest available phosphorus in soil, in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, *i.e.* 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. Further, 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.

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The higher amount of available potassium in farm yard manure treated plot might have resulted, due to the fact that, on application of farm yard manure pronounced increased cation exchange capacity in soil, which is mainly capable of holding large amount of exchangeable potassium. Further, it helped in releasing exchangeable potassium from non-exchangeable pool (Tadesse *et al.* 2013) (Yaduvanshi *et al.* 2013) (Parewa *et al*. 2014) (Singh *et al*. 2014a) (Upadhyay and Vishwakarma 2014) (Ram *et al*. 2016) (Gawde *et al.* 2017) (Bhatt *et al.* 2017) (Bharti and Raj 2017) (Brar *et al.* 2015) (Patel *et al.* 2018).

It could also ascribed due to the reduction in potassium fixation and release of poatssium 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) (Bahadur *et al.* 2013).

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-fertilizers and nitrogen levels, marked significantly highest available sulphur in soil and it varied from 19.61-32.44, 19.86-32.71 and 19.73-32.57 kg ha^{-1}, respectively, are presented in table 5. However, treatment (T_9) consisting of 75 % mitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, *i.e.* 32.44, 32.71 and 32.57 kg ha^{-1}, evidenced significantly highest available sulphur in soil, in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, *i.e.* 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.

Further, 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, during both the years and on pooled basis. Primarily, the increase in available sulphur was due to use of single superphosphate as a source of phosphorus, which contains appreciable amount of sulphur. In addition to this, the highest available sulphur in organic treatment might be attributed to mineralization of available nitrogen, phosphorus, potassium and sulphur nutrients from farm yard manure. 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 available nitrogen, phosphorus, potassium and sulphur nutrients. Similar results are in conformity with authors. (Agarwal, *et al.*, 2010) (Ravankar, *et al.*, 2005) (Bahadur *et al.* 2013) (Upadhyay and Vishwakarma 2014) (Ram *et al*. 2016) (Gawde *et al.* 2017) (Bhatt *et al.* 2017) (Bharti and Raj 2017) (Brar *et al.* 2015) (Patel *et al.* 2018).

Table 5: Effect of integrated nutrients on available phosphorus, potassium and sulphur during wheat cultivation.

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T	Available P (kg ha^{-1})			Available K (kg ha^{-1})			Available S (kg ha^{-1})		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**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, P-Phosphorus, K-Potassium, S-Sulphur.

Outcome of the result says that, the organically treated plot including bio-fertilizers and nitrogen levels, marked significantly highest available iron in soil and it varied from 3.12-3.84, 3.21-3.95 and 3.17-3.90 mg kg^{-1}, respectively. However, the treatment (T_9) consisting of 75 % nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, have noted highest available iron, *i.e.* 3.84, 3.95 and 3.90 mg kg^{-1}, when compared with chemically treated plot (T_3) consisting of 100% nitrogen, *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.

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The data pertaining to manganese availability in soil shows that, significant variation existed among the different treatments. The range of available manganese was ranged from 4.30-6.20, 4.39-6.32 and 4.35-6.24 mg kg^{-1}, respectively, are presented in table 6. In contrast, treatment (T_9) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, *i.e.* 3.72, 3.81 and 3.77 mg kg^{-1}, evidenced significantly

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lowest available manganese in soil, in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, *i.e.* 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.

Further, 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 copper availability in soil shows that, significant variation existed among the different treatments. The range of available copper was observed from 0.28-0.98, 0.33-1.01 and 0.31-0.99 mg kg^{-1}, respectively. In contrast, from various treatments, (T_9) consisting of 75 % nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, *i.e.* 0.28, 0.33 and 0.31 mg kg^{-1}, evidenced significantly lowest available copper in soil, in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, *i.e.* 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. Further, 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.

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The reason for low copper 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 copper availability which is related to the presence of carbonates that favour copper precipitation and adsorption (Bradl, 2004). In addition, organic matter restricts copper 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) (Bahadur *et al.* 2013) (Upadhyay and Vishwakarma 2014) (Ram *et al*. 2016) (Gawde *et al*. 2017) (Bhatt *et al.* 2017) (Bharti and Raj 2017) (Brar *et al.* 2015) (Patel *et al.* 2018).

