

Studies on Zinc Sulphate and Boron Nutrition on Cowpea - Fingermillet Crop Rotation System

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ABSTRACT

A field experiment was conducted to study the impact of zinc sulphate and boron nutrition on cowpea and finger millet crop rotation during *khariif* at DLAP, University of Agricultural Sciences, Bengaluru. The experiment was laid out in randomized complete block design having twelve treatments and replicated thrice. The genotype used for cowpea was KBC-2 and finger millet was GPU-28 and the amount of rainfall received during cropping system was 553.8 mm (cowpea) and 571.2 mm (finger millet). The treatment comprised of Zn, B, Mo application method through soil, foliar spray and seed treatment with control. Soil application of NPK + ZnSO₄ @ 12.5 kg/ha + Borax @ 10 kg/ha + Mo (2 g/kg seed) recorded significantly higher grain / seed yield (12.26, 10.75 & 14.33q/ha, respectively) and straw yield (8.23, 7.14 & 42.60 q/ha, respectively) compared to control (7.91, 6.95, 22.81 and 5.80, 5.40, 30.89q/ha, respectively) in Cowpea – Cowpea, Cowpea – Finger Millet and Finger Millet – Cowpea cropping system.

COWPEA is considered one of the most Nominant vegetable legume. The pods were harvested either at green stage for fresh market or at mature stage for dry seeds. Cowpea seeds are a nutrition component in the human diet as well as a nutritious livestock feed. Pulses are the chief source of dietary proteins in India. The protein in cowpea seeds is rich in lysine and tryptophan amino acids compared to cereal grains. It is well known that, sandy soil is infertile and has very small amounts of micro elements and higher soil micro nutrients deficiencies. The availability and uptake of micro nutrients by plants decrease with increasing soil pH. The mobility of micro nutrients in soil, plant and their translocation to plants as well as interaction among themselves are influenced by soil properties. Micro nutrients in the soil and plant play an important role in plants nutrition. The deficiency of micro nutrients that recognized as essential to higher plants impair the important metabolic functions and result in poor growth and yield of crops. Molybdenum is an essential element. It is a constituent of the nitrogenase enzyme and every bacteria which fixes nitrogen needs molybdenum during the fixation processes. Molybdenum has a positive effect on yield, quality and nodules forming in legume crops (Werner Bergmann, 1992). The functions of molybdenum in leguminous plants include nitrate reduction, nodulation, nitrogen fixation and general metabolism (Togay *et al.*, 2008). Keeping these aspects in mind, investigation was carried out to study

the importance of micro nutrients on productivity of cowpea - finger millet crop rotation system.

MATERIAL AND METHODS

A field experiment was conducted at DLAP, University of Agricultural Sciences, Bengaluru, during *Khariif* in three years crop rotation system. The experiment was laid out in randomized complete block design having twelve treatments and replicated thrice. The treatment comprised of T₁: Control, T₂: NPK + FYM (Rec), T₃: NPK + ZnSO₄ @ 12.5 kg/ha (soil), T₄: NPK + ZnSO₄ @ 0.50% (foliar spray), T₅: NPK + Borax @ 10 kg/ha (soil), T₆: NPK + Borax @ 0.25% (foliar spray), T₇: NPK + Mo (2 g/kg seed), T₈: NPK + ZnSO₄ @ 12.5 kg/ha + Borax @ 10 kg/ha (soil), T₉: NPK + ZnSO₄ @ 0.50% + Borax @ 0.25% (foliar spray), T₁₀: NPK + ZnSO₄ @ 12.50 kg/ha + Mo (2 g/kg seed), T₁₁: NPK + Borax @ 10 kg/ha + Mo (2 g/kg seed), T₁₂: NPK + ZnSO₄ @ 12.5 kg/ha + Borax @ 10 kg/ha + Mo (2 g/kg seed). Recommended fertilizer dose of N, P₂O₅ and K₂O per hectare in the form of Urea, SSP and MOP was applied as basal at the time of sowing. Molybdenum was not applied to finger millet crop, but, still treatments are retained for taking up the next rotation crop with pulse crop. Five plants from net plot area were randomly selected and observations on growth and yield parameters, which were recorded at harvest. At harvest, yield and its components were

determined at maturity stage. All the data pertaining to the present investigation were statistically analyzed as per the method described by Panse and Sukhatme (1967). The level of significance used in 'F' and 't' test was $p=0.05$.

