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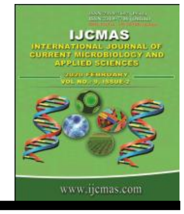

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Long Term Effect of Integrated Nutrient Management on Secondary and Micronutrient of Alluvial Soils

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A B S T R A C T

The present work studied the data from a 34 years old long-term rice–wheat cropping sequence to evaluate the effects of integrated nutrient management (INM) on secondary and micronutrient under alluvial soil. The treatment included three organic sources *viz.* FYM, wheat straw (WS) and green manuring (GM) with *Sesbania aculeate* replacing 25% and 50% of the optimum N during *kharif* season, treatment replacing 50% N through organic manure were given 100% RDF in wheat while those receiving 25% N replacement in rice got only 75% RDF in wheat. The results indicated that the replacement of 50% and 25% N of RDF to rice through organics either FYM/GM/ WS, significantly augment the DTPA-Zn, Cu, Fe &Mn, available S and boron (B) content of post-harvest soil. It has been found that the integrated nutrient management increased the soil DTPA extractable Zn from 38 - 75%, Cu 38 - 72%, Fe 27 - 53%, Mn 14 - 57%, Available S 68 - 95%, and hot water soluble B 93 - 160%, than 100% RDF over a period of 34 years continuous cultivation might be due to the prominent contribution of INM leads to maintain the soil heath and it developed inherent capacity of soil as compare to sole mineral fertilization.

Introduction

Long-term fertilizer treatments provide valuable figures on impact of endless cropping and intensive fertilization on soil properties. Secondary and micronutrients are essential for the growth of plants and animals and deficiencies in soil not only limit the crop production but also have negative effects on human nutrition and health (Govindaraj *et al.*, 2011). Similarly, excessive agro-ecosystem inputs of micronutrients such as iron (Fe), manganese (Mn), copper (Cu),and zinc (Zn), which are heavy metals, can possibly lead to toxicity in plants and animals and consequently pose a threat to human health through the food chain (Westfall *et al.*, 2005; Soriano-Disla *et al.*, 2010). Continuous use of high analysis fertilizers and restricted supply of organic manures was leads of secondary and micronutrient deficiencies in soil and plants. The overall deficiency of micronutrient in Indian soil was found to be 47 per cent for Zn, 2 per cent for Cu, 13 per cent for Fe and 4 per cent for Mn (Sakal and Singh, 2001). Chemical fertilizers alone are unable to maintain secondary and micronutrients in soil (Subba Rao and Srivastava 1998). Removal of sulphur by crops in India is about 1.26 mt whereas; its replenishment through fertilizers is only about 0.76 mt (Tiwari and Gupta, 2006), Sulphur can play its role as yield and quality driver nutrient in crop production when it is applied in the soil wisely. The original geological substrate and subsequent geochemical land pedogenic regimes determine total levels of secondary and micronutrients in soils, but their total contents are rarely indicative of plant availability, which is also influenced by soil pH, organic-matter content, adsorptive surfaces, and other physical, chemical, and biological factors in the rhizosphere. Thus, its availability in a given soil can also be strongly affected by fertilization practices. For example, long-term applications of inorganic nitrogen (N) and phosphorus (P) fertilizers reportedly result in depletion of soil available S, Zn, Fe, Mn, Cu and B in the plow layer, while incorporation of organic manure significantly increases contents of S, Zn, Fe, Mn, Cu and B in soils. Gao *et al.,* (2000) found that manure is a better source of available Fe, Mn and Zn than synthetic fertilizers, but manure applications accelerated the depletion of available Cu on a purple paddy soil in southwestern China after 9 years of fertilization. In contrast, in northern Italy, high liquid manure inputs reportedly increase risks of copper contamination on silty clay loam soils (Mantovi1 *et al.,* 2003). The application of organic materials is fundamentally important in that they supply various kinds of secondary and micronutrient; improve soil fertility and productivity(Suzuki, 1997). Clearly, there are urgent needs to understand the effects of current practices on secondary and micronutrients in key agricultural regions such as the Indo-Gangetic plane of alluvial soils to identify the most efficient practices for managing them. Therefore, the study presented here evaluated the long term effect of integrated nutrient management on secondary and micronutrient of alluvial soils.

