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Direct and Residual Effect of Zinc and Boron on Growth, Yield and Chemical Properties of Soils under Paddy - Cowpea Cropping System

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ABSTRACT

A field experiment was conducted during *kharif* and *rabi* season of 2019-20 in paddy - cowpea cropping system at Bhairapura village, Hassan district, Karnataka to study direct and residual effect of zinc and boron on growth, yield and chemical properties of soils. Paddy was the test crop to study the direct effect and cowpea crop was raised to study the residual effect. The experiments were laid out in randomized complete block design with thirteen treatments and replicated thrice. The experimental results revealed that application of NPK and FYM along with zinc as $ZnSO_4$ @ 25 kg ha^{-1} and boron as borax @ 5 kg ha^{-1} recorded significantly higher plant height (86.53 cm), number of tillers $hill^{-1}$ (25.50), number of grains $panicle^{-1}$ (129.60), thousand grain weight (28.65 g) and grain yield (60.45 q ha^{-1}) of paddy. The residual effect of zinc as $ZnSO_4$ (25 kg ha^{-1}) and boron as borax (5 kg ha^{-1}) significantly recorded higher plant height (88.12 cm), number of branches $plant^{-1}$ (17.47), number of pods $plant^{-1}$ (27.10), hundred seed weight (15.33 g) and seed yield (1358.54 kg ha^{-1}) of cowpea. Higher major (N, P, K and S) and micronutrient (Zn and B) status of soils was also recorded in T_5 treatment (NPK + FYM + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 5 kg ha^{-1}) which was on par with T_7 treatment that received NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax and the lower value was found in absolute control (T_1).

Keywords : Zinc, Boron, Paddy yield, Cowpea yield, Soil nutrient status

RICE (*Oryza sativa* L.) is a key staple food that feeds over half of the world's population. It serves as a major source of calories for about 80 per cent of the world population. It is grown in more than 100 countries, predominantly in Asia. Rice provides 21 per cent of energy and 15 per cent of protein requirements of human populations globally (Depar *et al*., 2011). To feed ever-rising world population, which is estimated to be 10 billion by the end of this century, an increase in rice production per unit area is directly needed. After nitrogen (N), phosphorus (P) and potassium (K), micronutrients deficiency that of zinc and boron is widespread in rice growing areas of country that leads to substantial loss in yield and quality of grain with respect to protein and fat contents. Fertilizers particularly zinc and boron in addition to recommended dose of major nutrients is needed to increase yield, uptake and total content of essential nutrients in rice.

Zinc and boron are essential micro nutrient elements required by plants in small quantities for their successful growth and development. Zn is established as an essential nutrient with well defined functions as co factor as well as constituent of many enzymes in synthesis of many hormones and enzymes. Zinc, on the other hand is essential for tryptophan synthesis and the generation of growth hormones such as indole acetic acid (auxins). It is found in enzymes such as carbonic anhydrase, superoxide dismutase and alcoholic dehydrogenase and it also plays a role in plant protein and nucleic acid metabolism.

Boron plays an important role in growth and nutrition of the crop plants and it promotes proper cell division, cell elongation, cell wall strength, flowering, pollination, seed set, sugar translocation, respiration, RNA metabolism, indole acetic acid metabolism and phenol metabolism in plants. The reason for the lowest grain yield in boron deprived plots might be the higher pollen infertility and lower grain filling as it plays very active role in both processes (Rashid *et al*., 2004). Boron nutrition is more significant in cereals during the reproductive stage than during the vegetative stage.

Zinc found adsorbed on solid surfaces or on exchange sites of clay minerals and organic materials. The availability of zinc diminishes as soil pH rises. High soil pH can cause zinc deficiency in calcareous soils, as well as zinc precipitation as insoluble amorphous soil zinc and $ZnSiO_4$, reducing accessible zinc in the soil. Zinc adsorption on the surface of $CaCO_3$ may also reduce the amount of zinc in the solution. Zinc adsorption by clay minerals, Fe/Al oxides, organic matter and $CaCO_3$ increases when soil pH rises. Zinc deficiency can be identified by distinctive visual symptoms that appear in leaves. In rice, zinc deficiency is called as Khaira disease where in plants show white patches on foliage and become stunted in growth. The concentration of zinc in plants is a function of available zinc in soil.