RESULTS AND DISCUSSION

Cowpea – Cowpea Cropping system

Crop : Cowpea : Significantly higher seed yield of cowpea (12.26 q ha^{-1}) was obtained with soil application of NPK + ZnSO_4 @ 12.5 kg / ha + Borax @ 10 kg / ha + Mo (2 g/kg seed) and was higher to an extent 35.23 per cent compared to control (7.91 q ha^{-1}) (Table I). The higher seed yield was

mainly due to positive association between yield attributing characters *viz.*, plant height, number of branches, number of pods/plant, pod length. Significantly higher plant height (67.81 cm), number of branches (8.25), number of pods / plant (15.16), pod length (13.84 cm) were recorded by soil application of NPK + ZnSO_4 @ 12.5 kg/ha + Borax @ 10 kg/ha + Mo (2 g / kg seed) compared to other treatments and control ($38.75, 3.75, 8.53$ & 9.04 , respectively).

The results on seed quality parameters of cowpea were found to be significant. The results indicated that, higher dry weight of shoot and root (36.29 mg), germination (97%) and vigour index (3520.13) were recorded with soil application of NPK + ZnSO_4 @

TABLE I

Effect of zinc, boron and molybdenum on growth, yield and yield parameters of Cowpea at harvest in cowpea - cowpea based cropping system

Treatments	Plant height (cm)	No. of branches /Plant	No. of leaves /Plant	No. of pods / Plant	Pod length (cm)	Seed yield (q / ha)	Haulm yield (q / ha)
Control	38.75	3.75	18.75	8.53	9.04	7.91	5.80
NPK + FYM (Rec)	47.75	6.00	25.00	12.51	13.15	10.08	6.57
NPK + ZnSO_4 @ 12.5 kg/ha (soil)	48.25	6.75	25.75	12.07	12.18	10.33	6.69
NPK + ZnSO_4 @ 0.50% (foliar spray)	42.50	5.25	23.50	10.51	11.17	9.03	6.18
NPK + Borax @ 10 kg/ha (soil)	43.25	6.00	24.00	10.85	11.48	9.37	6.30
NPK + Borax @ 0.25% (foliar spray)	41.25	4.50	23.25	10.26	11.16	8.65	6.13
NPK + Mo (2 g/kg seed)	41.50	3.58	21.25	9.99	10.90	8.22	5.98
NPK + ZnSO_4 @ 12.5 kg/ha + Borax @ 10 kg/ha (soil)	60.00	7.25	29.00	14.21	13.03	11.33	7.52
NPK + ZnSO_4 @ 0.50% + Borax @ 0.25% (foliar spray)	48.25	6.75	27.78	13.46	12.64	10.88	7.16
NPK + ZnSO_4 @ 12.50 kg/ha + Mo (2 g/kg seed)	63.50	8.00	30.20	14.62	13.29	11.89	8.03
NPK + Borax @ 10 kg/ha + Mo (2 g/kg seed)	48.25	6.00	25.00	10.96	11.69	9.90	6.043
NPK + ZnSO_4 @ 12.5 kg/ha + Borax @ 10 kg/ha + Mo (2 g/kg seed)	67.81	8.25	31.75	15.16	13.84	12.26	8.23
S.Em \pm	0.56	0.36	0.41	0.31	0.31	0.36	0.31
CD at 5%	0.68	1.08	1.25	0.95	0.93	1.09	0.93

TABLE II

Effect of zinc, boron and molybdenum on growth, yield and yield parameters of Cowpea at harvest in Cowpea - Finger millet based cropping system

