The Pharma Innovation Journal 2021; 10(1): 506-511

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2021; 10(1): 506-511

www.thepharmajournal.com
Received: 22-11-2020
Accepted: 24-12-2020

AD Yadav
Regional Agril. Research Station, Karjat, Dist Raigad, Maharashtra, India

DG Jondhale
Regional Agril. Research Station, Karjat, Dist Raigad, Maharashtra, India

NH Khobragade
Regional Agril. Research Station, Karjat, Dist Raigad, Maharashtra, India

TJ Bedse
Regional Agril. Research Station, Karjat, Dist Raigad, Maharashtra, India

AV Dahiphale
Regional Agril. Research Station, Karjat, Dist Raigad, Maharashtra, India

SB Bhagat
Regional Agril. Research Station, Karjat, Dist Raigad, Maharashtra, India

Corresponding Author:
DG Jondhale
Regional Agril. Research Station, Karjat, Dist Raigad, Maharashtra, India

Influence of soil application of zinc and boron on content and uptake of macronutrients by cowpea (*Vigna unguiculata* L. Walp) in alfisols of Konkan region of Maharashtra

AD Yadav, DG Jondhale, NH Khobragade, TJ Bedse, AV Dahiphale and SB Bhagat

Abstract
To study the effect of zinc and boron on content and uptake of macronutrients by Cowpea (*Vigna unguiculata* L. Walp) a field experiment was conducted at the Research and Education Farm, Department of Agricultural Botany, College of Agriculture, Dapoli (Maharashtra) on alfisols deficient in available zinc and boron. Results showed that N, P and K contents in stover at flowering (3.55, 0.336 and 2.52) stover at harvest (2.57, 0.183 and 1.77) and seed (2.77, 0.311 and 1.20) and their uptake in stover at harvest (85.93,6.08 and 59.33) uptake in seed at harvest (62.34,6.98, and27.24) and Total uptake (148.27,13.06 and 86.57) was significantly increased due to application of 25:60:40 N :P_20 : K_20 kg ha^{-1} + Rhizobium and PSB @ 25 g kg^{-1} seed + B @ 2.00 + Zn @ 7.5 kg ha^{-1}. Further the content and uptake of N, P and K increased in the treatment which received increased level of zinc and boron application.

Keywords: cowpea, macro nutrient content, macro nutrient uptake, alfisols

Introduction
Excavations at Harappa (Indus-Saraswati civilization; 3200–2000 BC) have revealed that cowpea was one of the grain legumes grown (Mehra, 2002) [11]. Cowpea is a good source of food, fodder, vegetables and certain snacks (Singh *et al*. 2012) [18]. It is a crop that can be used as catch crop, mulch crop, intercrop, mixed crop and green crop. In India per capita/day availability of pulses had decreased from 69 g during sixties to 35 g as against the FAO/WHO's current recommendation of 80 g per day (Ali and Gupta 2012) [2]. Pulses play an important role in providing a nutritionally balanced diet. These are the principal source of protein for vegetarian. Even today, pulses and milk provide the full complement of proteins to people who avoid eating meat. Cowpea is minor pulse crop in India. Cowpea is highly responsive to fertilizer application and dose of fertilizer depends on the initial soil fertility. Although cowpea is a legume, it gives good response to application of recommended dose of fertilizer (Ahlawat and Shivakumar 2005) [1]. Boron (B) and zinc (Zn) are the essential plant micronutrients and their importance for crop productivity is similar to that of major nutrients (Rattan *et al*. 2009; Padbhushan and Kumar 2014) [14, 12]. Studies on B and Zn fertilizer proved that the application of B and Zn greatly influenced growth, yield and quality of legume crops (Debnath *et al*. 2015) [6]. The deficiency symptoms of B and Zn as well as low yield have been recorded on many legume and other field crops including vegetable crops grown in north-eastern Hill region (Kumar *et al*. 2016) [9]. The reports on application of micronutrients on content and uptake of legumes in alfisols of south Konkan region are very meager. The study was therefore, conducted to assess the levels of B and Zn fertilization on content and uptake macronutrients by cowpea grown in soil of Ratnagiri district of Maharashtra.

