Original Research Article

Effect of balance and imbalanced fertilization on soil physical properties, growth and yield of rice in Chhattisgarh

ABSTRACT

Effect of balance and imbalanced fertilizationon soil physical Properties, nutrient uptake, growth and yield of rice in Chhattisgarh was studied under long-term fertilizer experiment during kharif 2019-20 at research farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). The experiment comprised of different levels or doses of NPK fertilizers alone and in combination with zinc sulphate, farmyard manure (FYM), blue green algae (BGA) and green manuring (GM) was laid out in randomized block design with four replications and ten treatments viz. Control, 50% NPK, 100% NPK, 150% NPK, 100% NPK+$ZnSO_4$@ 10kgha^{-1},100% NP, 100% N, 100% NPK + FYM @5t ha^{-1}, 50% NPK+BGA@ 10kg ha^{-1} and 50% NPK + GM @40kg ha^{-1}.The results showed that the physical properties like total porosity, gravimetric and volumetric moisture content, hydraulic conductivity, infiltration rate, water stable aggregates and mean weight diameter of the soil were increased, while the bulk density was reduced significantly with the 100% NPK FYM treatment over all other treatments. However, the use of imbalanced (100% N and 100% NP) fertilizer, super optimal (150% NPK) and sub optimal (50% NPK) rate of inorganic fertilizer as compared to the unfertilized control showed significant effect on the physical properties of soil. Integrated nutrient management practice including FYM and recommended dose of NPK showed as best treatment with respect to growth and yield parameters like plant height, no. of tillers and no. of grains as compare to other treatments. The grain (5065 kg ha-1) and straw (7075 kg ha^{-1}) yield of rice was registered higher in 150% NPK treatment followed by 100% NPK FYM treatment (4855 kg ha^{-1} and 6565 kg ha^{-1}) and lowest in control treatment (2350 kg ha^{-1} and 2680 kg ha^{-1}).

Keywords - *Total porosity, gravimetric and volumetric moisture content, hydraulic conductivity, infiltration rate, water stable aggregates and mean weight diameter.*

INTRODUCTION -

The negative impacts of imbalanced fertilizers, coupled with escalating prices, have led to growing interests in the use of organic materials as a source of nutrients. The soil organic matter plays an important role in improvement of soil physical, chemical and biological properties and ultimately increasing soil productivity and crop yields (Antil *et al.,* 2011). Long-term experiment have shown that crop residues incorporation, farm yard manures and green manuresincreased soil organic carbon and nutrient availability as compared to the nitrogenous fertilizers alone. Balanced use of nutrients is one of the most important factors for sustaining agricultural production and soil health. The results emanating from long-term fertilizer experiments across the country have clearly indicated that imbalance use of chemical fertilizers has resulted in numerous problems *viz.*micronutrient deficiencies, nutrient imbalances in soil and plant system, environmental degradation and deterioration of soil health.

The combined use of organic and inorganic sources of plant nutrients not only pushed the production and profitability of field crops but also helped in maintaining the fertility status of the soil. The advantage of combining organic and inorganic sources of nutrients in integrated nutrient management has been proved superior to the use of each component separately (Palaniappan and Annadurai 2007).

C.G. state is popularly known as “Rice bowl of India” because maximum area is covered under rice during kharifand contribute major share in national rice production. Rice is cultivated in an area of 4.61 M ha with the production of 6.8 million tones and productivity of 17.17 q /ha.

Comment [RL1]: •The introduction that you created is still very general. Please add briefly, concisely and clearly regarding how the treatment you provide can contribute to influencing the physical properties of the soil, growth and plant yields especially in rice. This explanation is better supported by various literature and previous research about the treatment you use.
•The purpose of the research has not been explain, it should be added.

MATERIALS AND METHODS

Study Site Description

A field experiment was conducted on *Vertisol* of Research Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidhyalaya, Raipur, Chhattisgarh. Raipur is situated at 210 4' North Latitude and 810 4' East Longitude with the altitude of 293 meter above mean sea level.

