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Enhancing Crop Productivity through Zn and B Fertilization in Maize- Blackgram Cropping System

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Field experiment was conducted during 2011-12 in maize-blackgram cropping system to determine the effect of boron (B) and zinc (Zn) on the yield and yield components in B and Zn-deficient red soils (Fine loamy hyperthermic Udic Haplustalfs) of *Pattukkottai series* in Pudukkottai district, Tamil Nadu. The treatments included for the main crop maize hybrid (NK-6240) and residual blackgram (var.Vamban-3) were three levels of NPK as main plot treatments M_1: Control (No N, P and K), M_2: 75% NPK kg ha^{-1}, M_3: 100% NPK ha^{-1} (250:75:75)and nine levels of sub plot treatments as $ZnSO_4$ @ 37.5 kg ha^{-1}(S2), 50kg $ZnSO_4$ ha^{-1}(S3), 10 kg Borax ha^{-1}(S4), 15 kg Borax ha^{-1} (S5), 37.5 kg $ZnSO_4$ ha^{-1} +10 kg Borax ha^{-1} (S6), 37.5 kg $ZnSO_4$ ha^{-1} +15 kg Borax ha^{-1} (S7), 50 kg $ZnSO_4$ ha^{-1} +10 kg Borax ha^{-1} (S8) and 50 kg $ZnSO_4$ ha^{-1} +15 kg Borax ha^{-1} (S9) and also without application of fertilizers was maintained as absolute control (S1) in split plot design. Results revealed that application of $ZnSO_4$ and Borax @ 37.5 kg +10 kg ha_{-1} respectively combined with recommended 100% NPK ha_{-1} (M_3S_6) significantly recorded the highest grain (6.93 t ha_{-1}) and stover yield (12.57 t ha_{-1}). For residual crop black gram, application of $ZnSO_4$ and Borax @ 50 kg and10 kg ha^{-1} respectively combined with recommended 100% NPK ha $^{-1}$ (M_3S_8) significantly recorded the highest seed (747.9 kg ha_{-1}) and haulm yield (80.8 kg ha_{-1}). Among the different levels of macro with micronutrient combinations, the highest gross income (Rs.1,33,391) was recorded under the treatment 100 % NPK + Zn_{10} $B_{1.0}$ (M_3S_8) than 37.5 kg $ZnSO_4$ ha_{-1} +10 kg Borax ha_{-1}(M_3S_6). Hence, in Zn and B deficient soil, combined application of 100% NPK along with 50 kg and10 kg of $ZnSO_4$ and Borax ha^{-1}respectively (M_3S_8) may be recommended for enhancing yield and gross income in maize-blackgram cropping system

Key words: Maize- blackgram, Zinc, Boron, Grain, Stover, Seed and Haulm yield

Micronutrient deficiencies in crop plants are widespread because of increased micronutrient demands from intensive cropping practices and adaptation of high-yielding cultivars which may have higher micronutrient demand, enhanced production of crops on marginal soils that contain low levels of essential micronutrients, increased use of high-analysis fertilizers with low amounts of micronutrients, decreased use of animal manures, composts, and crop residues, soils having inherently low in micronutrient reserves, use of liming in acid soils, and involvement of natural and anthropogenic factors that limit adequate supplies and create elemental imbalance (Fageria *et al*., 2002). Among micronutrients, boron (B) and zinc (Zn)play a key role in pollination and seed set processes, so that their deficiency can cause decrease in seed formation and subsequent yield reduction.

Maize, one of the important food crops in the world is sensitive to Zn deficiency. Stunted and chlorotic plants due to Zn deficiency are often observed on early grown plants (Liu *et al*., 1996). Maize is a Zn- intensive plant with a high Zn- demand that positively responds to Zn dressing under low levels of available Zn in the soil (Kovacevic *et al*.,2004). Boron is an essential element for plant growth and yield. Among the cereals, maize is relatively more susceptible to B deficiency (Agarwala and Sharma, 1979). Boron also plays an important role in increasing the grain yield in maize as stated by Yiying Li and Hong Lang, (1997). Rehem *et al*., (1998) stated that B plays a key role in water and nutrients transportation from root to shoot. Vitosh *et al.,* (1997) opined that B is involved in carbohydrates metabolism and it is essentially necessary for protein synthesis, pollen germination and seed and cell wall formation.

