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Evaluation of integrated nutrients through physical properties of soil under wheat (*Triticum aestivum* L.) crop [Cv.PBW-343] cultivation in Inceptisols

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Abstract

Integrated use of farm yard manure, seed inoculation with bio-fertilizers (*Azotobacter* spp and *Azospirilium* spp) and chemical fertilizers was carried out for evaluation of integrated nutrients through physical properties of soil under wheat (*Triticum aestivum* L.) crop [Cv.PBW-343] cultivation in Inseptisol, during cumulative study period of 2018-19 and 2019-20, at Research Farm, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj District of Uttar Pradesh. However, Significantly, with regard to physical soil parameters, cumulative mean value for percent water stable aggregates (54.22%), percent pore space (74.32%), and percent maximum water holding capacity (70.45%) was increased with reduced bulk density (1.11 Mg m^{-3}) opined in treatment (T_9) with 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobactor* spp + *Azospirillum* spp (3kg ha^{-1}) + Zn in comparison with chemical treatment (T_3) alone over control, (T_1). Thus, it could be concluded that integrated nutrients with respect to farm yard manure application along with bio-fertilizers and nitrogen, phosphrous and potassium, improves soil health condition and improves soil dynamics, soil biodiversity, developing the biological activities, increasing the environmental hygiene, soil conservation and supporting the ecology.

Keywords: Wheat, farm yard manure, bio-fertilizers, integrated nutrient management, etc

1. Introduction

In present Indian scenario, for the peoples of our country, wheat mainly serves as life sustaining crop and it is considered as cornerstone of nation's food security system (Anonymous, 2018) [1]. Increasing wheat production is a challenge for the nations to fulfill food requirements by growing populations of the world (Campuzano *et al.*, 2012) [4]. However, Uttar Pradesh is the major wheat producing state with the productivity of 3.27 tons per ha (Ministry of Agriculture & Farmers' Welfare, 2019).

In order to sustain soil health and improvement in soil functional capacity against blanket application of chemical fertilizers irrespectively, the alternative way is through holistic approach of organic manure application. Therefore, problems like multinutrient deficiency in soil, restoration of nutrients in soil, deterioration of crop productivity, soil toxicity and also to avoid financial crisis, could be overcome with valuable resource input availability.

Besides, bio-fertilizers are also act as live formulation of beneficial micro-organism in building up soil nutrient pool which made sufficient for growth of plant. Incorporation of organic sources like FYM with seed inoculation of *Azatobactor* spp and *Azospirilium* spp along with NPK fertilizers is effective in ameliorating antagonistic effects resulting from hidden deficiencies, nutrient imbalance in soil. Thus, soil dynamics could be improved.

Moreover, the region of Prayagraj district falls under order *Inceptisol* and sub group *Typic Ustipsamment*, which constitutes a greater proportion of sand, poor organic carbon status, which shows an imperative approach in uplifting innovative integrated techniques towards changing agriculture scenario was specified.

2. 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 agricultural, 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 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 with twelve treatment combinations (table 1) which is replicated thrice, recommended dose of fertilizers *i.e.* nitrogen, phosphorus and potassium (100%) was applied in the ratio of 120:60:40 kg ha^{-1}, respectively. The sources of nitrogen were 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 *Azospirillum* 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 13th and 14th of November month during 2018 and 2019 with row spacing of 22.5 cm and plant spacing of 5 cm.

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 hypnotized that, the integrated nutrients like farm yard manure, nitrogen levels with zinc 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 knowing nutrient availability in soil.

Among twelve treatments, during field experimentation, the conjunctive use of farm yard manure, seed inoculation with *Azotobacter* spp and *Azospirillum* spp and different nitrogen-levels, together come with best results. Soil physical properties have made the foundation of several chemical and biological processes in soil, which mainly governed by key indicators in relation to climate change, which includes particle size analysis, bulk density, percent soil pore space, maximum water holding capacity and water stable aggregates and they analyzed under lab condition with standard methods employed are presented in table 2.

