

Review Article

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A Brief Review on Effect of Continuous Application of Fertilizers and Manures on Soil Physical Properties, Nutrient Uptake, Growth and Yield of Rice on *Chromustert*

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ABSTRACT

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This review pertinent to the present investigation entitled, "Effect of continuous application of fertilizers and manures on soil physical properties, nutrient uptake, growth and yield of rice on *Chromustert*" has been reviewed in this chapter under the following heads: I. Effect of continuous application of inorganic fertilizer and organic manures on soil physico-chemical properties. II. Effect of continuous application of inorganic fertilizer and organic manures on soil nutrient status. III. Effect of continuous application of inorganic fertilizer and organic manures on growth parameters, yield and nutrient uptake.

Introduction

Effect of continuous application of inorganic fertilizer and organic manures on soil physico-chemical properties

Bulk density

Prasad and Singh (1980) reported that continuous use of FYM and NPK fertilizers over a period of 20 years helped in maintaining and improving the physical properties and organic carbon content of an acidic red loam soil, while the application of fertilizer nitrogen alone slightly deteriorated soil physical properties. Treatment effect on bulk density of soil was not significant, although in some of the treatments there was a tendency for the bulk density to increase

from the initial level. The lowest bulk density was found in FYM+PK (1.29 Mg/m^3) plot. A decline in bulk density due to the application of organic matter has been reported by Pandey *et al.*, (1985).

Rabindra *et al.*, (1985) found that the combined application of in-organics and organic material maintained and improved the physical condition of the soil and the productivity. Urea as the organic sources of fertilizer N was found to be better than other sources tried in maintaining the soil physical condition and productivity. The lowest bulk density was found under normal dose of NPK+ 25t FYM ha^{-1} and the highest bulk density was found in no manure (control).

Studies conducted by Sharma and Sharma (1994) also revealed that there was a reduction in soil bulk density from the initial value due to increased fertilizer levels or FYM application, but in unmanured plots bulk density remained stable around initial value.

Bellakki and Badanur (1997) reported that *in situ* incorporation of sun hemp for ten years from 1984-94 reduced the bulk density as compared with fertilizer application.

Premi (2003) and Mandal *et al.*, (2003) reported that combined use of organic and inorganic sources of N decreased the bulk density of soil.

Bajpai *et al.*, (2006) found that incorporation of organic sources considerably decreased the bulk density of the soil. The lowest bulk density was observed in the 50 per cent NPK through fertilizer + 50 percent N through green manure treatment (1.43 Mg m^{-3}), while the highest was noted in control plot (1.56 Mg m^{-3}).

Chaudhary and Thakur (2007) revealed that FYM along with fertilizers had a positive response on penetration resistance and bulk density of soil.

Hati *et al.*, (2007) suggested that the bulk density was reduced significantly with the 100% NPK + FYM treatment over all other treatments.

Bandyopadhyay *et al.*, (2010) reported that conjunctive use of recommended dose of fertilizer and farmyard manure (NPK + FYM) resulted in significant ($P < 0.05$) decrease of bulk density.

Katkar *et al.*, (2012) noticed that the application of farm yard manure @ 10 tonnes/ha recorded significant decrease in

bulk density as compared to 100% NPK and 150% NPK through chemical fertilizer without organics.

Hydraulic conductivity

Prasad and Singh (1980) found that in acidic red loam soil, the use of FYM @ 20 t/ha with inorganic fertilizer providing P and K had significantly higher hydraulic conductivity (2.5 cm hr^{-1}) over the control and after 20 years it is similar to initial value (2.0 cm hr^{-1}).

Bhatia and Shukla (1982) reported that nitrogenous and phosphate fertilizers have a tendency to increase hydraulic conductivity probably due to increased large pores in soil.

Mishra and Sharma (1997) reported that in calcareous silt loam soil, increasing level of fertilizer dose significantly increase the hydraulic conductivity. Among the application of inorganic fertilizer, 100% NPK alone treated plot recorded ($14.7 \times 10^{-7} \text{ m sec}^{-1}$) reduced hydraulic conductivity ($23.7 \times 10^{-7} \text{ m sec}^{-1}$).

The combined application of FYM and fertilizers has favourable effect on the hydraulic conductivity of soil. Favourable treatment effects on aggregation and BD were well reflected in their effect on hydraulic conductivity.

Selvi *et al.*, (2005) observed that different treatment effects on aggregation and bulk density were well reflected on hydraulic conductivity. Increasing levels of fertilizers significantly increased hydraulic conductivity. Combined application of FYM and NPK also resulted in significantly highest hydraulic conductivity than NPK application. Highest hydraulic conductivity was noted in 100 percent NPK + Zn SO_4 treated plot (1.99 cm hr^{-1}) and lowest was found in control (1.44 cm hr^{-1}) plot.