In India, maize occupies 7.42 million ha with a production and productivity of 14.2 million tonnes and 1983 kg ha_{-1}, respectively (Singh *et al.,* 2007). Maize is grown in Tamil Nadu in about an area of 2.44 lakh ha with a total production of 11.38 lakh tonnes and a productivity of 4461 kg ha_{-1} (Season and Crop Report, 2009 -10). Blackgram is a promising pulse crop and it is preferred much for its nutritional quality of high protein. India has the largest area of 2 million ha under blackgram cultivation in the world. However, the yield average of 567 kg ha_{-1}

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is lower among the countries in the world. In Tamil Nadu, Blackgram is being grown in an area of 2.59 lakh ha with a total production of 0.98 lakh tonnes and the productivity of 380 kg ha_{-1} (Season and Crop Report, 2009-10). Among the micronutrients, zinc deficiency in agricultural crops is a common disorder in a wide variety of soils and about 49% as well as 58% of the soils used for cultivation in India and in Tamil Nadu, respectively are Zn-deficient. Zinc deficiency in Indian soils is expected to increase from 42 % in 1970 to 63% by 2025 due to continuous depletion of soil fertility. The overall per cent deficiency of micronutrients in Tamil Nadu soils *viz.*, Zn, Fe, Mn and Cu are estimated to be 58, 17, 6 and 6 per cent, respectively (Velu *et al.*, 2008).

At present for alleviating Zn and boron deficiency, zinc sulphate and borax are the common fertilizers available to the farmers in the market. Moreover, the yield of these crops are comparatively low in Tamil Nadu because of our farmers' inadequate knowledge about the beneficial role of micronutrients, especially zinc and boron in increasing the production of crops .Since NPK fertilizer does not produce a proportionate increase in crop production and sustainability, adoption of balanced fertilization involving major, secondary and micronutrient is needed for the efficient use of nutrients in the current production scenario. In this background, field experiments were carried out in soils having various levels of zinc sulphate and borax to study the effect of zinc and boron in maize and blackgram cropping system.

Materials and Methods

The field experiment was conducted during 2011-12 in maize- blackgram cropping system in the farmer's holdings of B and Zn-deficient red soils (Fine loamy *hyperthermic Ultic Haplustalfs*) in Pudukkottai district, Tamil Nadu in a split plot design, which was replicated thrice.The mechanical composition of the experimental soil belongs to sandy loam texture. The pore space was 40.86 and 41.33 per cent, respectively. Bulk density and particle density of the soil were 1.39 Mg m_{-3} and 2.42 Mg m_{-3} respectively. The soil was near neutral in reaction and free from salinity (pH 6.67 and electrical conductivity of 0.09 dSm_{-1}). The organic carbon content of the soil was low (0.29 %) and the CEC value as 11.0 C mol (p_{+}) kg_{-1} of soil. The major nutrients status of the soil was medium in available

N (289 kg ha_{-1}), available P(15.2 kg ha_{-1}) and available K (249 kg ha_{-1}), respectively. The available S in the soils was high (25 mg kg_{1}). The soil was deficient in DTPA Zn (0.80 mg kg_{-1}) and hot water soluble B (0.26 mg kg_{-1}) and sufficient in Cu (1.71 mg kg_{-1}), Fe (16.8 mg kg_{-1}) and Mn (9.10 mg kg_{-1}).