Table 1: Experimental treatment combination of in-organic fertilizer, 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 + *Azotobactor* spp and *Azospirillum* spp @ 3kg ha^{-1}
T_6	T_4 + *Azotobactor* spp and *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 + FYM @ 5 t ha^{-1}
T_{11}	50% N + *Azotobactor* spp and *Azospirillum* spp @ 3kg ha^{-1}
T_{12}	T_{10} + *Azotobactor* spp and *Azospirillum* spp @ 3kg ha^{-1} + Zn @ 25 kg ha^{-1}

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

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

Sl.no	Physical properties	Author (s)	Methodology	Unit
1.	Aggregate stability	Yoder, 1936 [11]	Yoder wet sieve method	Percentage
2.	Particle size analysis	Bouyoucous, 1927 [3]	Hydrometer method	Percentage
3.	Bulk density	Muthuaval *et al*., 1992[6]	Copper core cylinder method	$Mg\ m^{-3}$
4.	Soil porosity	-	-	Percentage
5.	Maximum water holding capacity	Muthuaval *et al*., 1992[6]	Measuring cylinder followed by water displacement method	Percentage

Physical properties of the soil

Particle size analysis (%)

Particle size analysis says the percent sand, silt and clay in a soil samples was determined by bouyoucos hydrometer method as described by Bouyoucos (1927) [3] using sodium hexa-meta phosphate as dispersing agent. In this method, the quantity of silt and clay particles was determined by measuring the density of soil-water suspension at a given depth as a function of time using hydrometer reading.

Water stable aggregates (%)

A percent water stable aggregate was determined by using wet sieving method as described by Yoder (1936) [11]. Fifty grams of air-dried soil clods, measuring around 5 mm was placed in upper most set of graded sieves which arrange in descending order of screen holes diameter or mesh sizes of 5.0, 2.0, 1.0, 0.5, 0.25 and 0.16-mm. Receiving pan was kept at the bottom. The diameter and height of the sieves was maintained 21cm and 5 cm, respectively. The sample was wet sieved in salt free water using Yoder sieving machine. Oscillation of nests vertically by raising and lowering up to 35 times per minutes for a period of 10 minutes. Then, nests of sieves from tub was removed and drained off the water from tub. Later dried on paper towel and transferred to aluminum can and oven dried at 105 ^{0}C for 24 hours. Mass of oven dry aggregates was recorded.

Maximum water holding capacity (MWHC %)

The maximum water holding or retaining capacity of a given soil sample was determined by using measuring cylinder as displacement method described by Muthuaval *et al*. (1992) [6] and expressed in percentage.

Bulk density (Mg m^{-3})

Bulk density of soil was determined by copper core method as described by Muthuaval *et al*. (1992) [6] and expressed in Mg m^{-3}.

Per cent porosity

The per cent porosity was calculated by using the formula given below

$$\text{Per cent porosity} = 1 - \frac{\text{Bulk density}}{\text{Particle density}} \text{X100}$$

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.

3. Result and Discussion

On the basis of two years analysis, the physical parameters like percent water stable aggregates, particle size analysis, bulk density, percent pore space and percent maximum water holding capacity, according to their characteristics, with respect to treatments subjected with organic and in-organic sources, gave its best.

The range of water stable aggregates was recorded from 40.38-53.99, 40.86-54.45 and 40.62-54.22% respectively, during 2018-19, 2019-20 and as well as on pooled basis is presented in the table 3. However, the highest percent water stable aggregates, was found significantly on application of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, noting, 53.99, 54.45 and 54.22%, respectively and lowest was found in control noting, 40.38, 40.86 and 40.62%, respectively. Further treatment (T_9) followed by treatment (T_6) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}), *i.e.* 53.75, 54.19 and 53.97% and treatment (T_8) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + zinc, *i.e.* 52.83, 53.33 and 53.08%, in which both treatment found similar results and stand statistically at par with treatment (T_9), on par with treatment (T_4) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1}, *i.e.* 52.50, 52.95 and 52.72%, respectively, during both the years and on pooled basis.

The high humic like substances viz, farm yard manure application, which made the soil highly pores. Therefore, soil get build up its capacity in holding the water molecules to a greater extent. Hence, we may expect higher water stable aggregates at organically treated plots.

The spreading of organic amendments improved the maximum water holding capacity in soils with farm yard manure treated plots on comparison with inorganic treated plot. The range was recorded from 55.65-69.25, 56.82-71.66 and 56.23-70.45%, respectively, during 2018-19, 2019-20 and as well as on pooled basis is presented in the table 3. Particularly, treatment (T_9) consisting of 75% nitrogen + farm yard manure @ 5t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, noting, 69.25, 71.66 and 70.45%, noticed maximum water holding capacity, in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, noting, 59.00, 59.91 and 59.46%, which was low, over control (T_1), *i.e.* 57.10, 57.64 and 57.37%, respectively. Further treatment (T_9) was followed by the treatment (T_6) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}), *i.e.* 66.19, 66.62 and 66.40%, (both statistically at par with each other) and on par with treatment (T_8) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1}+ zinc, *i.e.* 65.22, 65.65 and 65.43%, respectively, during both the years and on pooled basis.

