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Effect of crop residue and fertilizer on soil micronutrients in rice growing Alfisol

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Abstract
An experiment was conducted during *Kharif,* 2019-20 at the Research Farm of Department of Agronomy, Dr. BSKKV., Dapoli, Maharashtra, to study the "Effect of crop residues and fertilizer on soil micronutrients in rice growing Alfisol". The study was taken on *ex-situ* incorporation of crop residue along with fertilizers in soil for development of soil fertility and crop productivity. The results emerged out indicated that the application of rice straw @ 2.5 t ha^{-1} + ain leaf residue @ 2.5 t ha^{-1} along with 100% NPK was found to be significantly beneficial for improving soil micronutrients status in rice growing Alfisol. Lower micronutrients status of soil were noticed by 50%, 75% and 100% NPK than conjoint use of organic residue and fertilizer in soil. Significantly higher micronutrients content in soil were also observed by the application of rice straw @ 2.5 t ha^{-1} + ain leaf residue @ 2.5 t ha^{-1} along with 100% NPK over 50%, 75% and 100% NPK alone. Use of crop residue in conjunction with chemical fertilizers can improve soil micronutrients status. Thus, integrated use of rice straw @ 2.5 t ha^{-1} + ain leaf residue @ 2.5 t ha^{-1} and 100% NPK was found to be feasible and proved overall superior impact on rice crop in Alfisols.

Keywords: Zinc, iron, manganese, copper, rice, Alfisol

Introduction
Rice is a dominant crop in India and also in Konkan region of Maharashtra. The production of rice in India 291.95 million tonnes and the rice production in Konkan region is about 11.28 lakh tonnes with productivity around 2.81 t ha^{-1} (Anonymous, 2020) [2]. The farmers are doing traditionally rice residue and many indigenous nutritious forest species residue managemnt practices in Konkan region of Maharashtra. In contrast to selected indigenous forest tree species residue i.e. *Terminalia tomentosa* is widely adopting on rice bund plantation. Such types of nutritious species can mitigate the nutrient demand in soil. Crop residues, fertilizers and its mixtures play an important role in the function of Agro-ecosystems because it sustains overall soil quality and crop productivity. The incorporation of crop residue either partially or completely in the field depends upon cultivation method. Incorporation of plant residue in combination with fertilizers can increase SOC, Micronutrient content or if used as mulch, the residue can modify the soil temperature (Saha and Ghosh, 2013) [14]. Since last two decades, people are taking interest to improve soil quality throughout the world. They recognized the fragility of natural resource for development of soil health. Among of them, residue management is the technology which is beneficial for soil improving soil micronutrients status (Kumari *et al*., 2018) [7]. Residue management might be the right proposition for improvement of soil quality and providing favourable environment for crop growth. Balanced used of organic manure along with fertilizer is necessary for sustaining soil fertility by improving micronutrient status of soil and productivity of crops (Meshram *et al*., 2014) [9]. The incorporation of organic matter either in the form of crop residue, organic manure or amendment along with fertilizers has significant effect on soil micronutrient status. Residue decomposition is a major pathway for providing organic and inorganic elements for the nutrient cycling processes and controls nutrient return to the Agro-ecosystem. Impact of decomposing farm *in situ* and *ex-situ* various crop residues in soil reflected on residual effect of nutrients in soil and productivity of crop. By addition of nutritious residues in soil which helps to developed soil fertility. (Adams and Angradi, 1996) [1]. The recycling of crop residues has the advantage of converting the surplus farm waste into useful product for meeting nutrient requirement of crops. Continuous cultivation of rice without adding any residues in same field is heavily depleting the soil nutrient status.

In Konkan region of Maharashtra, peoples are doing "rabbing" practices and it enriched the heavey metals in the soil which is realy harmful for balance ecosystem. Inplace of rabbing, residue incorporation in soil with integration of fertilizers improves soil fertility and crop productivity. So, there is a need to adopt ways and means to manage this valuable resource.