Cowpea (*Vigna unguiculata* Walp.) is one of the most important vegetable crops grown as pulse, vegetable and fodder. It is poor man's protein source and considered one of the most ancient human food sources. It is an important source of nutrients and provides high quality, inexpensive protein to diet based on cereal grains and starchy foods. Cowpea is highly responsive to fertilizer application and dose of fertilizer depends on the initial soil fertility. Despite being a legume, cowpea responds well to a residual application of the necessary fertiliser dose. Keeping the above points in view, the experiments were undertaken with an objective to study direct and residual effect of zinc and boron on growth, yield and chemical properties of soils under paddy-cowpea cropping system.

Material and Methods

Field experiment was conducted on farmer's field at Bhairapura village, Hassan district, Karnataka during *kharif and rabi* season, to study direct and residual effect of zinc and boron on growth, yield and chemical properties of soils under paddy - cowpea cropping system. A composite surface soil sample (0-15 cm depth) was collected for analysis before the commencement of the experiment.

The initial soil status of the experimental site is presented in Table 1. The experiment was laid out in randomised complete block design (RCBD) with Thirteen treatments (13) and replicated thrice (3) with using Rishi Poonam variety of paddy and KBC 9 variety of Cowpea. The treatments were *viz.* T_1: Control, T_2: Package of practice (NPK + FYM + 20 kg ha^{-1} $ZnSO_4$), T_3: NPK + FYM + 25 kg ha^{-1} $ZnSO_4$, T_4: NPK + FYM + 20 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax, T_5: NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax, T_6: NPK + FYM + 20 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax, T_7: NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax, T_8: NPK + 20 kg ha^{-1} $ZnSO_4$, T_9: NPK + 25 kg ha^{-1} $ZnSO_4$, T_{10}: NPK + 20 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax, T_{11}: NPK + 25 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax, T_{12}: NPK + 20 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax and T_{13}: NPK + 25 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax. $ZnSO_4$ and borax were used to add zinc and boron at two levels, 20 and 25 kg $ZnSO_4$ ha^{-1} and 5 and 10 kg borax ha^{-1}, respectively. At transplanting, recommended dose of FYM (10 t ha^{-1}), 50 per cent of the nitrogen, 100 percent of phosphorus and potassium were applied as urea, DAP and MOP fertilizer. The remaining nitrogen was provided in two equal split doses of 25 per cent each at the tillering and panicle initiation stages *via* urea.

Table 1
Initial physico-chemical properties of the experimental site

Particulars	Content
Texture	Sandy loam
pH (1:2.5)	5.65
EC (dSm^{-1} at 25^{0}C)	0.27
Organic Carbon (%)	0.41
Available N (kg ha^{-1})	285.85
Available P_2O_5 (kg ha^{-1})	18.52
Available K_2O (kg ha^{-1})	189.50
Exchangeable Ca [C mol (P+) kg^{-1}]	5.55
Exchangeable Mg [C mol (P+) kg^{-1}]	2.30
Available S (mg kg^{-1})	14.25
DTPA – Extractable Zn (mg kg^{-1})	1.08
DTPA – Extractable Cu (mg kg^{-1})	1.31
DTPA – Extractable Fe (mg kg^{-1})	3.35
DTPA – Extractable Mn (mg kg^{-1})	2.02
Hot water soluble B (mg kg^{-1})	0.46

Nutrient composition of FYM used in the experiment

Parameters	Value
N (%)	1.21
P (%)	0.18
K (%)	1.02
Zn (mg kg^{-1})	18.13
B (mg kg^{-1})	2.51

Twenty five day's old rice seedlings were transplanted in well-puddled and levelled plots at a spacing of 20 x 10 cm, with 2 to 3 seedlings per hill. Plots were irrigated after two days of transplanting to maintain 2.0 cm level of submergence for eight days. Later, these plots were irrigated to maintain the water level to a height of 5 cm throughout the crop growth except last ten days to harvest.