Katkar *et al.*, (2012) revealed that the direct addition of organic matter through farm yard manure and increase in root biomass which helped in growth and development of soil micro-organisms cause beneficial effect on improvement in mean weight diameter, available water holding capacity and hydraulic conductivity.

Infiltration rate

Acharya *et al.*, (1988) studied the infiltration rate and cumulative infiltration rate (for 180 min), which showed a greater variation owing to the imposition of different treatments. 100 per cent NPK + FYM and 150 per cent NPK showed the highest infiltration rate of 18.9 and 18.4 cm hr⁻¹ respectively.

More (1994) on sodic *Vertisol* under rice-wheat rotation observed that application of FYM; organic waste and manures decreased soil pH but increased the infiltration rate.

Bellaki and Badanur (1997) found that the improvement in infiltration rate of *Vertisol* in 50% RDF + 50% N applied either through green manure or FYM in Sorghum-Safflower crop rotation over 10 year under dry land condition. *Sesbania* GM and Mungbeen residue incorporation resulted in reduction of bulk density and increase in soil aggregation which in turn increased the infiltration rate and percolation rate in rice-wheat cropping system (Mandal *et al.*, 1999).

Harne (2001) observed that the combined application of FYM @ 3.37 t ha⁻¹ + 55 Kg N and GM @ 1.9 t ha⁻¹ + 40 Kg N showed significantly increased infiltration rate i.e. 3.10 and 3.60 mm day⁻¹ respectively, over general recommended dose treated plot (2.50 mm day⁻¹). This indicates that in *Vertisol*, addition of coarse organic matter with inorganic fertilizers increased the basic infiltration rate. This higher infiltration rate

could be associated with decreased bulk density and increased porosity of *Vertisol*.

Gangwar *et al.*, (2002) reported that in rice-wheat system, there was tremendous increase in infiltration rate from 0.58 mm hr⁻¹ of initial value to 1.97 mm hr⁻¹ with the addition of *Sesbania seaban* lopping @ 5 t ha⁻¹ year as green manure incorporation in sandy loam soil. This higher infiltration rate could be associated with decreased bulk density and increased porosity of *Vertisol*.

Marathe and Bharambe (2005) noted that application of recommended dose of fertilizer had higher infiltration rate (1.27 cm hr⁻¹) and cumulative infiltration (108 mm) over control (0.80 cm hr⁻¹ and 63 mm).

Sharma (2005) reported that green manuring with *sesbania* or green gram residues incorporation in combination with 100 per cent N (120 kg ha⁻¹) treated plot recorded increased infiltration rate i.e. 2.21 and 2.19 cm hr⁻¹ respectively, over the fallow plots (2.13 cm hr⁻¹). These treatments are pre-rice treatment and observations were recorded at the time of wheat sowing. Residue incorporation resulted in reduction in BD and increase in soil aggregation, which in turn increased infiltration, percolation rate and hydraulic conductivity of soil.

Bajpai *et al.*, (2006) observed that integrated nutrient management in rice wheat system had marked influence on infiltration rate. However the infiltration rate was significantly higher (1.30 cm hr⁻¹) in 100 per cent recommended NPK through fertilizer in rice and wheat, over the control plot (0.85 cm hr⁻¹).

Tripti (2013) revealed that the application of organic manure along with chemical fertilizers had marked influence on infiltration rate. The higher infiltration rate in treatment

100% NPK + FYM and 50% NPK + GM as compared to other treatments. This indicates that the higher infiltration rate could be associated with decreased bulk density and increased porosity of the soil.

Soil aggregates

Mishra and Sharma (1997) revealed that the interaction effect of fertilizer and organic manures was not significant but its values indicated that combined application of fertilizer with FYM increased per cent fine (11.4%) and coarse aggregate (4.2%) size, in calcareous silt loam soil over control plot i.e. 10% fine and 3.9% coarse aggregates.

Marathe and Bharambe (2005) reported that application of recommended dose of fertilizer in *Vertisol* soil of Nagpur have per cent water stable aggregates (WSA) more than 0.25, 0.10 mm and mean weight diameter (MWD) recorded 40.4, 74.0 and 0.286 mm as compared to control i.e., 34.1, 64.1 and 0.233 mm, respectively.