Comment [RL2]: It would be better if you can added how the environmental conditions at your research location

Experimental details

The field experiment was conducted in randomized block design with four replicates in rice as a test crop and supplementing a part of nitrogen through different organic sources viz., FYM, green manure (*Crotolaria juncea*) and blue green algae. A set of ten treatments was repeated in the permanent laid out plots with following treatment details: T1 – Control, T2 - 50% of the recommended optimum NPK dose, T3 - 100% of the RDF NPK dose , T4 - 150% of the RDF optimum NPK dose, T5 - 100% of the rec. optimum NPK + ZnSO4 @ 10 kg ha^{-1} in kharif crop only, T6 - 100% NP of rec. optimum N and P dose, T7 - 100% N of rec. optimum N dose, T8 - 100% NPK + FYM (@5 t ha^{-1}), T9 - 50% NPK + BGA (10 kg ha^{-1}), T10 - 50% NPK + Green manure.

Comment [RL3]: Explain more detail

Comment [RL4]: Explain more detail, control is what treatment?

Soil sampling and analysis

For determining ofBulk density was determined by removing natural undisturbed core samplefrom soil by iron core sampler. Total porosity was estimated from the bulk density and particle density of the soil. Soil Moisture Content was estimated from Fresh weight of soil and dry weight of soil. Volumetric Moisture Content was estimated by multiplying bulk density with corresponding soil moisture content. Steady state infiltration rate was measured by using double ring infiltrometer. Reading were recorded at 5, 10, 15, 30 minutes and then one hour intervals till constant steady state rate was obtained (Gupta, 1999). The procedure used for aggregate analysis was Modified Yoder's wet sieving method (Yoder, 1936).Soil samples were collected in between from 0 to 15 cm depth segment after harvest of rice crop. At the time of sampling the sample were brokengently at their natural cleavage and air dried in the laboratory. Air - dried soil samples were passed through 4 mm sieve. These samples were cleaned by removing roots, lime, concentration etc. The nest of five sieve having 2,1,0.5,0.25 and 0.125 mm opening were mounted on sieve holders in the Yoder type wet sieving machine. Air dried triplicate soil samples were used for analysis. Out of them one sample was kept for moisture content estimation and the remaining two samples were used for aggregate analysis. In the sieve set the soil sample was placed at top sieve.Immediately prior to sieving, water level was raised rapidly to a point where it fairly covers the sample when sieve set at its highest position.

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RESULTS AND DISCUSSION

Comment [RL6]: It would be better if the result in each parameters added after the explanation or before the explanation.

Bulk Density

Bulk Density of soil (0 - 0.15 m depth) is measured at flowering and harvesting stages of rice crop. At flowering stage of the crop it ranged from 1.29 to 1.43 Mg $m^{-3}$and at harvesting stage of the crop varied from 1.30 to 1.47 Mg m^{-3} under different treatments. Bulk density was considerably less in organic manure plots. The lower values of bulk density 1.29 and 1.30 Mg m^{-3} at flowering and harvesting stage of crop respectively were recorded in 100% NPK+FYM treatment as compared to other treatments. (Table1)

Total Porosity

The 100% NPK + FYM, 50% NPK + GM and 50% NPK + BGA plots had greater micro porosity than control and 100% alone inorganic fertilizers plots at both (flowering and harvesting stage) stages of the crop. Increase in total and micro-porosity of the soil with fertilizer and manure treatments could be attributed to higher organic matter content, better aggregation and change in pore size distribution of soil. Hati *et al.* (2007) found that total porosity of the soil increases with fertilizer and compost application, depending upon the amount of materials added. (Table1)

Gravimetric and Volumetric moisture Content

The 100% NPK + FYM had the highest gravimetric moisture content(25.96 %) followed by 150% NPK (21.56 %) and lowest in control (18.54 %) at 45 DAT. Interaction between different treatment levels

were observed to be significant effect on both 45 DAT and 95 DAT of the crop. At 45 DAT the Gravimetric moisture content was recorded low values as compare to the flowering stage of the crop. The 100% NPK + FYM treatment had the highest Volumetric moisture content at flowering stage that was on par with 150% NPK results and the lowest volumetric moisture content was observed under control. (Table 2)

Infiltration rate

The higher infiltration rate was recorded in treatment 100% NPK+FYM (8.0 mm/hr), followed by 50% NPK+GM (7.0 mm/hr) and lowest(3.0 mm/hr) in control plots. The higher cumulative infiltration (Table 2) was recorded in 100% NPK + FYM (694 mm), followed by 50% NPK + BGA (625 mm) and lowest (443 mm) in control plots.