The treatments included for the main crop maize hybrid (NK-6240) and residual blackgram (var.Vamban-3) were three levels of NPK as main plot treatments M_1: Control (No N, P and K), M_2: 75% NPK kg ha_{-1}, M_3: 100% NPK ha_{-1} (250:75:75) and nine levels of sub plot treatments as $ZnSO_4$ @ 37.5 kg ha_{-1} (S2), 50 kg $ZnSO_4$ ha_{-1}(S3), 10 kg Borax ha_{-1}(S4), 15 kg Borax ha_{-1} (S5), 37.5 kg $ZnSO_4$ ha_{-1} + 10 kg Borax ha_{-1} (S6), 37.5 kg $ZnSO_4$ ha_{-1} +15 kg Borax ha^{-1} (S7), 50 kg $ZnSO_4$ ha^{-1} +10 kg Borax ha^{-1} (S8) and 50 kg $ZnSO_4$ ha_{-1} + 15 kg Borax ha_{-1} (S9) and a control (S1) without application of fertilizers in split plot design. The fertilizers used were urea (46% N), single super phosphate (16% P), muriate of potash (60% K), zinc sulphate (Zn - 21%), borax (B-11%) and gypsum (18% S). The fertilizer schedule followed for the maize hybrid NK 6240 was 250:75:75N, P_2O_5 and K_2O $Kgha^{-1}$ and for residual crop blackgram as 25: 50: 25 Kg N, P_2O_5 and K_2O ha_{-1}. Uniform dose of 40 Kg S ha_{-1} in the form of gypsum for maize and 20 Kg $ha_{-1}$for blackgram was applied to all treatment plots. The recommended dose of 250:75 Kg N and P_2O_5 ha^{-1} were applied through urea super phosphate to all the treatments. The recommended (100 %) dose of 75 KgK_2O ha_{-1} was applied basally through muriate of potash before sowing of seeds and the required quantity of Zn and B were also applied through $ZnSO_4$ and borax. No micronutrient fertilizers (Zn and B) were applied to the residual crop, blackgram, so that the residual effect of Zn and B fertilizers applied to the main crop can be studied.

Results and Discussion

Maize main crop

Dry matter production

The dry matter production of maize crop was significantly influenced by different treatment combinations over control in all the critical stages. During the harvest stage, the highest DMP (Table 1) was associated (18.28 t ha_{-1}) with the application of 37.5 kg $ZnSO_4$ ha_{-1} +10 kg Borax ha_{-1} along with 100% recommended NPK (M_3S_6) and the lowest (6.78 t ha^{-1}) was recorded in control (M_1S_1) than the treatments with NPK or Zn and B or combined with NPK or Zn and B. The favourable influence of B on dry matter production may be due to the enhanced availability of B in the soil that plays a significant role in growth attributes which in turn influences dry matter production. The increase in dry matter production with the addition of B was also observed by Bhilegaonkar *et al*., (1995).

Yield attributes

The results for the yield attributes indicated that the beneficial effect of the micronutrients (Zn and B) in influencing the number of grains cob_{-1} and 100 grain weight (g) was noticed in this experiment (Table 2). Application of 37.5 kg $ZnSO_4$ ha_1+10 kg Borax ha_{-1} along with 100% recommended NPK (M_3S_6) to the soil showed a profound effect in increasing the yield parameters.The same treatment registered significantly the highest number of grains cob_{-1}(556) and 100 grain weight (41.7 g). As boron

Table 1. Effect of micronutrients (Zn and B) on dry matter production(t ha-1) of maize at different growth stages

NPK levels	Micronutrients levels (kg ha-1)									
	$S_1(Zn_0B_0)$	$S_2(Zn_{7.5})$	$S_3(Zn_{10})$	$S_4(B_{1.0})$	$S_5(B_{1.5})$	$S_6(Zn_{7.5}B_{1.0})$	$S_7(Zn_{7.5}B_{1.5})$	$S_8(Zn_{10}B_{1.0})$	$S_9(Zn_{10}B_{1.5})$	Mean
Vegetative Stage (t ha-1)										
M_1 (0)	0.34	0.53	0.42	0.37	0.46	0.66	0.64	0.54	0.47	**0.49**
M_2 (75%)	0.53	0.69	0.58	0.55	0.60	0.82	0.80	0.71	0.62	**0.66**
M_3 (100%)	0.72	0.94	0.81	0.76	0.86	1.24	1.20	1.01	0.88	**0.94**
Mean	0.53	0.72	0.60	0.56	0.64	0.91	0.88	0.75	0.66	0.69
Tasselling Stage (t ha-1)										
M_1 (0)	0.42	0.84	0.53	0.46	0.77	0.96	0.93	0.86	0.79	**0.73**
M_2 (75%)	1.05	1.54	1.22	1.10	1.23	1.94	1.91	1.57	1.35	**1.43**
M_3 (100%)	1.27	2.84	1.86	2.46	1.48	3.29	3.16	2.93	2.47	**2.42**
Mean	0.91	1.74	1.20	1.34	1.16	2.06	2.00	1.79	1.54	1.53
Cob initiation Stage (t ha-1)										
M_1 (0)	2.76	3.52	3.06	2.86	3.20	3.95	3.91	3.58	3.27	**3.35**
M_2 (75%)	3.95	4.94	4.21	4.06	4.35	6.19	6.15	5.06	4.47	**4.82**
M_3 (100%)	4.14	6.60	4.89	4.39	5.56	8.07	7.89	6.64	5.64	**5.98**
Mean	3.62	5.02	4.05	3.77	4.37	6.07	5.98	5.09	4.46	4.72
Harvest Stage (t ha-1)										
M_1 (0)	6.78	9.07	7.40	8.30	7.07	10.20	10.13	9.19	8.61	**8.53**
M_2 (75%)	8.88	11.33	9.75	9.52	9.60	14.79	12.16	12.97	11.58	**11.18**
M_3 (100%)	13.29	16.71	14.66	15.50	13.91	18.28	16.42	16.84	15.74	**15.71**
Mean	9.65	12.37	10.60	11.11	10.19	14.22	12.90	13.00	11.98	11.80