Materials and Methods
The present investigation pertaining to the studies on the "Content and uptake of macronutrients by cowpea (*Vigna unguiculata* L.Walp) as influenced by soil application of zinc and boron in alfisols of Konkan region of Maharashtra" was conducted during *Rabi*, 2019-20 at Research and Education Farm, Department of Agricultural Botany, College of Agriculture, Dapoli. The analytical work was carried out in the research laboratory of the

Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dapoli on alfisols soil with soil pH 5.51, EC 0.013 dS m^{-1}, Organic Carbon 11.4 g kg^{-1}, available N 179.0 kg ha^{-1}, available P_2O_5 8.54 kg ha^{-1} and available K_2O 383.0 kg ha^{-1}, available B 0.26 mg kg^{-1}, available Fe 33.86 mg kg^{-1}, available Mn 61.61 mg kg^{-1}, available Zn 0.23 mg kg^{-1}, available Cu 3.44 mg kg^{-1}. The experimental site was located at altitude of 800 ft. (240m) and 8 km from Arabian sea having hot and humid climate. Cowpea variety Konkan Sadabahar (VCM-8) released by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli was taken as a test crop. Boron and zinc were applied through Borax @ 1.0, 1.5 and 2.0 kg ha^{-1} and Zinc sulphate @ 2.5, 5.0 and 7.5 kg ha^{-1} either alone (T_3, T_4 and T_5 for B and T_6, T_7 and T_8 for Zn) or in combinations (T_9, T_{10} and T_{11}) in pertinent treatment (Table 1). Seeds of cowpea were inoculated with PSB (Phosphate Solubilizing Bacteria) and Rhizobium biofertilizer @ 25 g per kg seeds each using Jaggery **:** water suspension as a sticking material. Inoculated seeds were dried under shade on clean gunny bag and used for dibbled. The plant nutrients were applied through fertilizer *viz*., urea, single super phosphate and muriate of potash for N, P and K, respectively. Along with this, FYM @ 5 t ha^{-1} was also used as the organic source of nutrient. The composition of FYM as well as inorganic fertilizers used in the present study is given in Table 2. For getting maximum yield of cowpea as well as for improving the soil health, application of $N:P_2O_5:K_2O$ @ 25:60:40 kg ha^{-1} along with seed inoculation of *Rhizobium* and PSB @ 25g kg^{-1}seed during *rabi* season in lateritic soils of Konkan is recommended (Anonymous, 2014). The plant samples collected at peg initiation and at harvest of crop were digested with conc. H_2SO_4 using H_2O_2 and the total nitrogen content was determined by Kjelplus apparatus (Tandon, 1993) [20]. For determination of P and K 1.0 g plant sample was digested with di-acid mixture (HNO_3 + $HClO_4$) with the ratio 9**:**4 and acid extract was used for determination of P and K (Singh *et al*., 1999) [19]. Macro- nutrient uptake (N, P and K uptake) was computed by multiplying the seed yield / stover yield in kg ha^{-1} with respective per cent nutrient content and product was divided by 100. The uptake of nutrients by seed and stover were expressed as nutrient uptake by crop in kg ha^{-1}. The nutrient uptake by seed and stover were summed up to express total nutrient uptake by crop in kg ha^{-1}.

Result and Discussion

Effect of boron and zinc application on Yield (q ha^{-1})

The data regarding seed yield of cowpea as influenced by application of graded doses of B and Zn either alone or in combinations along with recommended dose of fertilizers *i.e.* 25:60:40 $N:P_20_5:K_20$ kg ha^{-1} + rhizobium and PSB @ 25g kg^{-1}seed varied from 10.56 to 22.51 q ha^{-1} (Table 3) indicating thereby that the Zn and B gave synergic effect on the biological yield.