The pronouncing effect of organics and bio-fertilizer inoculation resulting in improving the physical properties of the soil, increasing soil fertility and increasing the availability of many nutrient elements for the purpose of plant uptake, which in turn on improving the growth and its components of wheat plant, might be due to the availability of soil microorganisms to convert the unavailable forms of nutrient elements to available form by generating of carbon dioxide from bio-fertilizers. (Mahdi, *et al.*, 2010) (Saber, 1994) [10] (Tadesse, *et al.*, 2013) [8] (Parewa *et al.*, 2014) [7].

Table 3: Effect of integrated nutrients on water stable aggregates and maximum water holding capacity (%) of soil during wheat cultivation

Treatments	Water stable aggregates (%)			Maximum water holding capacity (%)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	40.38	40.86	40.62	57.10	57.64	57.37
T_2	42.72	43.19	42.96	60.72	61.11	60.92
T_3	42.00	42.50	42.25	59.00	59.91	59.46
T_4	52.50	52.95	52.72	62.55	62.94	62.75
T_5	40.79	41.27	41.03	61.45	61.86	61.65
T_6	53.75	54.19	53.97	66.19	66.62	66.40
T_7	41.70	42.17	41.93	55.65	56.82	56.23
T_8	52.83	53.33	53.08	65.22	65.65	65.43
T_9	53.99	54.45	54.22	69.25	71.66	70.45
T_{10}	51.67	52.16	51.92	62.29	62.70	62.49
T_{11}	46.66	47.12	46.89	61.75	62.17	61.96
T_{12}	50.88	51.33	51.10	62.13	62.66	62.39
F- test	**S**	**S**	**S**	**S**	**S**	**S**
S. Ed. (±)	1.930	1.963	1.943	3.445	3.248	3.298
C. D. (P = 0.05)	3.984	4.052	4.011	7.110	6.704	6.807

Note: S-significant

Further, on particle size analysis where, significantly lowest sand percent was found in treatment (T_9) *i.e.* 75% nitrogen + farm yard manure @5t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, noting, 14.01, 14.50 and 14.25%, as compared to treatment (T_3) i.e. 100% nitrogen, noting, 24.32, 24.77 and 24.55%, over control (T_1), noting, 21.32, 21.76 and 21.54%, respectively. Likewise, on percent silt content, the significantly lowest was found in treatment (T_7) noting, 20.81, 19.87 and 20.34%, as compared to other organically treated plots, followed by the treatment (T_2), *i.e.*75% nitrogen, noting, 21.46, 20.52 and 20.99% (both are statistically at par with each other), on par with treatment (T_3), respectively. Significantly highest clay percent was found in treatment (T_9) noting, 62.71, 63.20 and 62.95%, as compared to treatment (T_3) noting, 53.68, 54.13 and 53.90%, over control (T_1) noting, 52.88, 53.32 and 53.10%, respectively. Results are in collaboration with authors. (Mahdi, *et al.*, 2010) (Saber, 1994) [10] (Tadesse, *et al.*, 2013) [8] (Parewa *et al.*, 2014) [7]. The mentioned above data of sand, silt and clay, gives total percentage of sum of a soil particle give rise to 100 percent, was experimented during 2018-19, 2019-20 and as well as on pooled basis, are presented in table 4.

Table 4: Effect on particle size analysis through integrated nutrients under wheat crop cultivation

Treatments	Percent sand content			Percent silt content			Percent clay content		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	21.32	21.76	21.54	25.80	24.92	25.36	52.88	53.32	53.10
T_2	23.67	24.14	23.91	21.46	20.52	20.99	54.87	55.34	55.10
T_3	24.32	24.77	24.55	22.00	21.10	21.55	53.68	54.13	53.90
T_4	18.09	18.50	18.30	23.11	22.24	22.67	58.80	59.26	59.03
T_5	21.44	21.89	21.67	23.01	22.11	22.56	55.55	56.00	55.77
T_6	15.36	14.37	14.87	24.36	24.85	24.60	60.28	60.78	60.53
T_7	22.37	22.84	22.61	20.81	19.87	20.34	56.82	57.29	57.06
T_8	18.28	17.28	17.78	22.59	23.09	22.84	59.13	59.63	59.38
T_9	14.01	14.50	14.25	23.28	22.30	22.79	62.71	63.20	62.95
T_{10}	20.47	20.94	20.71	23.96	23.02	23.49	55.57	56.04	55.80
T_{11}	21.34	21.82	21.58	24.32	23.36	23.84	54.34	54.82	54.58
T_{12}	19.66	20.14	19.90	24.13	23.17	23.65	56.21	56.69	56.45
F- test	S	S	S	S	S	S	S	S	S
S. Ed. (±)	0.651	0.739	0.674	0.508	0.236	0.318	1.271	0.508	0.878
C. D.(0.05)	1.344	1.524	1.392	1.048	0.486	0.656	2.624	1.048	1.813