Materials and Methods

The present study was carried out during 2017-18 in a permanent plot experiment established at Bihar Agricultural College Research Farm (25°23'N, 87°07'E and 37.19m.S.L), Sabour, Bhagalpur, Bihar, India under IFS scheme started from 1984 comprising four replication and twelve treatment permutations. The treatment included three organic sources *viz.* FYM, wheat straw (WS) and green manuring (GM) with *sesbania aculeate* replacing 25% and 50% of the optimum N during *kharif* season, treatment replacing 50% N through organic manure were given 100% RDF in wheat while those receiving 25% N replacement in rice got only 75% RDF in wheat. Thus it was making six INM treatment permutations, which were assessed against 100% RDF along with unfertilized absolute control.The required amount of FYM, wheat straw and green manure (*Sesbania aculata)* was applied 3 weeks before rice transplanting as per treatment to substitute a specified amount of N. The FYM, wheat straw and *Sesbania aculata* used in this experiment contain 0.50, 0.25 and 0.53% N, respectively. The initial physico-chemical properties of the experimental soil is Ustochrept clayey soil having pH 7.24, EC 0.24, organic carbon 0.46%, available N 246 kg/ha, available P_2O_5 23.60 kg /ha and available K_2O 155 kg /ha.The FYM, GM and WS were incorporated into the field by cross discing. Puddling was done at the time of transplanting the rice nursery. The average annual rainfall is about 500 to 550 mm, most of which is received during the rainy seasons. The climate of the tract is typically semi-arid climate and scarcity of water.

Soil samples were collected from 0 to 15 cm soil layers from all the replications after harvesting of the *rabi* crop in May 2018. The soil samples were analyzed for: DTPA extractable- Zn, Cu, Fe & Mn. 005 M DTPA, 0.01 M Calcium Chloride and 0.1 M Tri-ethanolamine (TEA) at pH (7.3) ((Lindsey and Norvell, 1978). Hot water soluble B determined by Azomethalin-H colorimetric method ((Wolf 1974), Available Sulphur by Turbidimetric method (Chesnin and Yien, 1950).

Results and Discussion

Indian agriculture during the past 50 years has achieved a fourfold growth in food production by adopting modern agricultural practices. The availability of fertilizer responsive, high yielding varieties (HYV) of rice and wheat has made it possible to produce 15–20 t ha^{-1} $year^{-1}$ of biomass drymatter.

Initially, this became possible by using nitrogenous (N) fertilisers alone, as the soil could provide all other essential nutrients needed by plants. However, within a few years, the nutrient reserves in soil were gradually exhausted and it was no longer possible to sustain higher yields even by applying both N and phosphorus (P) (Kanwar and Randhawa, 1974; Singh, 1988). Thus, in areas of high cropping intensity, deficiencies of secondary nutrients and micronutrients were frequently observed in cereal, oilseed, pulse and vegetable crops, which became critical in obtaining and sustaining higher crop production over the years (Singh, 2001; Singh *et al.*, 2004).

DTPA-extractable Zn

The significant changes were recorded in the status of DTPA-extractable Zn content of soil over a period of 34 years due to various treatment integration and the results showed (Table-2.) that the extractable zinc content increased from 0.83-1.49 mg kg^{-1} with various combination of inorganic and organic nutrient management practices. The DTPA-extractable zinc content (1.49 mg kg^{-1}) of soil highest value was obtained with T_6 -50% NPK of RDF + 50% N through FYM in rice crop and 100% NPK of RDF in wheat crop applied which was significantly superior over all the treatments like T_7 (1.27 mg kg^{-1}), T_8 (1.25 mg kg^{-1}), T_{11} (1.19 mg kg^{-1}), T_9 (1.14 mg kg^{-1}), T_1 (0.92 mg kg^{-1}), T_2& T_{12} (0.88 mg kg^{-1}), T_3 (0.87 mg kg^{-1}), T_5 (0.86 mg kg^{-1}) and T_4 (0.83 mg kg^{-1}) except statistically similar treatment T_{10} (1.31 mg kg^{-1}).