Cowpea cultivated as a succeeding crop. Need based plant production and protection measures were taken up and the crops were grown to maturity and harvested. Soil samples (0-15 cm depth) from individual plots were collected at harvest of both crops for analysis of physico-chemical properties of soil by standard method (Piper, 1966; Jackson, 1973; Walkley & Black, 1934; Subbaiah & Asija, 1956; Page *et al.,* 1982; Lindsay & Norwell, 1978; Berger & Troug, 1939 and Tisdale *et al.,* 1985). The biometric observations like growth and yield parameters were recorded plot wise. Post-harvest soil samples from various treatments were collected and analysed for nutrient status.

Results and Discussion

Growth and Yield Parameters of Paddy

The results presented in the Table 2 indicates that treatment T_5 which received application of recommended levels of major nutrient fertilizers (NPK) and FYM along with $ZnSO_4$ @ 25 kg ha^{-1} and Borax @ 5 kg ha^{-1} recorded significantly highest plant height (86.53 cm) and number of tillers $hill^{-1}$ (25.50) and it was on par with the treatment T_7 which received NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax. Lower plant height (72.11 cm) and number of tillers $hill^{-1}$ (13.15) was recorded in T_1 treatment (Control). It is a well-known fact that boron is essential in enhancing carbohydrate metabolism, sugar transport, cell wall structure, protein metabolism, root growth and stimulating other physiological processes of plant (Ashour and Reda, 1972). However, combined application of Zn and B the paddy crop responded well and resulted in enhanced growth and yield. These results were in accordance with that of Reddy *et al.* (2020), Balachandar *et al.* (2003) and Mahendra kumar *et al.* (2017) who reported that increase in plant height and the number of tillers $hill^{-1}$ of crop due to the application of boron and zinc. In this study, a synergistic effect of boron and zinc was found in increasing plant height and the number of tillers $hill^{-1}$ of paddy.

Significantly highest number of grains $panicle^{-1}$ (129.60) and thousand grain weight (28.65 g) were recorded in T_5 treatment which received NPK + 25 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax which was on par with treatment T_7 (NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax). The lowest number of grains $panicle^{-1}$ (100.61) and thousand grain weight (19.31 g) was recorded in T_1 treatment (control) as compared to other treatments. The results very clearly indicated that the application of both the nutrients may increase the number of grains $panicle^{-1}$ and also the need for application of boron increase the thousand grain weight. These results were in accordance with that of Santosh *et al.* (2019) and Shankar *et al.* (2016).

A significant increase in grain yield of rice was noticed over the control due to application of different levels of $ZnSO_4$ and borax along with FYM. The highest grain yield (60.45 q ha^{-1}) was recorded in the T_5 treatment which received NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax which was significantly superior over all other treatments and it was on par with T_7 treatment (NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax) and the lowest grain yield (47.11 q ha^{-1}) was recorded in T_1 treatment (control). Application of Zn and B, when used alone as well as when applied in combination with FYM, resulted in significantly higher grain yield than the control. In this experiment, the crop yield increased to a much greater extent due to the combined use of Zn and B along

TABLE 2

Effect of levels of zinc and boron on growth and yield parameters of paddy in paddy - cowpea cropping system

Treatment	Plant height (cm)	Number of tillers $hill^{-1}$	No. of grain $panicle^{-1}$	Thousand grain weight (g)	Grain yield (q ha^{-1})
T_1 : Absolute Control	72.11	13.15	100.61	19.31	47.11
T_2 : Package of practice (NPK + FYM + 20 kg ha^{-1} $ZnSO_4$)	77.55	19.61	111.33	23.57	53.36
T_3 : NPK + FYM + 25 kg ha^{-1} $ZnSO_4$	79.69	21.11	115.57	24.79	54.95
T_4 : NPK + FYM + 20 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax	84.44	23.83	124.71	27.39	58.73
T_5 : NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax	86.53	25.50	129.60	28.65	60.45
T_6 : NPK + FYM + 20 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax	83.92	23.43	123.66	26.91	58.34
T_7 : NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax	86.22	25.08	128.36	28.18	60.02
T_8 : NPK + 20 kg ha^{-1} $ZnSO_4$	76.56	18.22	108.59	22.85	52.30
T_9 : NPK + 25 kg ha^{-1} $ZnSO_4$	78.70	19.89	113.14	24.07	53.94
T_{10} : NPK + 20 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax	80.43	20.86	118.07	25.21	55.35
T_{11} : NPK + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax	82.53	22.51	122.46	26.55	56.87
T_{12} : NPK + 20 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax	80.04	20.47	117.54	24.91	55.13
T_{13} : NPK + 25 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax	82.16	21.93	121.81	26.12	56.26
S.Em±	0.63	0.51	1.41	0.41	0.56
C.D. at 5 %	1.85	1.48	4.09	1.19	1.62

