ORIGINAL RESEARCH ARTICLE OPEN ACCESS

Long Term Fertilization Effect on Soil Organic Carbon and Productivity of Rice Crop under Rice-Rice Cropping System in Godavari Delta, India

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Received: 6th October, 2014 Accepted: 25th May, 2015

Abstract

The effect of long term fertilization with organic and inorganic sources of nutrition on the grain yield and organic carbon content in post harvest soil under rice-rice system in alluvial soils was studied for 22 years during *kharif* and 21 years for *rabi*. Application of 100% NPKZnS + FYM @ 5 t ha^{-1} recorded highest grain yield and soil organic carbon content. 100% NPKZnS produced on par for grain yield production and lower soil organic carbon than 100% NPKZnS + FYM @ 5 t ha^{-1}. Nitrogen substitution with FYM/ GM performed lower than 100% NPKZnS treatment in grain yield production. However nitrogen substitution with FYM/ GM performed superior than 100% NPKZnS in increasing organic carbon content. Between GM and FYM, FYM performed better than GM during *kharif*. Application of FYM@10tha^{-1} alone was found on par with 100%NPKZnS in grain production during *kharif* only but registered higher organic carbon content.

Key words: Rice-rice system, long term effect, organics, inorganics, balanced fertilization, N- substitution, grain yield, organic carbon content

Introduction

Continuous use of high level of chemical fertilizers had lead to soil degradation problems, which also proved detrimental to soil health. A declining trend in the productivity of rice even when grown under adequate application of N, P and K was reported by Nambiar and Abrol (1989). Soil fertility and productivity in Godavari delta are likely to be affected due to intensive rice monoculture with imbalanced fertilization under excessive use of irrigation water. Earlier results of long term fertility management at Maruteru indicated a significant improvement in grain and straw yields due to combined application of organic and inorganic treatments (Anonymous, 2005). Therefore, the present investigation was undertaken to explore the effect of organic and inorganic nutrition on soil fertility and productivity.

Materials and Methods

Experimental site A field experiment on long term soil fertility management in rice- rice system was being assessed over the years (initiated during 1989) on Godavari alluvials (Vertic chromusterts) at Maruteru. The data for *kharif* and *rabi* seasons were pooled (1989 to 2011) and analysed. The soil was clay- loam in texture and with pH of 6.3, EC of 0.79 dSm^{-1}, organic carbon (0.72%), available N (249 kg ha^{-1}), Olsens P_2O_5 (26.9 kg ha^{-1}) and ammonium acetate extractable K_2O (270 Kg ha^{-1}).

Treatmental Details The experiment was laid in randomized block design consisting of 16 treatments *viz*, T1- Control, T2-100% N, T3-100% NP, T4-100% NPKZnS, T5-100% NPK –Zn, T6-100% NPK – S, T7-100% N+50% PK, T8-50 % NPKZnS, T9-50% NPK+ 50% GM-N, T10-50% NPK + 50% FYM-N, T11-50% NPK + 25% GM-N+25% FYM-N, T12-FYM @ 10 t/ ha, T13-100%PK, T14-100% NPKZnS + FYM @ 5t ha^{-1}, T15-STCR fertilizer recommendation, and T16-50%NPK+Azospirillum, in three replications. Treatment No. 1 to 12 being imposed from 1989, treatment No. 13 was started in 1997, treatment 14 from 2000, T-15 from 2008 and T-16 from 2009 *Kharif* seasons on words. Experiment being conducted since 1989 in the same plots regularly except during *rabi*, 1993 and *Kharif*, 1996 where crop was failed due to floods. Thus so far the experiment was conducted for 22 *kharif* and 21 *rabi* seasons were completed. Nitrogen was applied in three equal splits as basal, at tillering and at panicle initiation stage. Entire phosphorus and potassium were applied as basal. Zinc sulphate @ 50 kg ha^{-1} was applied during *rabi* season except in treatments T-5, while in T-6 zinc oxide was applied to exclude sulphur. In T-6 treatment to exclude sulphur, P is supplied through DAP after duly taking care of its nitrogen content and in the rest of the treatments P

was supplied through SSP only. Before each season, the organic manures were analyzed for the nitrogen content to fix the quantity required as per the treatments. Water was maintained at 2 cm depth during vegetative and 5 cm during reproductive stage of the crop until ripening. The surface soil samples before and harvest of the crop were collected and analysed for the physico-chemical properties