Methods and Materials

The experiment was conducted at Research Farm, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra. The experimental soil is characterized by reddish colour, Lateritic type of Alfisols, particularly Kaolinitic, hyperthermic family of Typic Haplustalf. The present experiment was framed in Strip Plot Design (SPD) with twelve treatments and three. The treatments comprises T_1– Rice straw @ 5 t ha^{-1}(C_1) +100% NPK (F_1), T_2– Rice straw @ 5 t ha^{-1} (C_1) + 75% NPK (F_2), T_3– Rice straw @ 5 t ha^{-1} (C_1) + 50%NPK(F_3), T_4– Ain leaf residues@ 5t ha^{-1}(C_2) +100% NPK (F_1), T_5– Ain leaf residues@ 5 t ha^{-1}(C_2) +75%NPK(F_2), T_6 Ain leaf residues@ 5t ha^{-1}(C_2) +50%NPK(F_3), T_7–[Rice straw @2.5 t ha^{-1} + Ain leaf residues@2.5 t ha^{-1}](C_3) + 100% NPK (F_1), T_8–[Rice straw @2.5 t ha^{-1} + Ain leaf residues@2.5 t ha^{-1}](C_3) +75%NPK(F_2)[1], T_9–[Rice straw @2.5 t ha^{-1} + Ain leaf residues@2.5 t ha^{-1}] (C_3) + 50%NPK(F_3), T_{10}– Without residue (C_4) + 100% NPK (F_1), T_{11}– Without residue (C_4) + 75% NPK (F_2), T_{12} Without residue (C_4) + 50% NPK (F_3). The layout of field was done as per the strip plot design. The ridges were opened by tractor-operated ridger for preparing raised beds. Then levelled of raised and flat beds was done manually. Small bunds of 15-20 cm height were raised around each plot along with keeping a distance of 2 m between two replications. There were twelve plots in each replication and in all there were three replications. Hence, there were 36 plots of 4.50 m X 3.00 m after that crop residue added in this plot. We have collected residues of selected forest trees species which is dominant in Konkan region of Maharashtra and rice as a main crop of Konkan and naturally sun dried. We incorporated chapped crop residues in rice field before one $1\frac{1}{2}$ month transplanting of rice. The crops rice (Ratnagiri-1) and were raised during *kharif* (rainy) seasons respectively using recommended practices. Rice crops were transplanted with 20 x 15 cm spacing between rows and plants respectively. The 100% NPK recommended dose applied to the crops was 100:50:50 kg ha^{-1} for rice. The fertilizers used were urea, single super phosphate (SSP) and muriate of potash were applied as per treatments. Plot wise soil samples were analyzed for initial, tillering, flowering and at harvest stage of rice for physico-chemical properties of soil. DTPA extractable zinc, iron, manganese and copper in soil were estimated as per procedure described by Lindsay and Norvell (1978) [8] on Atomic Absorption Spectrophotometer (AAS) at different wavelengths.

Results and Discussion

DTPA extractable ferrous (Zn)

A perusal data given in (Table 1) showed that showed that the DTPA-Zn of soil varied from 0.99 to 1.44 (mg kg^{-1}) under crop residues and fertilizer management practices and had statistically significant (Table 1). Considering 0.6 mg kg^{-1} as critical limit for DTPA-Zn, these soils were found to be sufficient in available zinc content (Tandon, 1999) [16]. The DTPA-Zn of soil (1.46, 1.38 and 1.33 mg kg^{-1}) was received by rice straw @ 2.5 t ha^{-1} + ain leaf residue @ 2.5 t ha^{-1} at tillering, flowering and at harvest stage of rice crop than other. The lowest value of DTPA-Zn of (1.14, 1.09, 0.99 mg kg^{-1}) was recorded in control (no residue) during tillering, flowering and at harvest stage of rice.

Table 1: Effect of crop residues and fertilizer on DTPA-Zn of soil (mg kg^{-1})

Treatment	Tillering	Flowering	At harvest
Crop residues levels			
C_1 - Rice straw @ 5 t ha^{-1}	1.42	1.33	1.30
C_2 - Ain leaf residue @ 5 t ha^{-1}	1.45	1.39	1.32
C_3 - Rice straw @ 2.5 t ha^{-1} + Ain leaf residue @ 2.5 t ha^{-1}	1.46	1.38	1.33
C_4 – Control (No residue)	1.14	1.09	0.99
SE (m) ±	0.09	0.07	0.01
CD at 5%	-	-	0.04
F test	NS	NS	Sig
Fertilizer levels			
F_1- 100% NPK	1.44	1.36	1.31
F_2- 75% NPK	1.38	1.30	1.25
F_3- 50% NPK	1.28	1.23	1.14
SE (m) ±	0.08	0.065	0.014
CD at 5%	-	-	0.054
F test	NS	NS	Sig
Interaction C × F			
SE (m) ±	0.23	0.18	0.04
CD at 5%	-	-	0.12
F test	NS	NS	Sig
Initial value	1.05		