Imbalanced application of inorganic fertilizer decreased DTPA-extractable Zn contents in soil over control. Lowest DTPA-extractable Zn (0.83 mg kg^{-1}) was recorded in T_4-75% NPK of RDF in both crops. It might be due to nonstop use of only N, P, K fertilizers and mining of these micronutrients due to intensive cultivation of rice-wheat cropping sequence under the absence of any organic sources, it is necessities to regular use of organic fertilizer to maintain micronutrient status of soils.

Different research studies showed that addition of organic matter helps in accumulation of Zn in its available fraction due to its decomposition in the soil. H followed by).However, higher amount of organic matter favors decrease in the available form of Zn through chelation. FYM beneficial effect either complexion or mobilization of native Zn (Singh, 2007 and Sawarkar *et al.*, 2010).

DTPA-extractable Cu

The significant effect of the organic manure was recorded in the status of DTPA-extractable Cu varied from 1.48-3.24 mg/kg due to various organic and inorganic management treatments. The results showed that significantly superior of extractable Cu was noted under in T_6 50% N-FYM (3.24 mg/kg) and statically at par with $T_7$25% N-FYM (3.00 mg/kg), T_9 25%N-WS(2.86 mg/kg), T_{10} 50% N- GM (2.84 mg/kg) and T_8 50% N-WS (2.72 mg/kg) over in T_2-50% NPK(1.48 mg/kg). In present study DTPA-extractable Cu status decreased after application of inorganic fertilizer alone. Perusal of data revealed that in table (2). Lowest DTPA-extractable Cu was recorded in T_2-50% NPK (1.48 mg/kg). Available Cu contains increase may be ascribed to reduction in the redox-potential of the soil with the addition of organic sources which led to more release of micronutrients in an available form in the soil as compared with the application of chemical fertilizers only. Increment of DTPA-extractable Cu may be associated with the chelating action of organic sources (FYM, GM and WS) that are liberated due to decomposition of organic source that advantages in availability of micronutrients through the prevention of some particular processes like fixation, oxidation, precipitation and leaching (Dhaliwal *et al.,* 2019, Dhaliwal *et al.,* 2010 and walia *et al.,* 2010).

DTPA-extractable Fe

The combined application of inorganic fertilizer and organic manure was found significantly changes in the status of DTPA-extractable Fe in soil of post-harvest of wheat crop. The results revealed that DTPA-extractable Fe content increased from 24.11 to 37.03 mg kg^{-1} (Table 2) in amongst various treatments. Highest extractable Fe was noted under in T_6 -50% N-FYM (37.03 mg/kg) and statically at par with T_7-25% N-FYM (35.72 mg/kg), T_8-50% N-WS in (34.45mg/kg), T_{10}-50% N- GM(33.38 mg/kg), T_9-25%N-WS (31.85 mg/kg), T_{11}-25% N-GM (30.65mg/kg) over T_1 – (29.25).Lowest DTPA-extractable Fe was recorded in T_5-100% NPK (24.11mg/kg). In soil Fe cycle associated with decomposition of organic matter. Release of Fe due to Weathering of minerals is a very slow process governed mainly by pH and O_2 concentration and by the dissolution–precipitation phenomena (Mengel, 1994 and Lindsay, 1988). It was observed that, the rate of weathering of these minerals could be accelerated by the activities of living organisms (Baker and Banfield, 2003, Hansel *et al.,* 2004 and Liu *et al.,* 2006).

DTPA- extractable Mn

The data on DTPA-extractable Mn after harvest of wheat crop is presented in Table 2. DTPA-extractable Mn ranged between from 11.93 to 18.78 mg/kg between various combination of inorganic and organic nutrient management treatment. DTPA-extractable Mn was found significantly superior in T_6 -50% N-FYM (18.78mg/kg) and followed by T_{10}50% N- GM,T_7-25% N-FYM (15.25 mg/kg), T_{11} 25% N-GM, T_8 50% N-WS (13.76 mg/kg) and T_9 -25%N-WS(13.56 mg/kg) over T_5- (11.93mg/kg).Graded doses of chemical fertilizers also decreased the DTPA-extractable Mn contents in soil over control and graded dose of organic manure. Lowest DTPA-extractable Mn was observed in T_5-100% NPK in both crops (11.93 mg/kg), All the treatments where 50% NPK, 75% NPK and farmer practices in both crops was applied through inorganic fertilizer showed lower DTPA-extractable Mn in soil compared to the T1(14.00 mg kg^{-1}).