Results and Discussion

I. Long term effect of different Fertilizations on Grain Yield

Kharif crop was grown for 22 years in the same plot from 1989 to 2011 excluding *kharif*, 1996. Out of 22 years till the introduction of NPKZnS + FYM @ 5 tha^{-1} (T-14), the treatment 100% NPKZnS (T-4) performed the best in 7 out of 10 years (except T-6 in 1992, T-5 in 1998 & 1999) (Table 1). After the introduction of NPKZnS + FYM @ 5 tha^{-1} (T-14) treatment during *kharif*, 2000 in the rest of the period (2000 to 2011) NPKZnS + FYM @ 5 tha^{-1} (T-14) performed best except for two years (T-11 in 2000, T-4 in 2001).

Rabi Experiment was conducted for 21 years in the same plot from 1990 to 2011 excluding *rabi*, 1993. Out of 21 years till the introduction of NPKZnS + FYM @ 5 tha^{-1} (T-14) treatment, 100% NPKZnS (T-4) performed the best in 7 out of 10 years (except T-6 in 1991, T-9 in 1996 & 1998). After the introduction of NPKZnS + FYM @ 5 tha^{-1} (T-14) treatment from *rabi*,2001 in the rest of the period (2001 to 2011) NPKZnS + FYM @ 5 tha^{-1} (T-14) performed best except for one year (T-11 in 2002).

a) Influence of levels of Fertilization

Increased level of fertilization increased the grain yield. During *kharif*, at the starting year 100% NPKZnS (T-4) treatment increased yield significantly over control (T-1) and 50% NPKZnS (T-8). However, after 22 years of experimentation, it is revealed that graded levels of fertilization increased the yields significantly at both levels over control. During *rabi*, at the starting year and after 21 years of experimentation, it is revealed that graded levels of fertilization increased the yields significantly at both levels over control. This higher response during *rabi* over *kharif* to the added fertilization can be attributed to higher nutrient dose of fertilization to *rabi* crop than *kharif* season.

b) Individual plant nutrient response (Imbalanced fertilization)

During *Kharif* and *rabi*, after 22 years of experimentation, control performed lower than other fertilization treatments which indicates the response to fertilization (Table 2). Balanced fertilization of NPK recorded the highest response than imbalanced fertilization and sole application of FYM@10tha^{-1}(T-12). This indicated the superiority of balanced fertilization of NPK over imbalanced fertilization and organic sources alone (T-12). FYM @ 10tha^{-1} performance is lower during *rabi* than *kharif*, might be due to applied FYM rate ie 10 tha^{-1} is not meeting the requirement of short duration *rabi* crop or slow release of nutrients from FYM.

c) Nitrogen Substitution with organics

Nitrogen substitution with FYM/ GM performed lower than, 100% NPKZnS (T-4) treatment. During *Kharif*, at the starting year (1989) 100% NPKZnS (T-4), T-10 and T-9 treatment increased yield significantly over control (T-1) [Table 3]. Performance of T-10 was on par with 100% NPKZnS (T-4). However, after 22 years of experimentation, it is revealed that N- substitution with GM or FYM performed lower than 100% NPKZnS (T-4).

During *rabi*, at the starting year (1990) and after 21 years of experimentation, it is revealed that N- substitution with GM or FYM performed lower than 100% NPKZnS (T-4). This lower performance of N-substitution with either GM or FYM might be due to

- Lower P and K content in FYM /GM
- Less mineralization of organic sources under prevailing submerged conditions
- Slow release of nutrients from organic sources

d) Integrated Use of Organics and inorganics

During *Kharif*, at the starting year (1989 for all and 2000 for T-14), sole organics (T-12) performance is on par with control (T-1). Inorganics alone (100% NPKZnS, T-4) performed higher than control (T-1), on par with organics (T-12) and lower than conjunctive use over RDF (100% NPKZnS + FYM/PM @ 5 tha^{-1}, T-14). However, after 22 years of experimentation, it is revealed that 100% NPKZnS + FYM/PM @ 5 tha^{-1} (T-14) and 100%NPKZnS (T-4) are on par and 100% NPKZnS (T-4) and T-12 are on par (Table 4).