NPK: 100 kg N+ 50 kg P_2O_5+ 50 kg K_2O ha^{-1}, FYM: Farm yard manure (10 t ha^{-1})

with FYM than their use alone and without FYM. These results were in accordance with that of Behera *et al.* (2018), Muhammad *et al.* (2012), Quddus *et al.* (2011) and Jyoti *et al.* (2013).

Growth and Yield Parameters of Cowpea

Plant height and the number of branches $plant^{-1}$ in cowpea were influenced significantly by residual effect of zinc and boron. Treatment T_5 that received residual NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax recorded highest plant height (88.12 cm) and the number of branches $plant^{-1}$ (17.47) which was on par with treatment T_7 that received NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax. The lowest plant height (77.43 cm) and the number of branches $plant^{-1}$ (12.32) recorded in absolute control.

Significantly higher number of pods $plant^{-1}$ (27.10 pods $plant^{-1}$) and hundred seed weight (15.33 g) were recorded in T_5 treatment which received residual NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax and it was on par with treatment T_7 which received residual NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax (26.83 pods $plant^{-1}$ and 15.05 g). The lower number of pods $plant^{-1}$ (20.17 pods $plant^{-1}$) and hundred seed weight (10.08 g) were recorded in absolute control (T_1). Similar results were reported by Prashantha *et al.* (2019), Polara *et al.* (2010) and Aparna and Puttaiah, (2012).

Residual effect of zinc and boron significantly enhanced seed yield of cowpea and in treatment T_5 which received residual NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax recorded higher seed yield. (1358.54

TABLE 3
Residual effect of levels of zinc and boron on growth and yield parameters of cowpea in paddy - cowpea cropping system

Treatment	Plant height (cm)	No. of branches plant^{-1}	Hundred seed weight (g)	No. Pods plant^{-1}	Seed yield (kg ha^{-1})
T_1 : Absolute Control	77.43	12.32	10.08	20.17	1051.94
T_2 : Package of practice (NPK + FYM + 20 kg ha^{-1} $ZnSO_4$)	82.21	14.60	12.40	23.03	1178.39
T_3 : NPK + FYM + 25 kg ha^{-1} $ZnSO_4$	83.53	15.23	12.95	24.11	1216.34
T_4 : NPK + FYM + 20 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax	86.48	16.83	14.71	26.27	1324.99
T_5 : NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax	88.12	17.47	15.33	27.10	1358.54
T_6 : NPK + FYM + 20 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax	85.95	16.57	14.42	25.75	1301.70
T_7 : NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax	87.25	17.21	15.05	26.83	1345.34
T_8 : NPK + 20 kg ha^{-1} $ZnSO_4$	81.62	14.01	11.91	22.16	1142.85
T_9 : NPK + 25 kg ha^{-1} $ZnSO_4$	82.84	14.58	12.52	23.33	1190.32
T_{10} : NPK + 20 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax	84.34	15.81	13.69	24.77	1241.71
T_{11} : NPK + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax	85.62	16.34	14.28	25.80	1280.90
T_{12} : NPK + 20 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax	83.85	15.51	13.41	24.57	1234.71
T_{13} : NPK + 25 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax	85.09	16.14	14.09	25.68	1268.36
S.Em±	0.42	0.19	0.18	0.35	9.09
C.D. at 5 %	1.24	0.56	0.52	1.02	26.53

kg ha^{-1}) which was on par with treatment T_7 which received residual NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax. The lower seed yield (1051.94 kg ha^{-1}) was recorded in T_1 treatment (absolute control). These results are in accordance with that of Achin & Singh (2018), Shankar *et al.* (2016) and Prashantha *et al.* (2019).