Treatments	Plant height (cm)	No. of branches /Plant	No. of leaves /Plant	No. of pods / Plant	Pod length (cm)	Seed yield (q / ha)	Haulm yield (q / ha)
Control	39.56	3.83	19.11	6.97	8.36	6.95	5.40
NPK + FYM (Rec)	48.22	5.82	24.10	11.33	13.97	8.73	6.24
NPK + ZnSO ₄ @ 12.5 kg/ha (soil)	51.00	6.00	24.33	10.84	13.17	8.91	6.32
NPK + ZnSO ₄ @ 0.50% (foliar spray)	43.00	5.39	23.05	9.12	11.87	7.90	5.97
NPK + Borax @ 10 kg/ha (soil)	43.60	5.80	23.42	9.64	12.21	8.13	6.12
NPK + Borax @ 0.25% (foliar spray)	41.19	4.71	22.50	8.90	11.47	7.72	5.84
NPK + Mo (2 g/kg seed)	41.78	4.22	21.00	8.56	10.78	7.46	5.59
NPK + ZnSO ₄ @ 12.5 kg/ha + Borax @ 10 kg/ha (soil)	59.44	6.85	28.97	12.10	14.20	10.19	6.82
NPK + ZnSO ₄ @ 0.50% + Borax @ 0.25% (foliar spray)	51.25	6.20	26.88	11.44	13.50	9.63	6.52
NPK + ZnSO ₄ @ 12.50 kg/ha + Mo (2 g/kg seed)	62.40	7.28	30.00	11.96	14.40	10.35	6.88
NPK + Borax @ 10 kg/ha + Mo (2 g/kg seed)	48.21	5.88	24.00	10.17	12.47	8.43	6.16
NPK + ZnSO ₄ @ 12.5 kg/ha + Borax @ 10 kg/ha + Mo (2 g/kg seed)	65.73	7.70	30.11	12.13	14.89	10.75	7.14
S.Em±	0.45	0.34	0.46	0.18	0.26	0.21	0.28
CD at 5 %	1.36	1.03	1.39	0.54	0.78	0.65	0.84

12.5 kg / ha + Borax @ 10 kg / ha + Mo (2 g / kg seed) to control (22.45 mg, 87 %, & 1953.15, respectively).

The increase in seed quality parameters may be ascribed to better seed size, besides, zinc sulphate might have helped in synthesis of carbohydrates and protein in plants resulting in increased total soluble sugars and reducing sugars. Thus, improved the germination and vigour index of cowpea seeds.

Spraying of micronutrients greatly improved the root system of cowpea plants compared with control. Main root length and number of nodules were significantly improved with increasing mixture of

microelements concentrations and then reduced with increasing concentrations (Eisa and Ali, 2014). Spray of microelements such as Fe, Mo and B stimulated in better root system parameters and root nodules in legumes. Also, spraying cowpea plants with Fe, Mo and B at 100, 50 and 25 ppm, respectively, significantly increased vegetative growth, dry weight, mineral content and uptake of N, P and K as well as total yield compared with the control. Microelements as Fe and Mo play a vital role in synthesis of chlorophyll and chloroplast formation. Iron, molybdenum and boron play a vital role of enzymes activity as nitrogenase, catalase and peroxidase. Molybdenum is also very important for N – fixation.

TABLE III

Effect of zinc, boron and molybdenum on growth, yield and yield parameters of Finger millet at harvest in Finger millet - Cowpea based cropping system