Table.1 Different treatment combinations in the long-term experiment

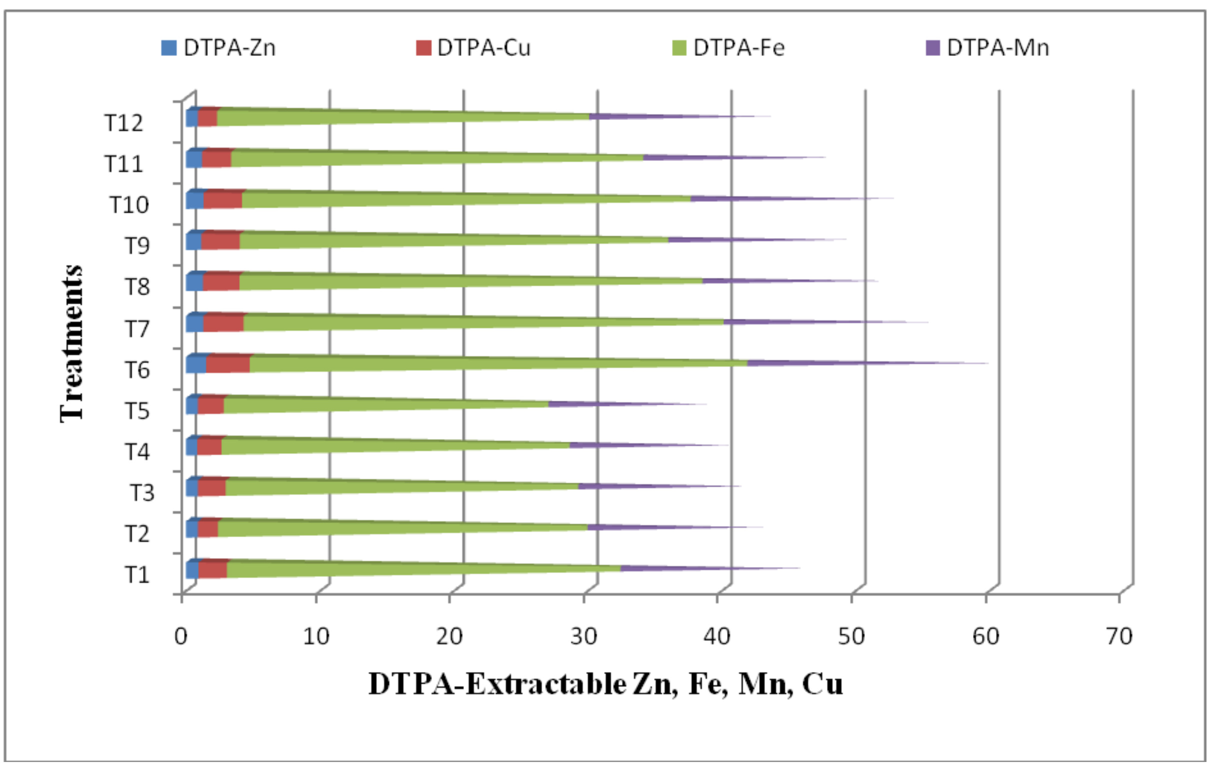
Treatments	Rice	Wheat
T_1	Control	Control
T_2	50% RD of NPK through fertilizer	50% RD of NPK through fertilizer
T_3	50% RD of NPK through fertilizer	100% RD of NPK through fertilizer
T_4	75% RD of NPK through fertilizer	75% RD of NPK through fertilizer
T_5	100% RD of NPK through fertilizer	100% RD of NPK through fertilizer
T_6	50% RD of NPK through fertilizer + 50% N through FYM	100% RD of NPK through fertilizer
T_7	75% RD of NPK through fertilizer + 25% N through FYM	75% RD of NPK through fertilizer
T_8	50% RD of NPK through fertilizer + 50% N through wheat straw	100% RD of NPK through fertilizer
T_9	75% RD of NPK through fertilizer + 25% N through wheat straw	75% RD of NPK through fertilizer
T_{10}	50% RD of NPK through fertilizer + 50% N through green manure	100% RD of NPK through fertilizer
T_{11}	75% RD of NPK through fertilizer + 25% N through green manure	75% RD of NPK through fertilizer
T_{12}	Farmer's practice ($N_{70}P_{30}K_{10}$)	Farmer's practice ($N_{80}P_{30}K_{15}$)