Selvi *et al.*, (2005) revealed that the continuous application of fertilizer (100% NPK) showed significant increase in MWD and per cent WSA values from 0.703 mm and 82.3% as compared to 0.696 mm and 72.6% in control. They further reported that increase in aggregate stability as compared to control due to balanced dose of fertilizer on soil structure may be because of the role played by phosphate ions in binding of soil particles (Sivasamy, 1982) or due to large amount of residues produced in the fertilized plots resulting in aggregate formation.

Hati *et al.*, (2007) studied that the MWD and % WSMA in 100% NPK + FYM were significantly higher than in the other treatments. Fertilizer plus manure application (100% NPK + FYM) increased by 35.3%, while recommended rate of fertilizer

application (100% NPK) increased it by 17.6% compared to the control. The MWD in 100% NPK was significantly more than in control and 100% N. This might be ascribed to higher organic matter content in the plots where NPK was applied alone or in conjunction with FYM.

Chakraborty *et al.*, (2010) observed that better aggregation was found with 100% NPK + farmyard manure, where macro aggregates were greater than 50% of total soil mass. Aggregation indices were positively and significantly correlated with soil organic carbon in 8 - 4 mm aggregates.

Crack volume

Dasog and Shashidhara (1993) studied the crack volume in a *Vertisol* under different crop covers and concluded that crack volume was highest in the plot under safflower (445 m² ha⁻¹) followed by plots under wheat (353 m² ha⁻¹) and chick pea (310 m² ha⁻¹). The crack volume was highest in plots planted with safflower because of its deep rooting and efficient moisture extraction and least in fallow plot (234 m³ ha⁻¹). The moisture content affect crack volume, also supported by EI Abedine and Robinson (1971) showing that crack width is affected by length of the dry period and the crack depth is inversely related to moisture content.

Vishwambharrao (2005), reported that increasing dose of chemical fertilizers along with organic manures responsible for decrease in crack volume, whereas omission of chemical fertilizer plot much higher crack volume than optimal and sub optimal application of chemical fertilizer.

pH

Sheeba and Chellamuthu (2000) observed that the continued application of varying

quantities of inorganic fertilizers and their combination with FYM over 22 years did not alter the pH appreciably.

Pothare *et al.*, (2007) reported that all the soil properties such as pH were favorably influenced with the conjunctive use of organics and inorganics.

Highest values were observed in the treatment of 100% NPK + 10 t FYM ha⁻¹. In general among all the treatments 100% NPK+FYM showed better result and control gave poorest results. Similar results were also observed by Agrawal *et al.*, (2010).

Rajeswar *et al.*, (2009) reported that all the pedons were neutral (7.4) to moderately alkaline (8.7) in reaction (pH) in soils of Garikapadu of Krishna (A.P.). Lower pH values were recorded in the surface as compared to subsurface horizons.

Mohana Rao *et al.*, (2013) reported that the pH of soil was not influenced statistically by various treatments.

The continuous use of manures and fertilizer, slightly lowered the pH. Increased dose of fertilizer decreased the pH. Sharma *et al.*, (2007) also reported non-significant results in soil pH after 31 year of experimentation.

Electrical conductivity

Pothare *et al.*, (2007) reported that all the soil properties such as electrical conductivity (EC) were favorably influenced with the conjunctive use of organics and inorganics. Highest values were observed in the treatment of 100% NPK + 10 t FYM ha⁻¹. The results were conformity by the findings of Agrawal *et al.*, (2010).

Rajeswar *et al.*, (2009) reported that the EC values varied from 0.10 to 0.32 dSm⁻¹ in the soils of Garikapadu, Krishna (A.P.).

Organic carbon

Tiwari *et al.*, (2002) reported from the experiment conducted on Typic Haplustalf: that the continued application of fertilizers alone also helped in increasing the organic carbon content of soil, which could be attributed to higher contribution of biomass of soil in the form of crop stubbles and residues.

Fan *et al.*, (2005) observed that the combination of organic and inorganic fertilization enhanced the accumulation of soil organic carbon and maintained the highest productivity. Hati *et al.*, (2007) stated that the balanced application of inorganic fertilizer and organic amendments greatly influenced the accumulation of organic matter in soil.

Pothare *et al.*, (2007) reported that all the soil properties such as organic carbon were favorably influenced with the conjunctive use of organic and inorganic. Highest values were observed in the treatment of 100% NPK + 10 t FYM ha⁻¹. Similar results were also experienced by Agrawal *et al.*, 2010.

Katkar *et al.*, (2012) described that the organic manures (FYM) along with recommended dose of fertilizers found to be viable option in increasing soil organic carbon, nutrient turn over, enhancing microbial biomass, thereby improvement in availability of nutrients in soil, maintenance of soil quality and achieving the sustainable productivity of sorghum and wheat for long run in rainfed as well as irrigated moisture regimes.