Treatment T_{11} (T_2 + B @ 2.0 kg ha^{-1} + Zn @ 7.5 kg ha^{-1}) registered the highest grain yield (33.50 q ha^{-1}) and strover yield ((33.50 q ha^{-1}), which was found to be at par with T_{10} and followed by T_9. These results suggest mutual synergism between Zn and B. Such synergistic effect of Zn and B on grain and straw yield of soybean was obtained by Malewar *et al.* (2001) [10] and Goswami and Rama (2014) [8].

Effect of boron and zinc application on Nutrient content in grain and straw

Nitrogen content

Application of graded doses of B and Zn either alone or in combinations along with recommended dose of fertilizers *i.e.* 25**:**60**:**40 $N:P_20_5:K_20$ kg ha^{-1} + rhizobium and PSB @ 25g kg^{-1} seed influenced the N content, which varied from 2.28 to 3.55 per cent in cowpea stover at flowering, 1.66 to 2.57 per cent in cowpea stover at harvest and 2.20 to 2.77 per cent in cowpea seed (Table 4). Application of graded doses of B and Zn either alone or in combinations along with recommended dose of fertilizers *i.e.* 25**:**60**:**40 $N:P_20_5:K_20$ kg ha^{-1} + rhizobium and PSB @ 25g kg^{-1}seed (from treatment T_2 to T_{11}) significantly increased nitrogen content in stover and seed of cowpea over the absolute control *i.e.* no fertilizer application (T_1). Significantly highest nitrogen content *i.e.* 3.55 per cent in stover at 45 DAS, 2.57 per cent in stover at harvest and 2.77 per cent in seed of cowpea was recorded in treatment T_{11} (T2 + B @ 2.00 + Zn @ 7.5 kg ha^{-1}), which was found to be at par with the treatments T_4, T_5, T_6, T_7, T_8 and T_{10} at 45 DAS and with T_3, T_4, T_5, T_6, T_7, T_8, T_9 and T_{10} at harvest. In case of seed content, treatment T_{11} found to be at par with all the treatments except T_1. The lowest values of nitrogen content *i.e.* 2.28 per cent in stover at 45 DAS, 1.66 per cent in stover at harvest and 2.20 per cent in seed were observed in control treatment (T_1) where RDF, B and/or Zn was not applied. The perusal of data also indicated that graded increase in nitrogen content in stover and seed was observed with graded application of B or Zn alone or in combination, but the higher values were obtained with the combined application than the sole. It was observed that the N content in stover decreased at harvest as compared to stover at flowering stage, probably due to translocation of N from the vegetative parts to the reproductive pods of plants which had greater nutrient requirement at grain filling stage. The results of the present study are in agreement with those reported by Debnath *et al*. (2018) [5] in Inceptisols (pH 5.5) of Arunachal Pradesh.

Phosphorus Content (%)

Application of graded doses of B and Zn either alone or in combinations along with recommended dose of fertilizers *i.e.* 25**:**60**:**40 $N:P_20_5:K_20$ kg ha^{-1} + rhizobium and PSB @ 25g kg^{-1}seed influenced the P content, which varied from 0.232 to 0.336 per cent in cowpea stover at flowering, 0.110 to 0.183 per cent in cowpea stover at harvest and 0.205 to 0.311 per cent in cowpea seed (Table 4). Application of graded doses of B and Zn either alone or in combinations along with recommended dose of fertilizers *i.e.* 25**:**60**:**40 $N:P_20_5:K_20$ kg ha^{-1} + rhizobium and PSB @ 25g kg^{-1}seed (from treatment T_2 to T_{11}) significantly increased phosphorus content in plant and seed of cowpea over the absolute control *i.e.* no fertilizer application (T_1). Increase in phosphorus content might be due to adequate supply of phosphate to soil through fertilizer and PSB and thereby greater mobilization of insoluble phosphorus along with enhanced transport of soil nutrients within the plant system (Trivedi *et al*. 1997) [21]. Significantly highest phosphorus content *i.e.* 0.336 per cent in stover at 45 DAS, 0.183 per cent in stover at harvest and 0.311 per cent in seed of cowpea was recorded in treatment T_{11} (T2 + B @ 2.00 + Zn @ 7.5 kg ha^{-1}), which was found to be at par with the treatments T_3, T_4, T_5, T_6, T_7, T_8 and T_{10} at 45 DAS and with T_4, T_5, T_6, T_7, T_8, T_9 and T_{10} at harvest. In case of seed content, treatment T_{11} found to be at par with T_4, T_5, T_6, T_7, T_8, T_9 and T_{10}. The lowest values of P content *i.e.* 0.232 per cent in stover at 45 DAS, 0.110 per cent in stover at harvest and 0.205 per cent in seed were observed in control treatment (T_1) where RDF, B and/or Zn was not applied. The perusal of data also indicated that graded increase in P content in stover and seed was observed with graded application of B or Zn alone or in combination, but the higher values were obtained with the combined application than the sole. The P content in stover decreased at harvest as compared to stover at flowering stage, probably due to translocation of P from the vegetative parts to the reproductive pods of plants which had greater nutrient requirement at grain filling stage. The results of the present study are in agreement with those reported by Debnath *et al*. (2018) [5] in Inceptisols (pH 5.5) of Arunachal Pradesh.