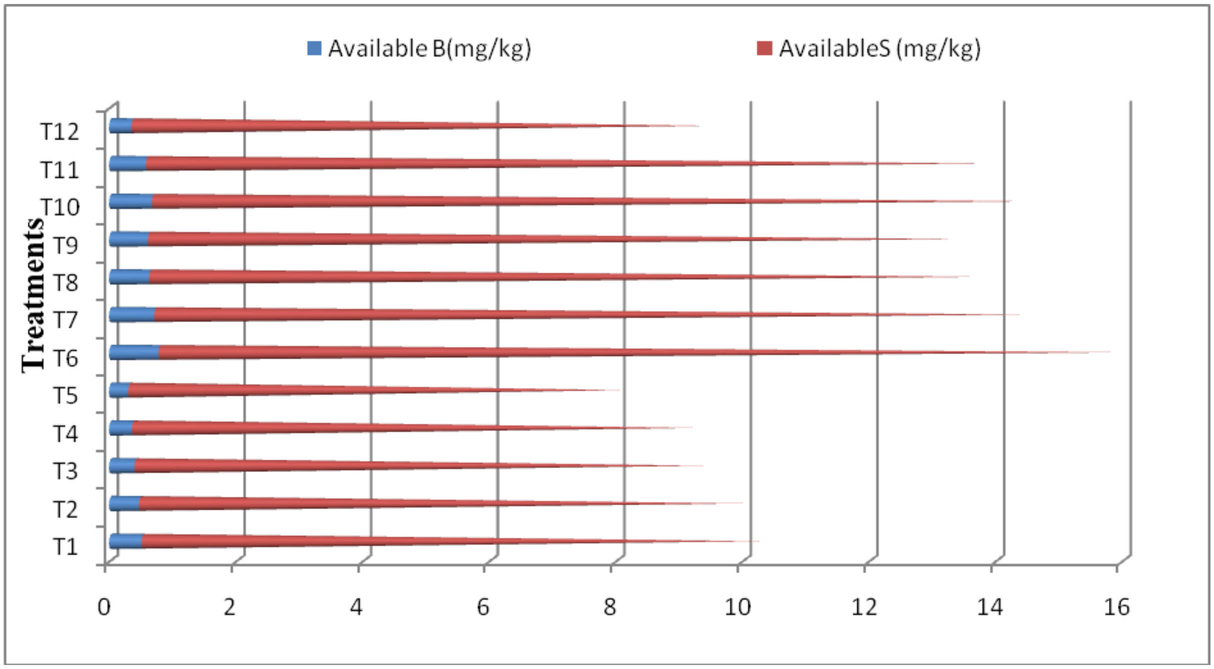
Table.2 Effect of long-term integrated nutrient management on DTPA-Extractable micronutrients of soil after 34th years of rice-wheat system

Treatment	DTPA-Zn (mg kg^{-1})	DTPA-Cu (mg kg^{-1})	DTPA-Fe (mg kg^{-1})	DTPA-Mn (mg kg^{-1})
T_1	0.92	2.12	29.25	14.00
T_2	0.88	1.48	27.47	13.12
T_3	0.87	2.06	26.20	12.69
T_4	0.83	1.80	25.87	12.06
T_5	0.86	1.94	24.11	11.93
T_6	1.49	3.24	37.03	18.78
T_7	1.27	3.00	35.72	15.25
T_8	1.25	2.72	34.45	13.76
T_9	1.14	2.86	31.85	13.56
T_{10}	1.31	2.84	33.38	15.37
T_{11}	1.19	2.16	30.65	14.24
T_{12}	0.88	1.42	27.65	13.62
S Em±	**0.07**	**0.17**	**2.38**	**1.03**
C.D(P=0.05)	**0.20**	**0.49**	**7.03**	**3.03**