In case of fertilizer levels, application of 100% NPK was noticed significantly higher (1.44, 1.36 and 1.31 mg kg^{-1}) influence of DTPA-Zn of soil than 75% NPK and 50% NPK, whereas the lowest values (1.28, 1.23 and 1.18 mg kg^{-1}) were noted in 50% NPK during at tillering, flowering and at harvest stage of rice. The interaction effect of crop residue and fertilizer was found non-significant at tillering and at flowering stage of rice and found significant only at harvest stage of rice may be due mineralization of native metals from soil. The increased zinc content under integrated use of residue and fertilizers might be due to the addition of organics and ultimately small amount of available zinc, the organic materials also form chelates and increases the availability of zinc in soil. (Quereshi *et al*. 1995 [12], Bellakki and Badanur 1997) [3]. Sharma *et al*. (2000) [15] observed that the DTPA-extractable Zn enhanced significantly due to crop residues and FYM incorporation compared to chemical fertilizers application alone in sunflower-Bengal gram cropping system. This increase in available micronutrients in soil may be ascribed to reduction in the redox-potential of the soil with the addition of organic manures, which led to more release of soil micronutrients in available form as compared to the application of chemical fertilizers alone. Prashanth *et al*. (2019) [11] in an experiment conducted at University of Agricultural Sciences, Bengaluru, in Alfisols with a 40-years experimentation, application of FYM @ 10 t ha^{-1} + 100% RDF followed by Maize residue @ 5 t ha^{-1} significantly increased the in availability of DTPA-Zn in soil as against 100% NPK alone and control.

DTPA extractable ferrous (Fe)

The data given in (Table 2) showed that DTPA extractable Fe in soil was significantly influenced by crop residue and fertilizer management practices. The available iron values of soil ranged from 15.59 to 28.09 mg kg^{-1}. Considering the critical limit for DTPA-Fe as 4.5 mg kg^{-1}, these soils were found to be sufficient in available iron content. The highest DTPA-Fe of soil (28.09 and 26.30 mg kg^{-1}) was received by rice straw @ 2.5 t ha^{-1} + ain leaf residue @ 2.5 t ha^{-1} at tillering and flowering stage of rice, whereas at harvest stage (22.89 mg kg^{-1}) was received by C_2 -ain leaf residue @ 5 t ha^{-1} of rice crop than other. It was found to be at par with C_1-rice straw @ 5 t ha^{-1} and C_2-ain leaf residue @ 5 t ha^{-1} at flowering stage of rice over its initial status of soil. The lowest values (18.56, 16.95, 15.59 mg kg^{-1}) were recorded in control (no residue) during tillering, flowering and harvest stage of rice. In case of fertilizer levels, application of 100% NPK was noted maximum availability of DTPA-Fe (27.68, 25.15 and 22.88 mg kg^{-1}) in soil at tillering, flowering and at harvest stage of rice than 50% NPK and 75% NPK alone.

Table 2: Effect of crop residues and fertilizer on DTPA-Fe of soil (mg kg^{-1})

Treatment	Tillering	Flowering	At harvest
Crop residues levels			
C_1 - Rice straw @ 5 t ha^{-1}	26.55	24.33	21.73
C_2– Ain leaf residue @ 5 t ha^{-1}	27.96	25.56	22.89
C_3 - Rice straw @ 2.5 t ha^{-1} + Ain leaf residue @ 2.5 t ha^{-1}	28.09	26.30	22.54
C_4 – Control (No residue)	18.57	16.95	15.59
SE (m) ±	2.42	2.36	0.03
CD at 5%	-	-	0.09
F test	NS	NS	Sig
Fertilizer levels			
F_1- 100% NPK	27.68	25.15	22.88
F_2- 75% NPK	25.42	23.27	20.69
F_3- 50% NPK	22.78	21.44	18.49
SE (m) ±	1.22	1.15	0.015
CD at 5%	-	-	0.050
F test	NS	NS	Sig
Interaction C × F			
SE (m) ±	4.44	4.21	0.07
CD at 5%	-	-	0.23
F test	NS	NS	Sig
Initial value	15.85		