During *rabi*, at the starting year (1990) and after 21 years of experimentation, NPKZnS + FYM/PM @ 5 tha^{-1} (T-14)) and 100% NPKZnS (T-4) are on par. T-12 is significantly lower to 100%NPKZnS + FYM/PM @ 5 tha^{-1} (T-14), 100% NPKZnS (T-4) and T-10. This higher performance of T-10 over T-12 signifies the conjunctive use over organics alone. Beena and Balachndran (2002) reported that application

of FYM @ 5 tha^{-1} in addition to recommended dose of fertilizer produced significantly higher grain yield in rice. Similar results were also reported by Jayakrishnakumar *et al.* (1994) and Pandey *et al.* (2001).This might be due to

- Conjunctive use of 50% NPKZnS + 50% N-FYM (T-10) is on par with sole organic (T-12) for *Kharif* season only might be FYM@10tha^{-1} meeting the requirement during *Kharif* season only and for *rabi,* rate of application of FYM is not meeting nutrient requirement of the crop.
- Between 100% NPKZnS (T-4) and 100%NPKZnS + FYM/PM @ 5 tha^{-1}(T-14) though the numerical advantage is noticed for both seasons, it will take some more time for making NPKZnS + FYM @ 5 tha^{-1} (T-14) significantly superior over 100% NPKZnS (T-4).

II. Impact on Soil Organic carbon

a) Influence of levels of Fertilization

Increased level of fertilization increased the grain yield and also resulted in higher residues to soil and hence higher organic carbon content recorded (Table 5). During *kharif*, at the starting year, both 100% NPKZnS (T-4), 50% NPKZnS (T-8) treatments increased yield significantly over control (T-1). However, after 22 years of experimentation, only 100% NPKZnS (T-4) treatment increased yield significantly over control (T-1) and (T-8). It is also revealed that graded levels of fertilization increased the yields and hence higher OC content recorded.

During *rabi*, at the starting year and after 21 years of experimentation, it is revealed that graded levels of fertilization increased the yields significantly at both levels over control. However, OC increased significantly with T-4 only after 21 years of experimentation.

b) Individual plant nutrient response

During *kharif* and *rabi* at the end of reporting period, control and nitrogen alone performed lower to the rest (Table 6). During *kharif* application of NPK performed similar to that FYM, but during *rabi*, FYM recorded higher OC content than NPK. Lower performance of N alone and NP combination during *kharif* and N alone during *rabi* can be attributed to deleterious effects of imbalanced fertilization. This resulted in lower yields and hence less crop residue recycling to soil and hence lower OC was recorded.

c) Nitrogen Substitution with organics

Nitrogen substitution with FYM/ GM performed superior than 100% NPKZnS (T-4) and T-1 treatment. Between T-1 and 100% NPKZnS (T-4), 100% NPKZnS (T-4) recorded significantly higher yield than T-1 and hence higher OC content (Table 7). Between GM and FYM, FYM performed better than GM during Kharif, whereas during rabi FYM and GM performed similarly. Yoshida and Padre (1975) also reported that the organic manures reduced N losses and conserved soil N forming organo-mineral complex, maintained supply of N to rice plant and increased the N uptake in grain.

d) Integrated Use of Organics and inorganics

During *Kharif*, at the starting year (1989 for all, 2000 for T-14) FYM performed better in increasing OC content (Table 8). However, after 22 years of experimentation, it is revealed that organics and inorganics performed at par and found significantly superior over control (T-1).