Moharana *et al.*, (2012) reported that the continuous application of FYM either alone or in combination with NPK resulted in considerable accumulation of total SOC in 10-15 CM soil layer than unfertilized control plots. Further they concluded that for sustainable crop production and maintaining

Soil Quality, input of organic manure like FYM is of major importance and should be advocated in the nutrient management of intensive cropping system for improving chemical and biological properties of soil.

Effect of continuous application of inorganic fertilizer and organic manures on soil nutrient status

Yashpal *et al.*, (1993) studied that larger buildup in available phosphorus with green manure and crop residue may be attributed to the influence of organic manure in increasing the labile phosphorus in soil through complex of cations like Ca^{2+} and Mg^{2+} which are mainly responsible for the fixation of phosphorus in calcareous soil.

Gupta (2000) reported the available N, P, and K status in soil also improved with the individual application of fertilizer nutrients but still higher build-up of available N, P, and K was noted in FYM/Compost treated plots. Sharma *et al.*, (2000) revealed that the favorable soil conditions under compost and crop residue might have helped in the mineralization of soil N leading to the buildup of higher available nitrogen.

Usman (2000) reported that effects of organic sources alone on the growth of rice plant and its growth parameters were not significant due to their slow supply of nutrients.

These growth parameters were improved when supplemented with mineral fertilizers at the rate of 100-75-60 kg N, P_2O_5 and K_2O ha^{-1} along with organic materials. Pothare *et al.*, (2007) reported that all the soil properties such as available NPK were favorably influenced with the conjunctive use of organics and inorganics. Highest values were observed in the treatment of 100% NPK + 10 t FYM ha^{-1} . The results were in agreement with the finding of Agrawal, *et al.*, 2010.

Kumar and Prasad (2008) suggested that the increase in available nitrogen due to incorporation of organic materials might be also attributed to the enhanced multiplication of microbes by the incorporation of crop residue and compost for the conversion of organically bound N to inorganic form.

Pandey *et al.*, (2009) revealed that there was buildup of available N, P and K with conjoint use of chemical fertilizers with compost and crop residue incorporation in soil. Addition of different organic materials increased the organic carbon and slightly decreased in soil pH.

Karmakar *et al.*, (2011) reported that the application of 50% NPK, 25% N through FYM, green manure and blue green algae increased the organic carbon, available N, P and K of soil. Improvement in soil physico-chemical properties might be due to direct application of organic manures along with chemical fertilizer and increased growth of the plant resulted in higher root biomass and its recycling.

Kumar, *et al.*, (2012) observed that the long-term integrated nutrient management through FYM in 50% RDF + 50% FYM treatment had resulted in highest available N, P and K. Walia *et al.*, also reported that long-term integrated nutrient management in rice-wheat cropping system increased the availability of NP and K nutrients.

Verma *et al.*, (2012) concluded that the balanced use of fertilizer alone or conjoint use of inorganics with organics resulted in a significant build-up of organic carbon and available N,P and K over three decades leading to sustained soil fertility and productivity.

Tilahum Tadesse *et al.*, (2013) concluded that the integrated use of farmyard manure and

inorganic fertilizers was found to improve the soil total N and available P. Moreover, the use of FYM significantly increased soil organic matter and available water holding capacity but decreased the soil bulk density, creating a good environment for growth and development of the rice crop.

Effect of continuous application of inorganic fertilizers and organic manures on nutrient content and uptake, growth parameters and yield

Sharma and Sharma (1994) reported that the application of FYM @ 30 Kg ha⁻¹ with 90 Kg N ha⁻¹ through urea resulted in more number of spikelet per panicle in the rice crop and ultimately gave significantly higher yield of rice crop, while due to residual effect of previously applied FYM increased yield by 8 percent additionally in the succeeding crop as compared to control (Sharma and Mishra, 1990).

Gupta *et al.*, (1995) reported that application of organic manures like FYM, rice husk, Saw dust and green manures in rice increased grain yield of rice - wheat cropping system. An increase in the productivity of rice - wheat sequence was reported from 4.35 to 8.40 t ha⁻¹ in control and with green manuring with Dhaincha, respectively (Mahapatra and Sharma, 1995). Application of FYM to rice increased the grain yield of both rice and wheat over control showing marked residual effect on soil fertility (Brar *et al.*, 1995).

A significant increase in grain and straw yields of rice over control by 5.90 and 6.36 percent was obtained with the application of 10 t ha⁻¹ FYM to rice crop (Singh *et al.*, 1996).