Note: S-significant

No significant effect was found on bulk density of soil. However, it varied from 1.11-1.32, 1.12-1.37 and 1.11-1.34 Mg m^{-3}, respectively, during 2018-19, 2019-20 and as well as on pooled basis, are presented in table 5. Statistically lower bulk density was opined in treatment (T_9) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* + (3kg ha^{-1}) + zinc, noting, 1.11, 1.12 and 1.11 Mg m^{-3} in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, noting 1.32, 1.37 and 1.34 Mg m^{-3}, which was high, over control (T_1), *i.e.* 1.16, 1.21 and 1.19 Mg m^{-3}, respectively. The lowering of bulk density in organic treated plots, integrated with bio-fertilizers and nitrogen levels, might have attributed due to higher organic carbon content in soil, higher percent bio pore space and better soil aggregation. As a result, we may expect higher root growth proliferation and higher root biomass of wheat at lower layers. The results are in proximity with findings (Tiraks, *et al.*, 1974) [9].

Increasing in percent pore space in sandy loam soil was observed which ranges from 62.64-74.28, 62.69-74.35 and 62.67-74.32% respectively, during 2018-19, 2019-20 and as well as on pooled basis, are presented in table 5. Therefore, statistically higher pore space was opined in treatment (T_9) consisting of 75% nitrogen + farm yard manure @ 5 t ha^{-1} + *Azotobacter* spp + *Azospirillum* spp (3kg ha^{-1}) + zinc, noting, 74.28, 74.35 and 74.32% in comparison with chemical treatment (T_3) consisting of 100% nitrogen alone, noting, 64.98, 65.04 and 65.01%, which was high, over control (T_1), *i.e.* 66.73, 66.81 and 66.77%, respectively. Significant increased pore space of soil subjected under farm yard manure treatment along with in-organics in wheat crop might have promoted as a result of microbial decomposition, where farm yard manure products such as polysaccharides and bacterial gums could have acted as soil particle binding agents. Further, binding agents decrease the soil bulk density by increasing soil water stable aggregates. The results are in conformity with findings (Bhatia and Shukla, 1982) [2].

Table 5: Effect on soil bulk density (Mg m^{-3}) and percent pore space through integrated nutrients under wheat cultivation

Treatments	Soil bulk density (Mg m^{-3})			Percent pore space		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_1	1.16	1.21	1.19	66.73	66.81	66.77
T_2	1.27	1.34	1.31	62.64	62.69	62.67
T_3	1.32	1.37	1.34	64.98	65.04	65.01
T_4	1.11	1.13	1.12	72.19	72.24	72.22
T_5	1.18	1.21	1.20	69.30	69.34	69.32
T_6	1.11	1.14	1.12	73.33	73.39	73.36
T_7	1.22	1.29	1.25	70.93	70.95	70.94
T_8	1.11	1.13	1.12	72.78	72.82	72.80
T_9	1.11	1.12	1.11	74.28	74.35	74.32
T_{10}	1.12	1.15	1.13	70.83	70.85	70.84
T_{11}	1.16	1.20	1.18	61.75	62.17	61.96
T_{12}	1.11	1.12	1.12	62.13	62.66	62.39
F- test	NS	NS	NS	S	S	S
S. Ed. (±)	0.254	0.267	0.257	3.445	3.248	3.298
C. D. (P = 0.05)	0.525	0.550	0.530	7.110	6.704	6.807

Note: S-significant, NS-Non significant

4. Conclusion

It is concluded from findings that, the application of farm yard manure along with bio-fertilizers and nitrogen, phosphorus and potassium, improves soil health condition and improves soil dynamics, soil bio-diversity, developing the biological activities, increasing the environmental hygiene, conservation and supporting the ecology.

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