	Vegetative				Tasselling				Cob initiation				Harvest			
	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
SEd	0.01	0.01	0.02	0.02	0.02	0.03	0.05	0.05	0.04	0.08	0.13	0.13	0.18	0.19	0.33	0.33
CD (0.05)	0.02	0.02	0.04	0.04	0.04	0.06	0.10	0.11	0.12	0.15	0.27	0.27	0.26	0.39	0.68	0.69

is reported to be involved in reproductive process and development of more grain (Nyomora *et al.,* 1997) there are ample chances for the development of more grains on a cob occupying the entire length with grains. Increase in 100 seed weight due to boron application might have enhanced the uptake

Table 2. Effect of micronutrients (Zn and B) on number of grains cob-1and 100 grain weight (g) of maize

NPK levels	Micronutrients levels (kg ha-1)									
	Number of grains cob-1									
	$S_1(Zn_0B_0)$	$S_2(Zn_{37.5})$	$S_3(Zn_{50})$	$S_4(B_{10})$	$S_5(B_{15})$	$S_6(Zn_{37.5}B_{10})$	$S_7(Zn_{37.5}B_{15})$	$S_8(Zn_{50}B_{10})$	$S_9(Zn_{50}B_{15})$	Mean
M_1 (0)	305	336	310	325	319	380	373	340	328	**335**
M_2 (75%)	322	351	328	344	337	423	412	366	349	**359**
M_3 (100%)	341	420	350	387	363	556	472	436	391	**413**
Mean	323	369	329	352	340	453	419	381	356	369
100 Grain weight (g)										
M_1 (0)	20.1	23.6	20.9	21.7	20.2	28.5	27.6	24.5	22.1	**23.2**
M_2 (75%)	21.7	23	28.5	24.4	22.2	33	32.4	29.1	25.2	**26.6**
M_3 (100%)	24.0	34.1	26.4	30.4	24.9	41.2	36.2	34.7	30.9	**31.4**
Mean	21.9	26.9	25.3	25.5	22.4	34.2	32.1	29.4	26.1	27.1

	Grains cob-1				100 Grain weight (g)			
	M	S	M at S	S at M	M	S	M at S	S at M
SEd	2.6	5.8	9.8	10.8	0.1	0.4	0.6	0.7
CD (0.05)	7.3	11.7	20.3	20.2	0.4	0.8	1.3	1.4

and translocation of sugar and is also implicated in carbohydrate metabolism (Mitra and Jana, 1991). The lowest number of grains cob-1 and 100 grain weight (g) was registered in the absolute control(312 g and 20.4g) respectively. According to Brown *et al.,* (1993) formation of male and female reproductive organs and pollination process are disturbed in Zn deficiency, which in result causes a severe reduction in plant yield.

Grain and Stover yield

The yield data revealed that significant differences were noticed among different treatment combinations over control (Table 3). In the main crop maize, the grain and stover yields ranged from2.30to 6. 93tha-1and 4.87to 12.57tha-1respectively. Application of 37.5 kg $ZnSO_4$ ha-1 +10 kg Borax ha-1 along with 100% recommended NPK (M_3S_6) registered significantly the highest yield of grain (6.93 t ha-1) and stover (12.57 t ha-1). This yield increase was mainly due to significant improvement in the yield attributes due to the balanced supply of nutrients. Further, this finding is in agreement with Parthiban and Prem Sekhar (2003) and by other workers (Paramasivam *et al.,* 2010; Singh and Vyas, 1998; Ziaeyan and Rajaie, 2009). Similar findings were also reported by Balyan *et al.*, (2006).