During *rabi*, at the starting year (1990), 100% NPKZnS + FYM/PM @ 5 tha^{-1} (T-14) performed best followed by T-12, T-10 and T-4. After 21 years of experimentation, conjunctive use (T-14) and sole organic (T-10) were significantly superior to sole inorganic, 100% NPKZnS (T-4) treatment (Table 8). However, which were significantly superior to control (T-1). This higher performance of 100%NPKZnS + FYM/PM @ 5 tha^{-1} (T-14), T-10 and T-12 signifies the conjunctive use. Larsen and Clapp (1984) also observed similar effects on grain yield due to combined application of organic and inorganic treatments.

Conclusions

Thus, long term fertilizer experiment results indicated that

- Application of 100%NPKZnS + FYM @ 5 tha^{-1} (T-14) recorded highest grain yield and organic carbon content. This signifies the conjunctive use of organics and inorganics in increasing grain yield and soil productivity also.
- Application of 100%NPKZnS was found on par with of 100%NPKZnS + FYM/PM @ 5 tha^{-1} in grain production only.
- Application of 100%NPKZnS was found superior to imbalanced fertilization
- Application of FYM@10tha^{-1} was found on par with 100%NPKZnS in grain production during *kharif* only but registered higher organic carbon content.
- N substitution with FYM/ GM recorded lower grain yield than100%NPKZnS but resulted in higher organic carbon content in the soil.

Acknowledgement

Financial and technical help to carry out this work by way of sponsoring the 'All India Coordinated Rice Improvement (AICRIP) Programme on Long term soil fertility management in low land rice soils of Godavari delta under rice-rice cropping system at Andhra Pradesh Rice Research Institute & Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Maruteru, W.G. Dt, Andhra Pradesh (India) by Directorate of Rice Research, Hyderabad, Indian Council of Agricultural Research is duly acknowledged.

References

Annonymous, 2005. Annual report of Andhra Pradesh Rice Research Institute, Maruteru, A.P. pp-120-123

Beena, C. and Balachndran, P.V. 2002. Effect of integrated nutrient management on yield in rice-rice cropping system in the oxisols of Kerala. *Crop Research* 23(3):446-449

Jayakrishnakumar, V., Sundresan Nair, S.M., Sahul Hameed, Tajuddin, E. and Ramchandran Nair, V. 1994. Influence of integrated supply of nitrogen through organic and inorganic sources on grain yield of wetland rice. *Oryza* 31:40-42

Larsen, W.E. and Clapp, C.E. 1984. Inorganic matter and rice, International Rice Research Institute, Philippines, 363-386.

Nambiar, K.K.M. and Abrol, I.P. 1989. Long term fertilizer experiment in Indian over view. *Fertilizer News* 34: 11-20 &26.

Pandey, N., Upadhayay, S.K., Jhoshi, B.S. and Tripathi, R.S. 2001. Integrated use of organic manures and inorganic N fertilizers for the cultivation of lowland rice in vertisol. *Indian Journal of Agricultural Research* 35(20):112-114.

Yoshida, T. and Padre, B.C. Jr.1975. Effect of organic matter application and water regimes on the transformation of fertilizer nitrogen in a Philippine soil. *Soil Science and plant Nutrition* 21:281-292.

Table 1. Influence of levels of Fertilization on grain yield (kg ha^{-1}) under rice - rice cropping system in Godavari Western Delta

Treatment	*Kharif*		*Rabi*	
	1989	22 years mean	1990	21 years mean
Control	2422^{a}	3058^{a}	1565^{a}	1905^{a}
50% NPKZnS	2785^{a}	4187^{b}	2849^{b}	4030^{b}
100%NPKZnS	3422^{b}	5100^{c}	4414^{c}	5419^{c}
CD (0.05%)	449	487	384	592

Table 2. Effect of Imbalanced Fertilization on grain yield (kg ha^{-1}) under rice-rice cropping system in Godavari Western Delta

Treatment	*Kharif*	*Rabi*
Control	3058^{a}	1905^{a}
N	4003^{b}	3849^{c}
NP	4384^{bc}	4628^{d}
PK	3889^{b}	2646^{b}
NPK	5100^{d}	5419^{e}
FYM@10tha^{-1}	4454^{c}	3781^{c}
CD (0.05%)	487	592