Treatments	Plant height (cm)	No. of tillers/ Plant	No. of leaves / Plant	Finger length (cm)	Grain yield (q / ha)	Straw yield (q / ha)
Control	71.08	3.70	34.00	4.61	22.81	30.89
NPK + FYM (Rec)	88.30	4.73	47.93	6.07	28.70	38.80
NPK + ZnSO ₄ @ 12.5 kg/ha (soil)	90.11	4.90	48.8	6.32	29.20	39.20
NPK + ZnSO ₄ @ 0.50% (foliar spray)	81.20	4.20	42.00	5.64	26.00	35.61
NPK + Borax @ 10 kg/ha (soil)	83.34	4.44	44.11	5.82	26.89	35.90
NPK + Borax @ 0.25% (foliar spray)	77.22	4.11	29.20	5.36	25.51	35.00
NPK + Mo (2 g/kg seed)	74.00	3.90	35.00	5.14	23.00	31.23
NPK + ZnSO ₄ @ 12.5 kg/ha + Borax @ 10 kg/ha (soil)	95.23	5.21	54.00	6.71	30.51	42.50
NPK + ZnSO ₄ @ 0.50% + Borax @ 0.25% (foliar spray)	75.55	3.91	39.60	5.20	24.30	32.33
NPK + ZnSO ₄ @ 12.50 kg/ha + Mo (2 g/kg seed)	92.40	5.00	51.00	6.50	29.60	40.50
NPK + Borax @ 10 kg/ha + Mo (2 g/kg seed)	86.26	4.50	45.10	5.98	27.50	36.74
NPK + ZnSO ₄ @ 12.5 kg/ha + Borax @ 10 kg/ha + Mo (2 g/kg seed)	98.92	5.49	55.70	7.00	31.71	42.60
S.Em±	0.28	0.27	3.62	0.26	0.35	0.31
CD at 5%	0.82	0.81	10.64	0.76	1.04	0.91

The micronutrient use efficiency was significantly influenced by foliar application of zinc sulphate and boron. Application of NPK + ZnSO₄ @ 0.50 per cent + Borax @ 0.25 per cent (foliar spray) recorded significantly higher micronutrient use efficiency (39.60) compared to rest of the treatments. Whereas, it is followed by application of NPK + ZnSO₄ @ 12.50 kg/ha + Mo (2 g / kg seed) (31.84). The B:C ratio was significantly influenced by soil application of zinc sulphate and boron. Soil application of NPK + ZnSO₄ @ 12.50 kg / ha + Mo (2 g / kg seed) recorded significantly higher B:C ratio (1.88) compared to rest of the treatments and control (1.40). However, it was

followed by application of NPK + ZnSO₄ @ 0.50 Per cent + Borax @ 0.25 per cent (foliar spray) (1.70).

Cowpea – Finger millet Cropping system

Crop : Cowpea : Results showed that growth and yield of cowpea influenced by zinc, boron and molybdenum and results were found to be significant. Among the treatments, soil application of NPK + ZnSO₄ @ 12.5 kg / ha + Borax @ 10 kg / ha + Mo (2 g / kg seed) registered significantly higher plant height (65.73), number of branches (7.70), number of pods / plant (12.13), pod length (14.89 cm) over other treatments compared to control (39.56 cm, 3.83, 6.97

TABLE IV
Effect of zinc, boron and molybdenum on seed quality parameters of Cowpea and Finger millet in different cropping system