The lowest grain and stover yield was registered in the absolute control (2.30 t ha-1 and 4.87 t ha-1). The use of micronutrients increased the yield when

Table 3. Effect of micronutrients (Zn and B) on grain and stover yield (t ha-1) of maize

NPK levels	Micronutrients levels (kg ha-1)									
	Grain yield (t ha-1)									
	$S_1(Zn_0B_0)$	$S_2(Zn_{37.5})$	$S_3(Zn_{50})$	$S_4(B_{10})$	$S_5(B_{15})$	$S_6(Zn_{37.5}B_{10})$	$S_7(Zn_{37.5}B_{15})$	$S_8(Zn_{50}B_{10})$	$S_9(Zn_{50}B_{15})$	Mean
M_1 (0)	2.30	2.72	2.47	2.57	2.32	3.05	3.02	2.75	2.70	**2.65**
M_2 (75%)	3.09	3.45	3.04	3.25	2.89	5.08	5.05	3.59	3.49	**3.66**
M_3 (100%)	3.94	5.90	4.69	5.13	4.34	6.93	6.38	6.54	5.24	**5.45**
Mean	3.11	4.02	3.40	3.65	3.18	5.02	4.82	4.29	3.81	3.92
Stover yield (t ha-1)										
M_1 (0)	4.87	6.97	5.37	6.27	5.17	7.78	7.77	7.07	6.41	**6.41**
M_2 (75%)	6.34	8.68	7.37	6.87	7.37	7.87	7.82	7.37	7.46	**7.46**
M_3 (100%)	10.32	11.97	11.02	11.47	10.57	12.57	11.10	12.07	11.39	**11.39**
Mean	7.18	9.21	7.92	8.20	7.70	9.41	8.90	8.84	8.42	8.42
	Grain yield					Stover yield				
	M	S	M at S	S at M		M	S	M at S	S at M	
SEd	0.04	0.06	0.11	0.11		0.06	0.14	0.24	0.24	
CD (0.05)	0.10	0.13	0.23	0.23		0.17	0.28	0.49	0.49	

applied in combination of macronutrients as compared to conventional fertilization which lack micronutrients (Bakry *et al.,* 2009; Singh *et al.,* 2009; Azhar Ghaffari, 2011). On-farm studies conducted during three seasons (2002–2004) demonstrated significant yield responses of maize, castor,

Table 4. Effect of micronutrients (Zn and B) on number of No.of pods plant-1and 100 seed weight (g) of residual black gram

NPK levels	Micronutrients levels (kg ha-1)									
	No.of pods Plant-1									
	$S_1(Zn_0B_0)$	$S_2(Zn_{37.5})$	$S_3(Zn_{50})$	$S_4(B_{10})$	$S_5(B_{15})$	$S_6(Zn_{37.5}B_{10})$	$S_7(Zn_{37.5}B_{15})$	$S_8(Zn_{50}B_{10})$	$S_9(Zn_{50}B_{15})$	Mean
M_1 (0)	8.9	10.0	12.7	9.8	11.3	14.7	14.5	17.1	16.6	**12.8**
M_2 (75%)	10.1	10.9	13.3	10.6	12.0	15.3	14.9	22.3	21.7	**14.5**
M_3 (100%)	13.6	15.1	18.8	14.7	16.3	21.1	20.7	25.6	25.4	**19.0**
Mean	10.8	12.0	14.9	11.7	13.2	17.0	16.7	21.6	21.2	15.4
100 seed weight (g)										
M_1 (0)	1.4	1.5	1.9	1.5	1.6	2.4	2.3	2.8	2.7	**2.0**
M_2 (75%)	2.0	2.2	2.7	2.2	2.5	2.9	2.8	3.4	3.3	**2.6**
M_3 (100%)	2.3	2.5	3.2	2.4	2.8	3.7	3.6	4.4	4.4	**3.3**
Mean	1.9	2.0	2.6	2.0	2.3	3.0	2.9	3.5	3.5	2.6
	No.of pods plant-1				100 seed weight					
	M	S	M at S	S at M	M	S	M at S	S at M		
SEd	0.1	0.2	0.4	0.4	0.1	0.1	0.1	0.1		
CD (0.05)	0.3	0.5	0.8	0.8	0.2	0.2	0.2	0.2		

groundnut and mungbean to the applications of S, B and Zn the yield responses were larger when S, B, and Zn were applied along with N and P (Rego *et al.,* 2007). It was concluded that balanced nutrition of crops was essential for sustained increases in yields of field crops.