Potassium Content (%)

Application of graded doses of B and Zn either alone or in combinations influenced the K content, which varied from 1.46 to 2.52 per cent in cowpea stover at flowering, 0.93 to 1.77 per cent in cowpea stover at harvest and 0.83 to 1.20 per cent in cowpea seed (Table 4). Application of graded doses of B and Zn either alone or in combinations along with recommended dose of fertilizers *i.e.* 25**:**60**:**40 N**:**P_20_5**:**K_20 kg ha^{-1} + rhizobium and PSB @ 25g kg^{-1}seed (from treatment T_2 to T_{11}) significantly increased potassium content in plant and seed of cowpea over the absolute control *i.e.* no fertilizer application (T_1). The lowest values of K content *i.e.* 1.46 per cent in stover at 45 DAS, 0.93 per cent in stover at harvest and 0.83 per cent in seed were observed in control treatment (T_1) where RDF, B and/or Zn was not applied. Significantly highest potassium content *i.e.* 2.52 per cent in stover at 45 DAS, 1.77 per cent in stover at harvest and 1.20 per cent in seed of cowpea was recorded in treatment T_{11} (T2 + B @ 2.00 + Zn @ 7.5 kg ha^{-1}), which was found to be at par with the treatment T_8 at 45 DAS and with T_5, T_7, T_8, T_9 and T_{10} at harvest. In case of seed content, treatment T_{11} was found to be at par with T_4, T_5, T_6, T_7, T_8, T_9 and T_{10}. The perusal of data also indicated that alike P, graded increase in K content in stover and seed was observed with graded application of B or Zn alone or in combination, but the higher values were obtained with the combined application than the sole. The results of the present study are in agreement with those reported by Debnath *et al*. (2018) [5] in Inceptisols (pH 5.5) of Arunachal Pradesh.

Effect of boron and zinc application on nutrient uptake by cowpea

Nitrogen Uptake (kg ha^{-1})