Water stable aggregates

The coarser (> 2mm) aggregate showed the significant difference amongst various treatments. The organic source of nutrient like FYM, GM and BGA showed significant increased in coarser aggregates (> 2 mm) over the control plot. (Table 3)

Mean weight diameter (MWD)

Mean weight diameter (MWD) was significantly influenced by different treatments and it had considerable increase with the increasing dose of NPK through organic and inorganics from 1.302 to 2.093 mm. The highest value of MWD was recorded under 50% NPK + GM plot (2.093 mm) and 100% NPK + FYM treated plot (2.051 mm) and the lowest value was recorded under control plot (1.302 mm). (Table 3)

Table 1- Effect of inorganic fertilizer and organic manure on bulk density and total porosity of soil during rice growth.

Treatments	Bulk density (Mg m^{-3})		Total porosity (%)	
	flowering stage	harvesting stage	flowering stage	harvesting stage
Control	1.40	1.43[a]	47.16	45.94
50% NPK	1.36	1.37[b]	48.67	48.01
100% NPK	1.35	1.37[b]	49.05	48.01
150% NPK	1.38	1.39[b]	47.92	47.54
100% NPK + Zn	1.40	1.42[ab]	47.16	46.12
100% NP	1.39	1.36[bc]	47.54	46.41
100% N	1.43	1.47[a]	46.03	44.52
100% NPK + FYM	1.29	1.30[c]	51.31	50.93
50 % NPK + BGA	1.32	1.34[c]	50.18	49.24
50% NPK + GM	1.31	1.32[c]	50.56	49.90
Sem (±)	0.05	0.02	2.00	2.26
CD (P = 0.05)	NS	0.06	NS	NS

Table 2. Gravimetric and volumetric moisture content and infiltration rate as effected by the continuous application of fertilizers and organic manure.

Comment [RL7]: It should be discussed more why the treatment just affected to bulk density in harvesting stage? And why the treatment of 100% N give the best result

Comment [RL8]: All the tables in the result should be tidied up and it would be better to create an open table model. All the word and value should be in center position

Comment [RL9]: Don't use double and wih one sentences

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Treatments	Gravimetric moisture content (θ_w %)		Volumetric moisture content (θ_v %)		Infiltration rate (mm hr^{-1})
	45 DAT	95 DAT	45 DAT	95 DAT	
Control	18.54^{c}	18.36^{d}	25.98^{b}	25.83^{bc}	3.0^{h}
50% NPK	19.97^{c}	19.72^{c}	27.12^{b}	26.87^{b}	4.0^{fg}
100% NPK	20.30^{bc}	20.01^{c}	27.36^{b}	27.00^{b}	5.0^{de}
150% NPK	21.56^{b}	21.27^{b}	29.69^{ab}	29.43^{b}	6.0^{c}
100% NPK + Zn	20.30^{b}	20.19^{bc}	28.34^{b}	28.93^{b}	4.0^{f}
100% NP	19.91^{c}	19.35^{cd}	27.64^{b}	26.92^{b}	5.0^{d}
100% N	18.70^{c}	18.44^{d}	26.70^{b}	23.93^{c}	5.0^{d}
100% NPK + FYM	25.96^{a}	24.48^{a}	33.60^{a}	34.84^{a}	8.0^{a}
50 % NPK + BGA	20.83^{b}	20.48^{b}	27.50^{b}	27.05^{b}	5.0^{d}
50% NPK + GM	22.49^{b}	21.79^{b}	29.41^{b}	28.61^{b}	7.0^{b}
Sem (±)	0.79	0.56	1.39	1.50	0.24
CD (P = 0.05)	2.30	1.63	4.03	4.35	0.11

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Table 3. Percent water stable aggregates and mean weight diameter under different treatments after 14 cycles of rice.