Treatments	Cowpea - Cowpea			Cowpea-Finger millet			Finger millet- Cowpea		
	Cowpea			Cowpea			Finger Millet		
	Dry weight of shoot & root (mg)	Germi nation %	Vigour index	Dry weight of shoot & root (mg)	Germi nation %	Vigour index	Dry weight of shoot & root (mg)	Germi nation %	Vigour index
Control	22.45	87	1953.15	20.98	89	1867.22	1.87	88	164.56
NPK + FYM (Rec)	30.93	91	2814.63	29.10	93	2706.30	4.26	95	404.70
NPK + ZnSO ₄ @ 12.5 kg/ha (soil)	31.86	93	2962.98	32.26	94	2938.44	4.35	94	408.90
NPK + ZnSO ₄ @ 0.50% (foliar spray)	27.46	89	2443.94	27.85	90	2506.44	3.41	93	317.13
NPK + Borax @ 10 kg/ha (soil)	27.84	90	2505.60	28.46	93	2646.78	3.54	93	329.22
NPK + Borax @ 0.25% (foliar spray)	25.76	90	2318.40	27.80	89	2474.20	2.80	91	254.80
NPK + Mo (2 g/kg seed)	25.30	89	2251.70	26.47	90	2382.30	2.48	90	223.20
NPK + ZnSO ₄ @ 12.5 kg/ha + Borax @ 10 kg/ha (soil)	34.11	96	3274.56	32.68	96	3137.28	4.79	97	464.63
NPK + ZnSO ₄ @ 0.50% + Borax @ 0.25% (foliar spray)	24.09	96	2312.64	25.28	96	2426.88	2.36	90	212.40
NPK + ZnSO ₄ @ 12.50 kg/ha + Mo (2 g/kg seed)	33.31	96	3197.76	32.31	91	3134.07	5.08	96	487.68
NPK + Borax @ 10 kg/ha + Mo (2 g/kg seed)	28.42	93	2643.06	28.67	91	2608.97	3.76	93	349.68
NPK + ZnSO ₄ @ 12.5 kg/ha + Borax @ 10 kg/ha + Mo (2 g/kg seed)	36.29	97	3520.13	35.70	98	3498.60	5.30	97	514.10
SEm _±	0.80	0.71	9.47	0.76	0.55	17.02	0.11	0.62	2.34
CD at 5%	2.40	2.13	28.40	2.29	1.65	51.03	0.34	1.86	7.03

TABLE V
Effect of zinc, boron and molybdenum on micro-nutrient use efficiency (MUE) and economics of cowpea and finger millet in Cowpea - finger millet based cropping system

Treatments	Cowpea - Cowpea		Cowpea - Finger millet		Finger millet - Cowpea	
	MUE	B:C ratio	MUE	B:C ratio	MUE	B:C ratio
Control	-	1.40	-	1.28	-	2.20
NPK + FYM (Rec)	-	1.25	-	1.12	-	1.78
NPK + ZnSO ₄ @ 12.5 kg/ha (soil)	19.36	1.69	15.68	1.48	51.12	2.69
NPK + ZnSO ₄ @ 0.50% (foliar spray)	22.40	1.50	19.00	1.35	63.80	2.42
NPK + Borax @ 10 kg/ha (soil)	14.60	1.23	11.80	1.10	40.80	2.00
NPK + Borax @ 0.25% (foliar spray)	29.60	1.39	30.80	1.26	108.00	2.14
NPK + Mo (2 g/kg seed)	-	1.41	-	1.30	-	2.25
NPK + ZnSO ₄ @ 12.5 kg/ha + Borax @ 10 kg/ha (soil)	15.20	1.40	14.40	1.24	34.22	2.28
NPK + ZnSO ₄ @ 0.50% + Borax @ 0.25% (foliar spray)	39.60	1.70	35.73	1.52	19.87	2.10
NPK + ZnSO ₄ @ 12.50 kg/ha + Mo (2 g/kg seed)	31.84	1.88	27.20	1.68	54.32	2.74
NPK + Borax @ 10 kg/ha + Mo (2 g/kg seed)	19.90	1.30	14.80	1.16	46.90	2.08
NPK + ZnSO ₄ @ 12.5 kg/ha + Borax @ 10 kg/ha + Mo (2 g/kg seed)	19.33	1.51	16.89	1.33	39.56	2.38

and 8.36 cm, respectively). These results are in accordance with the findings of Mohamed and Saif El-Yazal (2004) reported that using Fe + Zn + Mn at concentration of 0.08 per cent on cotton plants and Ali *et al.* (2009) using zinc at concentrations of 100 and 200 ppm on *Vicia faba* L. plants and El-Tantawy and Eisa (2009) using boron at a concentration of 25 ppm on table beet plants, recorded favourable anatomical changes in leaf and stem due to the micronutrients mixture.

Significantly higher dry weight of shoot and root (35.70 mg), germination (98 per cent) and vigour index (3498.60) were recorded with soil application of NPK + ZnSO₄ @ 12.5 kg / ha + Borax @ 10 kg / ha + Mo (2 g / kg seed) to control (only NPK) (20.98 mg, 89 per cent & 1867.22, respectively).