Chemical Properties of Soil

Available Nutrient Status of Soil after the Harvest of Paddy : The available nitrogen and phosphorus content of soil was significantly higher in T_5 (NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax) recorded 310.84 and 29.44 kg ha^{-1} and it was on par with T_7

TABLE 4

Effect of levels of zinc and boron on nutrient status of soil after the harvest of paddy

Treatment		kg ha^{-1}			mg kg^{-1}	
		Available N	Available P_2O_5	Available K2O	Zn	B
T_1 :	Absolute Control	280.65	19.06	190.21	0.98	0.39
T_2 :	Package of practice (NPK + FYM + 20 kg ha^{-1} $ZnSO_4$)	293.08	24.79	197.93	2.74	0.49
T_3 :	NPK + FYM + 25 kg ha^{-1} $ZnSO_4$	297.40	25.93	201.05	2.95	0.51
T_4 :	NPK + FYM + 20 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax	306.79	28.26	207.02	3.61	0.75
T_5 :	NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax	310.84	29.44	209.71	3.79	0.82
T_6 :	NPK + FYM + 20 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax	305.57	28.01	206.48	3.58	0.73
T_7 :	NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax	309.39	29.16	210.32	3.75	0.79
T_8 :	NPK + 20 kg ha^{-1} $ZnSO_4$	291.76	24.04	197.42	2.56	0.47
T_9 :	NPK + 25 kg ha^{-1} $ZnSO_4$	295.77	25.09	200.65	2.88	0.49
T_{10} :	NPK + 20 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax	299.77	26.41	201.75	3.13	0.67
T_{11} :	NPK + 25 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax	304.18	27.62	204.91	3.42	0.72
T_{12} :	NPK + 20 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax	298.40	26.28	201.57	3.11	0.65
T_{13} :	NPK + 25 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax	303.81	27.47	204.08	3.32	0.69
S.Em±		1.44	0.35	1.04	0.07	0.01
C.D. at 5 %		4.19	1.02	3.04	0.22	0.04

(NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax) and followed by T_4 and T_6 which was significantly superior than other treatments. Lower N and P status was observed in control (280.65 and 19.06 kg ha^{-1}). The increase in available nitrogen occurs due to the enhanced multiplication of microbes by the incorporation of crop residues which catalyze the conversion of organically bound N to inorganic form. Favourable soil conditions under crop residues incorporation might have helped in the mineralization of soil N leading to the buildup of higher available N (Prasad *et al*., 2010). The enhanced solubility of native phosphorus due to organic acids created during the decomposition of FYM could be ascribed to the higher accessible soil phosphorus. These findings are supported with that of Sharma *et al.* (2016).

Available potassium status in soil differed significantly at harvest of paddy. Significantly higher potassium status was recorded in T_7 (210.32 kg ha^{-1}) and it was on par with T_5 (NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax). Control (T_1) recorded lower available potassium status (190.21 kg ha^{-1}). Rao and Shukla (1997) reported that increase in release rate of K on application of fertilizers resulted in larger decline of K in reserve pool of the soil.

The DTPA extractable zinc content and hot water soluble boron of soil varied significantly at harvest of

TABLE 5

Residual effect of levels of zinc and boron on nutrient status of soil after the harvest of paddy

Treatment	kg ha^{-1}			mg kg^{-1}	
	Available N	Available P_2O_5	Available K_2O	Zn	B
T_1 : Absolute Control	270.87	18.87	180.44	0.94	0.36
T_2 : Package of practice (NPK + FYM + 20 kg ha^{-1} $ZnSO_4$)	282.09	24.36	190.70	2.66	0.46
T_3 : NPK + FYM + 25 kg ha^{-1} $ZnSO_4$	285.65	25.42	193.91	2.91	0.48
T_4 : NPK + FYM + 20 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax	294.46	27.73	200.48	3.52	0.72
T_5 : NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax	297.63	28.82	203.57	3.73	0.78
T_6 : NPK + FYM + 20 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax	293.70	27.28	199.59	3.48	0.69
T_7 : NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax	296.98	28.29	202.72	3.68	0.76
T_8 : NPK + 20 kg ha^{-1} $ZnSO_4$	280.29	23.57	188.27	2.49	0.41
T_9 : NPK + 25 kg ha^{-1} $ZnSO_4$	283.94	24.61	191.76	2.81	0.43
T_{10} : NPK + 20 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax	289.55	25.89	196.23	3.06	0.62
T_{11} : NPK + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax	292.67	27.06	199.05	3.30	0.66
T_{12} : NPK + 20 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax	288.36	25.54	195.88	2.97	0.60
T_{13} : NPK + 25 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax	291.59	26.84	198.70	3.24	0.64
S.Em±	1.04	0.36	1.08	0.08	0.01
C.D. at 5 %	3.04	1.04	3.10	0.21	0.04