The interaction effect of crop residue and fertilizer was found non-significant at tillering and flowering stage of rice. Crop residue level during at harvest stage as well as with the interaction effect of rice was noted statistically significant on DTPA-Fe of soil. About the interaction effects, conjoint use of 100% NPK and residues (rice straw @ 2.5 t ha^{-1} + ain leaf residue @ 2.5 t ha^{-1}) was higher improved in the DTPA-Fe of soil at tillering, flowering and at harvest stage of rice over control and its initial status of soil. Sharma *et al*. (2000) [15] observed that the DTPA-extractable Fe enhanced significantly due to crop residues and FYM incorporation compared to chemical fertilizers application alone in sunflower-Bengal gram cropping system. It may be due to that addition of any organic manure or crop residues which further suggest the necessity of regular use of organics for maintain micronutrient status of soils as well as integrated nutrient management is useful for maintaining available micronutrient status of soil over a period. Similarly, Richa Kumari *et al.* (2017) [13] and Krishnaprabu, (2019) [6] suggested that the application of crop residue along with fertilizers significantly improved DTPA-Fe in soil over control and its initial status of soil.

DTPA extractable manganese (Mn)

The data given in (Table 3) showed that DTPA extractable Mn of soil was significantly influenced by crop residues and fertilizer management practices. The available manganese in soil ranged from 30.12 to 39.80 mg kg^{-1}. Considering critical limit for DTPA-Mn as 2.0 mg kg^{-1} as given by Tandan (1999) [16], these soils were well supplied with manganese. Significantly higher DTPA-Mn of soil (39.80 and 36.69 mg kg^{-1}) was recorded by rice straw @ 2.5 t ha^{-1} + Ain leaf residue @ 2.5 t ha^{-1} at tillering and at harvest stage of rice, whereas at flowering stage was found significantly highest DTPA-Mn (37.94 mg kg^{-1}) in treatment receiving ain leaf residue @ 5 t ha^{-1} over its initial status of soil. Lowest value DTPA-Mn (34.75, 31.80 and 30.12 mg kg^{-1}) was recorded in control (no residue) during tillering, flowering and at harvest stage of rice. About the fertilizer levels, application of 100% NPK was found highest DTPA-Mn (39.41, 37.71 and 36.25 mg kg^{-1}) in soil at tillering, flowering and harvest stage of rice than 50% NPK (37.25, 34.41 and 33.46 mg kg^{-1}) in treatment during tillering, flowering and at harvest stage of rice.

Table 3: Effect of crop residues and fertilizer on DTPA-Mn of soil (mg kg^{-1})

Treatment	Tillering	Flowering	At harvest
Crop residues levels			
C_1 - Rice straw @ 5 t ha^{-1}	38.57	36.78	35.86
C_2– Ain leaf residue @ 5 t ha^{-1}	39.49	37.94	36.52
C_3 - Rice straw @ 2.5 t ha^{-1} +Ain leaf residue @ 2.5 t ha^{-1}	39.80	37.73	36.69
C_4 – Control (No residue)	34.75	31.80	30.12
SE (m) ±	1.42	1.42	0.04
CD at 5%	-	-	0.12
F test	NS	NS	Sig
Fertilizer levels			
F_1- 100% NPK	39.41	37.71	36.25
F_2- 75% NPK	37.80	36.08	34.69
F_3- 50% NPK	37.25	34.41	33.46
SE (m) ±	0.987	1.642	0.05
CD at 5%	-	-	0.17
F test	NS	NS	Sig
Interaction C × F			
SE (m) ±	4.05	4.43	0.12
CD at 5%	-	-	0.37
F test	NS	NS	Sig
Initial value	31.20		

The interaction effect of crop residue and fertilizer management was found non-significant at tillering and at flowering stage but it was significant only at harvest stage of rice. Thus, the results indicated the beneficial effect of residue in combination with NPK over only chemical fertilizers in maintaining the available manganese in soil. Similar results were observed by Quereshi *et al.* (1995) [12] and Bellakki and Badanur (1997) [3] and they suggested that an increase in DTPA-extractable micronutrients may be attributed to the reduction of cationic form accompanied by increase in its solubility under submerged conditions and chelating action of organic residues and manures. However, Sharma *et al*. (2000) [15] observed that the DTPA-Mn enhanced significantly due to crop residues and FYM incorporation compared to chemical fertilizers application alone in sunflower-bengal gram cropping system. Similarly, Dhaliwal *et al*. (2012) [4], Kamini Kumari and Prasad (2014) [5], Richa Kumari *et al.* (2017) [13], Pandey and Kumar (2018) [10], Krishnaprabu, (2019) [6] and Prashanth *et al*. (2019) [11] suggested that the application of crop residue along with fertilizers significantly improved DTPA-Mn in soil over control.