Outcome of the result from the two years says that, the organically treated plot including bio-fertilizers and nitrogen levels, marked significantly highest available zinc in soil and it varied from 1.13-1.78, 1.19-1.80 and 1.16-1.79 mg kg^{-1}, respectively. However, the treatment (T_9) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, have noted highest available zinc, *i.e.* 1.78, 1.79 and 1.79 mg kg^{-1}, when compared with chemically treated plot (T_3) consisting of 100% nitrogen, *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-fertilizers and farm yard manure, 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 nitrogen fixing *Azospirillum* spp and *Azotobacter* spp 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) (Bahadur *et al.* 2013) (Upadhyay and Vishwakarma 2014) (Ram *et al*. 2016) (Gawde *et al.* 2017) (Bhatt *et al.* 2017) (Bharti and Raj 2017) (Brar *et al.* 2015) (Patel *et al.* 2018).

Table 6: Effect of integrated nutrients on available soil micro-nutrients during wheat cultivation

T	**Available micro-nutrients (mg kg^{-1}) in soil.**											
	Available Fe			**Available Mn**			**Available Cu**			**Available Zn**		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
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, Fe- Iron, Mn-Manganese, Cu-copper, Zn-Zinc.

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-fertilizers and nitrogen levels and it varied from 0.84-1.42, 1.00-1.57 and 0.92-1.49 µg triphenyl-formazan g^{-1} day^{-1}, respectively. The highest percentage of enzyme activity labelled in the treatment (T_9) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, *i.e.* 1.42, 1.57 and 1.49 µg triphenyl-formazan g^{-1} day^{-1}, in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, *i.e.* 1.24, 1.26 and 1.25 µg triphenyl-formazan g^{-1} day^{-1}, which was low, over control (T_1), *i.e.* 0.84, 1.00 and 0.92 µg triphenyl-formazan g^{-1} day^{-1}, respectively.

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Further, the treatment (T_9) followed by the treatment (T_6), i.e. 1.37, 1.52 and 1.44 µg triphenyl-formazan 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 triphenyl-formazan 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 and dehydrogenase activities at all the growth stages of wheat crop. The work was in conformity with findings (Singh, *et al.*, 2015) (Bahadur *et al.* 2013) (Bhatt *et al.* 2016) (Akram *et al*. 2017) (Bhavani *et al.* 2017) (Patel *et al.* 2018).

Similarly, alkaline phosphatase activity it varied from 148.44-185.97, 152.27-186.73 and 152.05-186.35 µg para nitrophenol g^{-1} hr^{-1}, respectively. The highest percentage of phosphatase activity labelled in organic treatment (T_9) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, *i.e.* 185.97, 186.73 and 186.35 µg para nitrophenol g^{-1} hr^{-1}, in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, *i.e.* 164.53, 165.25 and 164.89 µg para nitrophenol g^{-1} hr^{-1}, which was very low, over control (T_1), *i.e.* 151.81, 152.27 and 152.05 µg para nitrophenol g^{-1} hr^{-1}, respectively. Further, the treatment (T_9) followed by and statistically at par with treatment (T_6) *i.e.* 183.20, 185.78 and 184.49 µg para nitrophenol g^{-1} hr^{-1}, during both the years and on pooled basis, are presented in table 7.

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The microbial bio-mass carbon in treated soil sample varied from 29.40-37.37, 30.66-37.87 and 30.42-37.59 gm kg^{-1}, respectively. The highest percentage of microbial bio-mass carbon labelled in the treatment T_9 consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, *i.e.* 37.37, 37.81 and 37.59 gm kg^{-1}, in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, *i.e.* 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**.**

Further, 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. Microbial biomass carbon have positively correlated with organic carbon content in soil. The work is in conformity with findings, (Beck, *et al.,* 1997) (Leiros, *et al.*, 2000) (Bhatt *et al.* 2016) (Akram *et al*. 2017) (Bhavani *et al.* 2017) (Patel *et al.* 2018).

Table 7: Effect of integrated nutrients on soil enzyme activities during wheat cultivation

T	DHA (µg TPF g^{-1} day^{-1})			APA (µg pNP g^{-1} hr^{-1})			MBC (gm kg^{-1})		
	2018-19	**2019-20**	**Pooled**	**2018-19**	**2019-120**	**Pooled**	**2018-19**	**2019-20**	**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.

4.0 CONCLUSION

The overall result, during two years (2018-19 and 2019-20) of research investigation, delivered to wheat growers that, for optimum yield 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, nutrient availability and economic productivity. However, Integrated treatments found better in organic ones in terms of soil dehydrogenase activity, alkaline phosphatase activity, soil urease activity, available nutrient status, organic carbon and cation exchange capacity. Biofertilizers like *Azatobacter* spp and *Azospirilium* spp (as seed inoculation) @ 3 kg ha^{-1} and farm yard manure @ 5 tha^{-1} has proved potential organic inputs for yield sustenance under wheat crop cultivation.

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