The micro nutrient use efficiency was significantly influenced by foliar application of zinc sulphate and boron. Application of NPK + ZnSO₄ @ 0.50 per cent + Borax @ 0.25 per cent (foliar spray) recorded significantly higher micronutrient use efficiency (35.73) compared to rest of the treatments. Whereas, it was followed by application of NPK + Borax @ 0.25 per cent (foliar spray) (30.80).

The B:C ratio was significantly influenced by soil application of zinc sulphate and boron. Foliar application of NPK + ZnSO₄ @ 12.5 kg/ha + Mo (2 g / kg seed) recorded significantly higher B:C ratio (1.68) compared to rest of the treatments and control (1.28). However, it was followed by foliar application of NPK + ZnSO₄ @ 0.50 per cent + Borax @ 0.25 per cent (1.52).

Finger millet - Cowpea Cropping system

Crop : Finger millet : The effect of zinc sulphate, boron and molybdenum on yield and yield attributes of finger millet under finger millet – cowpea cropping system were found to be significant. Significantly higher grain and straw yield of finger millet (31.71 and 42.60 q ha⁻¹) was obtained with soil application of NPK + ZnSO₄ @ 12.5 kg / ha + Borax @ 10 kg / ha + Mo (2 g / kg seed) and was higher to an extent 28.06 and 27.48 per cent compared to control (22.81 and 30.89 q ha⁻¹)

(Table I). Significantly higher plant height (98.92 cm), number of tillers / plant (5.49), number of fingers / plant (7.22) and finger length (7.00) were recorded by soil application of NPK + ZnSO₄ @ 12.5 kg / ha + Borax @ 0 kg / ha + Mo (2 g / kg seed) over other treatments compared to control (71.08 cm, 3.70, 6.47 & 4.61, respectively). The results on seed quality parameters of finger millet were found to be significant.

The results showed that, higher dry weight of shoot and root (5.30 mg), germination (97 %) and vigour index (514.10) were recorded with soil application of NPK + ZnSO₄ @ 12.5 kg / ha + Borax @ 10 kg / ha + Mo (2 g/kg seed) to control (1.87 mg, 88 per cent, & 164.56, respectively). The higher vigour index may be due to better source – sink relation and the availability of balanced nutrients to crops.

The micro nutrient use efficiency was significantly influenced by foliar application of zinc sulphate and boron. Application of NPK + Borax @ 0.25 per cent (foliar spray) recorded significantly higher micro nutrient use efficiency (108.00) compared to rest of the treatments. Whereas, it was followed by application of NPK + ZnSO₄ @ 0.50 per cent (foliar spray) (63.80). These results are in accordance with the findings of Nadia Gad and Abd El-Moez (2013). Molybdenum had a significant promotive effect on all vegetative growth parameters such as plant height, number of branches and leaves per plant, leaf area index, root length of cowpea plants after 80 days from sowing compared with untreated plants. Molybdenum at 16 ppm recorded superior growth parameters. Increasing molybdenum above 16 ppm decreased the promotive effect. Singh *et al.* (2006) found that Mo 10 Kg / ha soil increased the vegetative growth of blackgram compared with the control. Niranjana *et al.* (2005) also found that molybdenum at 2.0 g / Kg with seeds recorded the highest growth parameters and pods yield in groundnut compared control.

The B: C ratio was significantly influenced by soil application of zinc sulphate and boron. Soil application of NPK + ZnSO₄ @ 12.5 kg / ha (soil) recorded significantly higher B:C ratio (2.69) compared to rest of the treatments and control (2.20). However, it was followed by application of NPK + ZnSO₄ @ 0.50 per cent (foliar spray) (42).

From the above investigation, it can be concluded that soil application of NPK + ZnSO₄ @ 12.5 kg / ha + Borax @ 10 kg / ha + Mo (2 g / kg seed) and foliar application of NPK + ZnSO₄ @ 0.50 per cent + Borax @ 0.25 per cent proved effective on cowpea – finger millet crop rotation system.

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