DTPA extractable copper (Cu)

The data given in (Table.4) revealed that DTPA extractable Cu in soil was significantly influenced by crop residues and fertilizer management practices with rice crop in Alfisol. The available copper values of soil ranged from 4.09 to 6.43 mg kg^{-1} mg kg^{-1}. Considering critical limit for DTPA-Cu is 0.2 mg kg^{-1}, these soils were categorized as high in available copper content (Tandan 1999) [16]. The DTPA-Cu of soil (6.43, 6.08 and 5.58 mg kg^{-1}) was received by ain leaf residue @ 5 t ha^{-1} at tillering, flowering and at harvest stage of rice crop than other. It was followed by C_3-rice straw @ 2.5 t ha^{-1} + ain leaf residue @ 2.5 t ha^{-1} (5.46 mg kg^{-1}) which was at par with each other during harvest stage of rice. The lowest value of DTPA-Cu (4.64, 4.40 and 4.09 mg kg^{-1}) was recorded in control (no residue) during tillering, flowering and at harvest stage of rice. About the fertilizer levels, application of 100% NPK was observed significantly higher (6.43, 6.03 and 5.44 mg kg^{-1}) of DTPA-Cu in soil than 75% NPK and 50% NPK, whereas the lowest values (5.41, 5.07 and 4.87mg kg^{-1}) were noted in 50% NPK during at tillering, flowering and at harvest stage of rice. The interaction effect of crop residue and fertilizer was found non-significant at tillering and flowering stage of rice, but the significantly influenced only at harvest stage of rice. The increased in copper content with the application of 100% NPK + crop residues might be due to the addition of organics along with balance fertilizers and ultimately small amount of available copper can be supplied (Quereshi *et al*. 1995 [12], Bellakki and Badanur 1997) [3]. However, Sharma *et al*. (2000) [15] observed that the DTPA-Mn enhanced significantly due to crop residues and FYM incorporation as compared to chemical fertilizers application alone in sunflower-bengal gram cropping system. Similarly, Dhaliwal *et al*. (2012) [4] and Kamini Kumari and Prasad (2014) [5] reported that application of crop residue along with fertilizers increased availability of cu was attributed to enhanced microbial activity in the soil and the consequent release of complex organic substances that could have prevented micronutrients from precipitation, fixation, oxidation and leaching and also addition of these nutrients through organic sources. Recently, Krishnaprabu, (2019) [6] and Prashanth *et al*. (2019) [11] concluded the application of crop residue along with fertilizers significantly improved DTPA-Mn in soil over control.

Table 4: Effect of crop residues and fertilizer on DTPA-Cu of soil (mg kg^{-1})

Treatment	Tillering	Flowering	At harvest
Crop residues levels			
C_1 - Rice straw @ 5 t ha^{-1}	5.85	5.78	5.23
C_2– Ain leaf residue @ 5 t ha^{-1}	6.43	6.08	5.58
C_3 - Rice straw @ 2.5 t ha^{-1} + Ain leaf residue @ 2.5 t ha^{-1}	6.43	6.07	5.46
C_4 – Control (No residue)	4.64	4.40	4.09
SE (m) ±	0.40	0.43	0.04
CD at 5%	-	-	0.12
F test	NS	NS	Sig
Fertilizer levels			
F_1- 100% NPK	6.42	6.03	5.44
F_2- 75% NPK	5.68	5.64	4.97
F_3- 50% NPK	5.41	5.07	4.87
SE (m) ±	0.34	0.39	0.03
CD at 5%	-	-	0.10
F test	NS	NS	Sig
Interaction C × F			
SE (m) ±	1.04	1.09	0.08
CD at 5%	-	-	0.26
F test	NS	NS	Sig
Initial value	4.95		

Conclusions

It can be concluded that the application of rice straw @ 2.5 t ha^{-1} + ain leaf residue @ 2.5 t ha^{-1} along with 100% NPK is most useful for improving soil micronutrients status in Rice growing Alfisol. Significantly declining the micronutrient status of soil was due to 50%, 75% and 100% NPK alone. Overall, conjoint use of rice straw @ 2.5 t ha^{-1} + ain leaf residue @ 2.5 t ha^{-1} and 100% NPK was found to be overall superior effect on rice in Alfisol.

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