Blackgram residual crop

Yield attributes

The data revealed that the effect of the micronutrients (Zn and B) greatly influenced the yield attributes *viz.*, the number of grains cob-1 and 100 grain weight in residual black gram. Application of 50 kg $ZnSO_4$ ha-1+10 kg Borax ha-1 along with 100% recommended NPK (M_3S_8) evidenced marked effect

Table 5. Effect of micronutrients (Zn and B) on seed and haulm yield (kg ha-1) of residual black gram

NPK levels	Micronutrients levels (kg ha-1)									
	$S_1(Zn_0B_0)$	$S_2(Zn_{7.5})$	$S_3(Zn_{10})$	$S_4(B_{1.0})$	$S_5(B_{1.5})$	$S_6(Zn_{7.5}B_{1.0})$	$S_7(Zn_{7.5}B_{1.5})$	$S_8(Zn_{10}B_{1.0})$	$S_9(Zn_{10}B_{1.5})$	Mean
Seed yield (kg ha-1)										
M_1 (0)	329.0	337.1	361.8	336.4	346.8	387.3	382.2	415.8	408.3	**367.2**
M_2 (75%)	363.3	373.3	415.7	369.4	397.3	449.6	441.4	556.7	539.9	**434.1**
M_3 (100%)	422.9	433.9	496.1	433.7	456.1	558.9	552.8	747.9	722.7	**536.1**
Mean	371.7	381.4	424.5	379.8	400.1	465.3	458.8	573.5	557.0	445.8
Haulm yield (kg ha-1)										
M_1 (0)	393.8	402.9	427.6	402.5	415.3	452.2	446.1	492.7	490.2	**435.9**
M_2 (75%)	433.4	439.4	471.8	438.9	550.5	512.7	507.6	633.9	596.6	**509.4**
M_3 (100%)	499.8	510.7	553.0	510.2	523.0	641.8	633.7	800.8	795.7	**607.6**
Mean	442.3	451.0	484.1	450.5	496.3	535.6	529.1	642.5	627.5	517.7
	Seed yield (kg ha-1)					Haulm yield (kg ha-1)				
	M	S	M at S	S at M		M	S	M at S	S at M	
SEd	3.5	7.1	12.1	12.3		3.9	8.1	13.9	14.1	
CD (0.05)	9.9	14.3	25.2	25.2		10.8	16.4	28.8	28.5	

in increasing the yield parameters (Table 4).The same treatment registered significantly the higher number of pods plant$_{-1}$ (25.6) and 100 seed weight (4.4 g). The lowest number of pods plant$_{-1}$ (9.1) and 100 seed weight (2.1 g) was registered in the absolute control.

Seed and haulm yield

The results of the experiments revealed that significant differences were found within the treatment combinations over control (Table 5). For residual crop blackgram, the seed and haulm yield (table 6) ranged from 329 to 747.9 kgha$_{-1}$and 393.8to 800.8 kgha$_{-1}$respectively. Significant increase in seed yield (747.9 kg ha$_{-1}$) and haulm yield (800.8kg ha$_{-1}$) was recorded with the application of 50 kg $ZnSO_4$ha^{-1}+10 kg Borax ha^{-1} along with 100% recommended NPK (M_3S_8). Islam *et al.,* (1997) reported an yield increase of 41.8 percent due to the application of Zn + B + S in rice - mustard cropping system. The lowest pod and haulm yield was registered in the absolute control.

Among the different levels of macro and micronutrient combinations, the highest gross income (Rs. 1,33,391) was recorded under the treatment 100 % NPK + 37.5 kg $ZnSO_4$ +10 kg Borax ha^{-1}(M_3S_8) when compared the treatment which received Rs. 1,28,366 as gross income on application of 100 % NPK + 37.5 kg $ZnSO_4$ ha$_{-1}$+10 kg Borax ha^{-1}(M_3S_6).

In maize-blackgram cropping system, application of $ZnSO_4$ and Borax @ 50 kg and10 kg ha$_{-1}$ along with 100 per cent recommended NPK increased the yield as well the gross income considerably in zinc and boron deficient soils. It is essential that the availability of micronutrients status of cultivable soils has to be analysed on regular basis to ensure optimum yields.

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