paddy. Significantly higher zinc and boron content (3.79 and 0.82 mg kg^{-1}) was recorded in T_5 (NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 5 kg ha^{-1} Borax) and it was on par with T_7 which received NPK + FYM + 25 kg ha^{-1} $ZnSO_4$+ 10 kg ha^{-1} Borax. Control (T_1) recorded significantly lower zinc status (0.98 and 0.39 mg kg^{-1}). However, the soil application of Zn and B had a significant effect on available Zn and B in the soil after harvest. The difference in the quantities of applied Zn and B might be the reason for this and have good relation with synergistic in interaction. The results obtained were in accordance with results of Mahendrakumar (2014).

Available Nutrient Status of Soil after the Harvest of Cowpea : The status of major (N, P and K) and micro nutrient (Zn and B) in soil as influenced by two levels of zinc and boron after the harvest of cowpea is presented in Table 5 & 6. Increase in available nitrogen was noticed among the treatments due to residual effect of NPK and FYM along with zinc and boron.

Treatment T_5 which received NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax recorded significantly higher available nitrogen and phosphorus (297.63 and 28.82 kg ha^{-1}) content after the harvest of cowpea and it was on par with treatment T_7 which received NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 10 kg ha^{-1} Borax. Lower available nitrogen content (270.87 and 18.87 kg ha^{-1}) was recorded in T_1 treatment (Control). The application of NPK and FYM with zinc and boron increased available nitrogen among treatments. However, the increase in available nitrogen occurs due to the enhanced multiplication of microbes by the incorporation of crop residues which catalyze the conversion of organically bound N to inorganic form. Favourable soil conditions under crop residues incorporation might have helped in the mineralization of soil N leading to the buildup of higher available N (Prasad *et al*., 2010). Higher available soil phosphorus could be attributed to increased solubility of native phosphorus by means of organic acids produced during the course of decomposition of FYM. These results are in accordance with the results of Sheshadri Reddy (2005).

Available potassium showed significant difference among the treatments. Significantly higher potassium content (203.57 kg ha^{-1}) was observed in T_5 treatment (NPK + FYM + ZnSO4 @ 25 kg ha^{-1} + Borax @ 5 kg ha^{-1}) and it was on par with T_7 treatment (NPK + FYM + ZnSO4 @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1}). Control (T_1) recorded significantly lower available potassium (180.44 kg ha^{-1}). The increases in the available potassium status of soil was due to application of organic materials which might have ascribed to greater capacity of organic colloids to hold the nutrients at the exchange sites and also reduction in potassium fixation and release of potassium to the available pool of soil. These observations are in conformity with the results of Sheshadri Reddy (2005).

The status of zinc and boron in soil as influenced by residual effect of zinc and boron in paddy - cowpea cropping system are presented in Table 5. Significantly higher zinc and boron content was recorded in T_5 treatment which received NPK + FYM + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 5 kg ha^{-1} (3.73 and 0.78 mg kg^{-1}) and it was on par with T_7 treatment (NPK + FYM + $ZnSO_4$ @ 25 kg ha^{-1} + Borax @ 10 kg ha^{-1}). Treatment T_1 (control) recorded lower value. Prashantha *et al.* (2019) reported that, the residual effect of graded amounts of Zn and B in combination with NPK and FYM increased zinc and boron content of soil.

Considering the whole cropping system, application Zn and B along with NPK and FYM increased growth and yield of paddy as well as residual crop cowpea. From this study it can be concluded that direct and residual effect of NPK + FYM + 25 kg ha^{-1} $ZnSO_4$ + 5 kg ha^{-1} Borax recorded significantly higher growth and yield of paddy and cowpea compared to other treatments. Further there is significant increase in major and micro nutrient status of soils after the harvest of cowpea crop among treatments due to application of NPK and FYM with graded levels of zinc and boron compared to control.

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