Treatments	Percent water stable aggregates					MWD(mm)
	>2mm	2-1mm	1-0.5mm	0.5-0.25mm	<0.25mm	
Control	4.70^{i}	63.06^{ab} (67.76)*	19.97^{ab} (87.73)	7.68^{c} (95.41)	4.55^{bc} (99.96)	1.302^{g}
50% RDF	15.23^{fg}	57.87^{bc} (73.1)	14.51^{c} (87.61)	7.11^{cd} (94.72)	5.14^{b} (99.86)	1.532^{de}
100% RDF	22.03^{e}	44.63^{ef} (66.66)	22.51^{a} (89.71)	8.57^{c} (97.74)	2.22^{cd} (99.96)	1.626^{d}

Comment [RL12]: Give the note what the meaning of the values

150% RDF	32.1^{bc}	46.48^{de} (78.58)	11.48^{cd} (90.06)	7.51^{c} (97.57)	2.24^{c} (99.81)	1.924^{bc}
100% RDF + Zn	16.17^{f}	52.19^{c} (68.36)	9.01^{d} (77.37)	15.43^{ab} (92.8)	7.16^{b} (99.96)	1.468^{ef}
100% NP	19.24^{ef}	56.19^{c} (75.43)	12.37^{c} (87.8)	10.45^{c} (98.25)	1.54^{d} (99.79)	1.636^{d}
100% N	12.78^{gh}	68.92^{a} (81.7)	9.75^{d} (91.45)	6.09^{d} (97.54)	2.42^{c} (99.96)	1.559^{d}
100% NPK+FYM	48.56^{a}	16.05^{g} (64.61)	6.76^{e} (71.37)	16.77^{a} (88.34)	11.77^{a} (99.91)	2.051^{a}
50% NPK+BGA	31.54^{cd}	51.51^{cd} (83.05)	8.71^{de} (91.76)	7.38^{c} (99.14)	0.82^{d} (99.96)	1.963^{ab}
50% NPK+GM	37.11^{b}	49.84^{d} (89.65)	5.33^{e} (92.28)	4.45^{d} (96.73)	3.22^{c} (99.95)	2.093^{a}
SEm (±)	1.81	2.31	1.37	1.45	1.05	0.04
CD (P=0.05)	5.26	6.72	3.97	4.21	3.05	0.13

Plant height

(Table 4)Application of 100% NPK + FYM recorded the highest plant height at all stages of rice growth (45 DAT, 75 DAT and 105 DAT) which was at par with 150% NPK but significantly superior to control. The combined use of organic and inorganic sources of plant nutrients in varying proportions resulted better growth of the plants.

Number of tillers

Among the different fertilizer treatments, 150% NPK significantly enhanced the number of effective tillers per hill (6.95) over control (4.85). The treatments 150% NPK, 100% NPK + FYM, 100% N, 50% NPK + GM were statistically at par and significantly higher than other treatments. Nayak *et al.*(2007) reported a significant increase in number of effective tillers per hill due to application of chemical fertilizer with organic manure. (Table 4)

Comment [RL13]: It would be better if you added how your treatment works (the mechanism) until it can influence the various parameters you observed.

Number of grains

123 number of grains panicle^{-1}were noted in 100% NPK + FYM which was found significantly higher than that under control and completely chemically fertilized plot but remained at par with 50% NPK + GM and 50% NPK + BGA. (Table 4)

Yield

Grain yield of rice varied from 2350 to 5065 Kg ha^{-1} amongst different nutrient concentration alone and along with organics. Increase in grain yield over control (2350 Kg ha^{-1}) was 2945, 4345 and 5065 Kg ha^{-1} with the application of 50, 100 and 150% NPK, respectively. Among the treatments maximum grain (5065 Kg ha^{-1}) and straw yield (7075 Kg ha^{-1}) were obtained with 150% NPK. This may be due to the higher available nutrients and optimum soil properties in the plots receiving higher dose (150% NPK) of inorganic fertilizers. Similar results were also reported by Pandey *et al.* (2009). Incorporation of organic sources with inorganic sources of nutrition, the grain (4855 Kg ha^{-1}) and straw yield (6565 Kg ha^{-1}) of 100% NPK + FYM higher than 50% NPK + GM and 50% NPK + BGA. The integrated effects of fertilizer and farm yard manure, blue green algae and green manure were noted to be more beneficial than the use of chemical fertilizer alone. (Table 5)

Table 4. Effect of integrated plant nutrient management on growth parameters of rice.