Findings of Long-term fertilizer experiments conducted at various locations in India, indicated that 25 to 50% nitrogen needs of

rice can be substituted through FYM or green manure without any detrimental effect on the productivity of rice - wheat cropping system (Hedge, 1998).

FYM @ 3 t ha⁻¹ in combination with inorganic fertilizer gave higher grain yield 3.36 t ha⁻¹ as compared to control plot (1.49 t ha⁻¹) in rice crop, which also increased the nutrient uptake, Bat *et al.*, (1993), whereas, the grain yield, N, P and K uptake were highest with 5 tons FYM + 50 Kg N than 100:50:50 kg NPK ha⁻¹ and 10 t FYM ha⁻¹ only (Babu and Reddy, 2000).

Swarup and Yaduvanshi (2000) reported that in 3 years experiment there was no significant difference in yield at first year with the application of 100 percent NPK + GM (0.72 percent N), 150 percent NPK and 100 percent NPK + FYM @ 10 t ha⁻¹ yield 5.57, 6.25 and 6.12 t ha⁻¹, respectively.

During next year 100 percent NPK and GM and FYM gave significant better yield than 150 per cent NPK whereas, 100 percent NPK, 110 percent NPK and 50 percent NPK + GM yielded 5.60, 5.80 and 6.50 t ha⁻¹ respectively, which is more or less similar.

Kumar *et al.*, (2001) reported that the application of 100% NPK along with FYM @ 20 t ha⁻¹ increased the grain yield of rice significantly over the control. Similar trends were also found in straw yield.

Manna *et al.*, (2001) revealed that the increase in nutrient uptake may be due to an increase in available N, P and K contents in the soil and improved soil structure for higher uptake of nutrients.

Sharma and Bali (2001) studied that the incorporation of organic sources of nutrition, the grain yield of control significantly increased to the tune with compost, crop

residue and compost + crop residue, respectively. Compost or crop residue resulted in a small increase in grain yield but their combination was superior to either of them.

Sharma and Sharma (2002) reported that NPK + FYM increased 38 to 45, 7 to 10 and 25 to 42 Kg ha⁻¹ N, P and K uptake, respectively over N alone.

Ghosh and Singh (2003) evaluated the effect of conjoint use of farmyard manure and nitrogen on rice - wheat system in Uttaranchal mid-hill soils.

They observed that grain and straw yields increased with increasing rates of FYM and N fertilizer for both the crops, and the highest yields were obtained with 15 t ha⁻¹ FYM + 60 or 80 Kg ha⁻¹ N.

Phogat *et al.*, (2004) found that the total productivity of rice - wheat system increased significantly with green manure and FYM compared to control and with FYM over green manure in all the years.

Singh and Agarwal (2004) reported that the application of 10 t ha⁻¹ FYM in rice - wheat cropping system resulted in significantly higher N, P and K uptake compared with control.

Chaudary and Thakur (2007) have documented that the application of FYM in conjunction with chemical fertilizers had stimulatory effect on yield irrespective of crops and season: however, quantum of yield was much higher when applied in Kharif.

Pandey *et al.*, (2009) indicated that the integrated effect of compost and crop residue with fertilizers at any level of NPK resulted in maximum yield. Integrated effect of chemical fertilizers with organic manure and crop

residue also augmented N, P and K uptake over control. Urkurkar *et al.*, (2010) proved that over 16 years of the study period, highest rice and wheat yield was obtained when 50% of N was supplied through green manure in conjunction with 50% of NPK through inorganic fertilizers (50% recommended dose of fertilizer+ 50% N-green manure) than other treatments.

Karmakar *et al.*, (2011) reported that the application of 50% NPK through chemical fertilizers along with 25% N through FYM, green manuring and blue green algae recorded the highest plant height with effective tillers m⁻² and LAI which was at par with 100% NPK and 50% N FYM + GM + BGA but significantly superior to control and completely inorganically and organically fertilized plots.

Further they concluded that the integrated use of chemical fertilizer (50% RDF), FYM (25% N), green manure and blue green algae resulted in maximum yield and better N, P and K uptake.

Islam Fakhru *et al.*, (2013) revealed that the higher levels of yield attributes and N, P, K and S concentration in grain and straw were recorded in combined application of fertilizer and manure compared to chemical fertilizer alone.

Priyanka *et al.*, (2013) concluded that higher level of fertilizer and FYM significantly influenced the growth characters, nutrient content and yield of rice.

Singh *et al.*, (2013) reported that the addition of organic amendments like FYM, BGA and Azolla in integrated manner with chemical fertilizers produced higher quantity of grain and the seed quality was also more superior to those obtained in solo chemical fertilizer application and control treatments.

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