As influenced by the application of graded doses of B and Zn either alone or in combinations, nitrogen uptake varied from 27.55 to 85.93 kg ha^{-1} by stover, 23.09 to 62.34 kg ha^{-1} by seed and 50.64 to 148.27 kg ha^{-1} total uptake by cowpea (Table 5). Evaluation of the data indicated that the application of graded doses of B and Zn either alone or in combinations (from treatment T_2 to T_{11}) significantly increased N uptake by stover and seed of cowpea over the absolute control *i.e.* no fertilizer application (T_1). The lowest values of N uptake *i.e.* 27.55 kg ha^{-1} by stover, 23.09 kg ha^{-1} by seed and 50.64 kg ha^{-1} of total uptake by cowpea were observed in control treatment (T_1) where RDF, B and/or Zn was not applied. Graded increase in N uptake by stover and seed was observed with the graded application of B (T_3 to T_5) or Zn (T_6 to T_8), but, the higher values of N uptake by stover and seed were obtained with the combined graded application of B + Zn (T_9 to T_{11}). Significantly highest N uptake *i.e.* 85.93 kg ha^{-1} by stover, 62.34 kg ha^{-1} by seed and 148.27 kg ha^{-1} total N uptake by cowpea was recorded in treatment T_{11} (T_2 + B @ 2.00 + Zn @ 7.5 kg ha^{-1}), which was found to be at par with T_9 and T_{10} in case of stover uptake, T_{10} in case of seed uptake and total N uptake by cowpea. The treatment difference between T_3, T_4, T_5, T_6, T_7 and T_8 in case of stover uptake; T_4, T_5, T_8 and T_9 in case of seed uptake and T_5, T_8 and T_9 in case of total N uptake were at par. Chakirwa *et al*. (2019) [4] also reported that the increment of Zn content in the grain had a positive relationship with NK. The N uptake ranges reported here are in agreement with Rathod (2005) [16] and Rathod (2008) [15] in lateritic soils of Konkan.

Phosphorus Uptake (kg ha^{-1})

As influenced by the application of graded doses of B and Zn either alone or in combinations, phosphorus uptake varied from 1.87 to 6.08 kg ha^{-1} by stover, 2.15 to 6.98 kg ha^{-1} by seed and 4.02 to 13.06 kg ha^{-1} total uptake by cowpea (Table 5). Assessment of the data indicated that the application of graded doses of B and Zn either alone or in combinations (from treatment T_2 to T_{11}) significantly increased P uptake by plant and seed of cowpea over the absolute control *i.e.* no fertilizer application (T_1). The lowest values of P uptake *i.e.* 1.87 kg ha^{-1} by stover, 2.15 kg ha^{-1} by seed and 4.02 kg ha^{-1} of total P uptake by cowpea were observed in control treatment (T_1), where RDF, B and/or Zn was not applied. Graded increase in P uptake by stover and seed was observed with the graded application of B (T_3 to T_5) or Zn (T_6 to T_8), but, the higher values of P uptake by stover and seed were obtained with the combined graded application of B + Zn (T_9 to T_{11}). Significantly highest P uptake *i.e.* 6.08 kg ha^{-1} by stover, 6.98 kg ha^{-1} by seed and 13.06 kg ha^{-1} total uptake by cowpea was recorded in treatment T_{11} (T2 + B @ 2.00 + Zn @ 7.5 kg ha-1), which was found to be at par with T_{10} in case of stover uptake and significantly superior in case of seed uptake and total uptake. The treatment difference between T_4, T_5, T_7 and T_8 in case of stover uptake; T_5, T_8 and T_{10} in case of seed uptake and total P uptake were at par. The P uptake ranges reported here are in agreement with Rathod (2005) [16] and Rathod (2008) [15] in lateritic soils of Konkan.

Potassium Uptake (kg ha^{-1})