Treatments	Plant Height (cm)			Tillers per hill	Effective Tillers	No of grains
	45 DAT	75 DAT	105 DAT			
Control	49.06^{d}	77.76^{e}	83.6^{e}	6.5^{b}	4.85^{c}	77^{e}

50% NPK	56.98^{bc}	83.02^{cd}	97.9^{c}	7.4^{a}	6.25^{a}	97cd
100% NPK	63.62^{a}	97.06^{a}	103.22^{b}	7.725^{a}	5.875^{b}	106^{b}
150% NPK	67.85^{a}	98.59^{a}	105.5^{b}	7.95^{a}	6.95^{a}	107^{b}
100 % NPK + Zn	63.68^{a}	93.58^{b}	104.48^{b}	7.05^{ab}	5.95^{b}	98^{c}
100 % NP	62.68^{ab}	95.48^{b}	99.48^{c}	7.2^{a}	5.85^{b}	105^{b}
100% N	53.48^{cd}	82.85^{de}	97.77^{cd}	7.7^{a}	6.9^{a}	102^{bc}
100% NPK + FYM	68.37^{a}	102.87^{a}	112.8^{a}	8a	6.9^{a}	123^{a}
50% NPK + BGA	56.98^{b}	90.92^{bc}	102^{bc}	6.65^{b}	5.4^{bc}	98^{c}
50% NPK + GM	61.81^{a}	96.65^{ab}	104.04^{b}	7.35^{a}	6.05^{ab}	116^{ab}
SEm (±)	2.02	2.18	2.00	0.33	0.32	4.87
CD (P=0.05)	5.87 (S)	6.33 (S)	5.81 (S)	0.96 (S)	0.92 (S)	14.14 (S)

Table 5. Long term effect of various treatments on Grain and Straw yield of rice crop

Comment [RL14]: Consistent of using various treatments or explain detail about the treatment in general. Look the other title of the tables.

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Treatments	**Yield (Kg ha^{-1})**	
	Grain	**Straw**
Control	2350^{f}	2680^{d}
50% NPK	4045^{c}	4775^{b}
100% NPK	4345^{bc}	5555^{a}
150% NPK	5065^{a}	7075^{a}
100 % NPK + Zn	4135^{c}	5510^{ab}
100 % NP	4345^{bc}	5835^{a}
100% N	3950^{cd}	5390^{b}
100% NPK + FYM	4855^{ab}	6565^{a}
50% NPK + BGA	3675de	4615^{bc}
50% NPK + GM	4105^{c}	6555^{a}
SEm (±)	230	543.
CD (P=0.05)	667	1576

CONCLUSION

The bulk density of soil decreased with the application of farmyard manure, green manure and blue green algae in combination with fertilizers and use of imbalanced fertilizers increased the bulk density, which might be due to deterioration of soil structure. The lower values of bulk density 1.29 and 1.30 Mg m-3 at flowering and harvesting stage of crop respectively were recorded in 100% NPK+FYM treatment as compared to other treatments. The increase in percent moisture content in the organic manure treated plot may be due to increase in macro and micro pores of the soil and also better aggregation of soil separates. The application of FYM, green manure and crop residue decreased the bulk density and increase in soil aggregation which in turn increased the infiltration rate. The higher infiltration rate was recorded in treatment 100% NPK+FYM (8.0 mm/hr), followed by 50% NPK+GM (7.0 mm/hr) and lowest(3.0 mm/hr) in control plots.

The direct addition of organic matter through farm yard manure and subsequentincrease in root biomass which helped in growth and development of soil microorganisms causing beneficial effect on improvement in soil structure (Water stable aggregates and mean weight diameter and soil moisture content).The highest value of MWD was recorded under 50% NPK + GM plot (2.093 mm) and100% NPK + FYM treated plot (2.051 mm) and the lowest value was recorded under control plot (1.302 mm).

Use of recommended dose of nutrients through inorganic fertilizers through sustained the yields and improved the soil physical and chemical properties to the extent of combined use of the organics and inorganics. The grain (5065 kg ha^{-1}) and straw (7075 kg ha^{-1}) yield of rice was registered higher in 150% NPK treatment followed by 100% NPK + FYM treatment (4855 kg ha^{-1} and 6565 kg ha^{-1}) and lowest in control treatment (2350 kg ha^{-1} and 2680 kg ha^{-1}).

Comment [RL16]: All your explanation in conclusion is too long. The conclusion should be presented with short, dense, and clear. All the detail explanation of WHY should be added in Result and Discussion.

Comment [RL17]: The references you used are too few. Please add more and use more updated references

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