Table.3 Effect of long-term integrated nutrient management on available Boron (B) and Sulphur (S) of soil after 34th year of rice-wheat system

Treatment	Available B(mg/kg)	AvailableS (mg/kg)
T_1	0.51	9.75
T_2	0.47	9.50
T_3	0.40	8.96
T_4	0.36	8.87
T_5	0.30	7.78
T_6	0.78	15.16
T_7	0.71	13.81
T_8	0.63	13.12
T_9	0.61	12.83
T_{10}	0.67	13.83
T_{11}	0.58	13.34
T_{12}	0.35	9.10
S Em±	**0.06**	0.89
C.D(P=0.05)	**0.17**	2.64





Organic manuring is another way to increase the Mn availability in soils. Its decomposition liberates a number of organic acids, lowers the soil reaction and increases the intensity of reduction in soil (Dhaliwal, 2008, Dhaliwal *et al.*, 2019 and Walia *et al.*, 2010).

Available sulphur

The available sulphur was significantly enhanced among different treatments is shown in table 3. It was ranged from 7.78 to 15.16 mg/kg due to different treatments. The highest sulphur was recorded under $T_6$15.16 mg/kg (50% N substituted with FYM in rice) which is statistically at par with T_{10} (13.83 mg/kg), T_7 (13.81 mg/kg), T_1(13.34 mg/kg),T_8 (13.12mg/kg) and T_9(12.83mg/kg) than T_1 (9.75mg/kg). Application of inorganic fertilizer (50, 75 and 100% RDF farmer practices to both the crops) dose increased the available sulphur content in soil significantly decreased over control. It was recorded the data in T_1-control (9.75 mg/kg) compared than T_2 (9.50 mg/kg), T_{12} (9.10 mg/kg)), T_3 (8.96 mg/kg), T_4 (8.87 mg/kg) and T_5 (7.78 mg/kg). Continuous growing of cereal crops without application of sulphur containing fertilizers caused decline in available 'S' in the soils compared to control (Shirale *et al.*, 2013, Thakur and Sawarker, 2009). Similar result observed that Thakur *et al.*, (2011) after 36 years under long term nutrient management. It might be possible that use of inorganic and organic fertilizer significantly increased available S in soil because decomposition of organic matter and released organic acid in soil

Available Boron

The significantly changes in the status of soil available boron over a period of 34 years due to integrated nutrient management practices. The current study of available boron content in soil when harvesting of wheat crop increased from 0.30 mg kg^{-1} under treatment T_5-100%NPKto 0.78 mg kg^{-1} under treatment T_6 50% N-FYM. Review data in table (3) revealed that available boron in soil was noted significantly superior in T_6 treatment due to different treatments combination and statically at par with T_7 (0.71 mg kg^{-1}), T_{10} 0.67 (mg kg^{-1}), T_8 (0.63 mg kg^{-1}), T_9 (0.61 mg kg^{-1}) and followed by T_{11} (0.58 mg kg^{-1}) over T_5 (0.30 mg kg^{-1}) where 100%NPK was applied. All the treatment where 25% and50% N-FYM, WS, GM along with inorganic fertilizers was registered higher available Boron in soil. Graded doses of chemical fertilizers also decreased the available boron contents in soil over control and graded dose of organic manure. Lowest available boron was recorded in T_5 (0.30 mg kg^{-1}), All the treatments where 50% NPK, 75% NPK,100% NPK and farmer practices in both crops was applied through inorganic fertilizer showed lower available boron in soil compared to the T_1(0.51 mg kg^{-1}). FYM, GM, and WS are an important soil constituent affecting the availability of B. it is considered as the leading source of reserve B (Borax, 1998). It then replenishes the soil solution. Soil organic matter adsorbs more B than mineral soil (Gu and Lowe, 1990). The available B show a positive correlation with organic matter content (Saha *et al.*, 1998).

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