Table 3. Effect of Nitrogen Substitution with organics on grain yield (kg ha^{-1}) under rice - rice cropping system in Godavari Western Delta

Treatment	*Kharif*		*Rabi*	
	1989	22 years mean	1990	21 years mean
Control	2422^{a}	3058^{a}	1565^{a}	1905^{a}
50% NPKZnS + 50% GM	2931^{b}	4504^{b}	3537^{b}	4753^{b}
50% NPKZnS + 50% FYM	3168^{bc}	4678^{b}	3575^{b}	4737^{b}
100%NPKZnS	3422^{c}	5100^{c}	4414^{c}	5419^{c}
CD (0.05%)	449	487	384	592

Table 4. Effect of Integrated Use of Organics and inorganics on grain yield (kg ha^{-1}) under rice - rice cropping system in Godavari Western Delta

Treatment	*Kharif*		*Rabi*	
	1989	22 years mean	1990	21 years mean
Control	2422^{a}	3055^{a}	1659^{a}	1973^{a}
50% NPKZnS + 50% N- FYM	3168^{b}	4678^{b}	4350^{c}	4793^{c}
FYM@10tha^{-1}	2749^{ab}	4454^{b}	3396^{b}	3781^{b}
100%NPKZnS	3422^{b}	5100^{bc}	5821^{d}	5515^{d}
100%NPKZnS + FYM@5tha^{-1}	3979^{c}	5373^{c}	6002^{d}	6006^{d}
CD (0.05%)	449	487	384	592

Table 5. Influence of levels of Fertilization on soil organic carbon content (%) under rice - rice cropping system in Godavari Western Delta

Treatment	*Kharif*		*Rabi*	
	1989	22 years mean	1990	21 years mean
Control	0.35^{a}	0.97^{a}	0.555^{a}	0.76^{a}
50% NPKZnS	0.60^{b}	1.17^{a}	0.565^{a}	0.79^{a}
100%NPKZnS	0.55^{b}	1.24^{b}	0.575^{a}	1.13^{b}
CD (0.05%)	0.168	0.238	0.073	0.182

Table 6. Effect of Imbalanced Fertilization for 22 years on soil organic carbon content (%) under rice - rice cropping system in Godavari Western Delta

Treatment	*Kharif*	*Rabi*
Control	0.97^{a}	0.97^{a}
N	1.16^{a}	1.12^{a}
NP	1.19^{ab}	1.18^{b}
PK	1.22^{b}	1.23^{b}
NPK	1.24^{b}	1.22^{b}
FYM	1.45^{b}	1.47^{c}
CD (0.05%)	0.23^{8}	0.182

Table 7. Effect of Nitrogen Substitution with organics on soil organic carbon content (%) under rice - rice cropping system in Godavari Western Delta

Treatment	*Kharif*		*Rabi*	
	1989	22 years mean	1990	21 years mean
Control	0.35[a]	0.97[a]	0.555[a]	0.97[a]
50% NPKZnS + 50% N-GM	0.89[c]	1.34[b]	0.920[b]	1.35[bc]
50% NPKZnS + 50% N-FYM	1.12[d]	1.49[c]	0.915[b]	1.42[c]
100%NPKZnS	0.55[b]	1.24[b]	0.575[a]	1.22[b]
CD (0.05%)	0.168	0.238	0.0733	0.182

Table 8. Effect of Integrated Use of Organics and inorganics on soil organic carbon content (%) under rice - rice cropping system in Godavari Western Delta

Treatment	*Kharif*		*Rabi*	
	1989	22 years mean	1990	21 years mean
Control	0.35[a]	0.97[a]	0.555[a]	0.97[a]
50% NPKZnS + 50% N-FYM	1.12[c]	1.49[b]	0.915[b]	1.42[c]
FYM@10tha^{-1}	1.25[c]	1.46[b]	0.985[c]	1.47[c]
100%NPKZnS	0.55[b]	1.24[b]	0.575[a]	1.22[b]
100%NPKZnS + FYM@5tha^{-1}	1.26[c]	1.43[b]	1.20[d]	1.59[c]
CD (0.05%)	0.168	0.238	0.0733	0.182