As influenced by the application of graded doses of B and Zn either alone or in combinations, potassium uptake varied from 15.56 to 59.33 kg ha^{-1} by stover, 8.79 to 27.24 kg ha^{-1} by seed and 24.35 to 86.57 kg ha^{-1} total uptake by cowpea (Table 5). Appraisal of the data indicated that the application of graded doses of B and Zn either alone or in combinations (from treatment T_2 to T_{11}) significantly increased K uptake by stover and seed of cowpea over the absolute control *i.e.* no fertilizer application (T_1). The lowest values of K uptake *i.e.* 15.56 kg ha^{-1} by stover, 8.79 kg ha^{-1} by seed and 24.35 kg ha^{-1} of total K uptake by cowpea were observed in control treatment (T_1) where RDF, B and/or Zn was not applied. Graded increase in K uptake by stover and seed was observed with the graded application of B (T_3 to T_5) or Zn (T_6 to T_8), but, the higher values of K uptake by stover and seed were obtained with the combined graded application of B + Zn (T_9 to T_{11}). Significantly highest K uptake *i.e.* 59.33 kg ha^{-1} by stover, 27.24 kg ha^{-1} by seed and 86.57 kg ha^{-1} total uptake by cowpea was recorded in treatment T_{11} (T_2 + B @ 2.00 + Zn @ 7.5 kg ha^{-1}), which was found to be at par with T_9 and T_{10} in case of stover, seed and total uptake. The treatment difference between T_2, T_3, T_4, T_5, T_6, T_7 and T_8 in case of stover uptake; T_4, T_5, T_6, T_7 and T_8 in case of seed uptake and T_3, T_4, T_5, T_6, T_7 and T_8 in case of total K uptake were at par. These results corroborate the findings of Fagaria (2004) [7] and Sunitha *et* *al*. (2014) [17] who reported that zinc is an essential micronutrient for plant growth and plays an important role in the catalytic part of several enzymes its deficiency will result in stunted growth and nutrient uptakes. Potarzycki and Grzebisz (2009) [13] also reported that zinc exerts a great influence on basic plant life processes, such as (i) nitrogen metabolism–uptake of nitrogen and protein quality; (ii) photosynthesis-chlorophyll synthesis and carbon anhydrase activity. Chakirwa *et al*. (2019) [4] also reported that the increment of Zn content in the grain had a positive relationship with NK. The K uptake ranges reported here are in agreement with Rathod (2005) [16] and Rathod (2008) [15] in lateritic soils of Konkan.

Table 1: Details of the treatments

Treat. No.	Description of Treatment
T_1	Absolute Control (No Fertilizers and Biofertilizers)
T_2	25:60:40 N:P_20_5:K_20 kg ha^{-1}(RDF) + Rhizobium and PSB @ 25g kg^{-1}seed
T_3	T2 + Boron @ 1.0 kg ha^{-1}
T_4	T2 + Boron @ 1.5 kg ha^{-1}
T_5	T2 + Boron @ 2.0 kg ha^{-1}
T_6	T2 + Zinc @ 2.5 kg ha^{-1}
T_7	T2 + Zinc @ 5.0 kg ha^{-1}
T_8	T2 + Zinc @ 7.5 kg ha^{-1}
T_9	T2 + Boron @ 1.0 kg ha^{-1}+ Zinc @ 2.5 kg ha^{-1}
$T_{1}0$	T2 + Boron @1.5 kg ha^{-1}+ Zinc @ 5.0 kg ha^{-1}
T_{11}	T2 + Boron @1.5 kg ha^{-1} + Zinc @ 7.5 kg ha^{-1}

Table 2: Nutrient composition of various inorganic fertilizers and FYM used in the study

Sr. No.	Name of fertilizer	Composition (%)				
		N	P2O5	K	B	Zn
1.	Urea	45.2	-	-	-	-
2.	Single super phosphate	-	15.4	-	-	-
3.	Muriate of potash	-	-	59.2	-	-
4.	Borax	-	-	-	11.34	-
5.	Zinc sulphate	-	-	-	-	21.0
6.	FYM	0.62	0.16	0.51	-	-

Table 3: Yield of cowpea as influenced by application of boron and zinc

Treat. No.	Description of Treatment	Seed Yield (q ha-1)	Stover Yield (q ha-1)
T_1	Absolute Control (No Fertilizers and Biofertilizers)	10.56	16.74
T_2	25:60:40 N:P_20_5:K_20 kg ha^{-1}(RDF) + Rhizobium and PSB @ 25g kg^{-1}seed	16.10	24.70
T_3	T2 + Boron @ 1.0 kg ha^{-1}	16.72	25.50
T_4	T2 + Boron @ 1.5 kg ha^{-1}	17.49	27.13
T_5	T2 + Boron @ 2.0 kg ha^{-1}	18.59	28.20
T_6	T2 + Zinc @ 2.5 kg ha^{-1}	15.14	24.50
T_7	T2 + Zinc @ 5.0 kg ha^{-1}	16.87	25.20
T_8	T2 + Zinc @ 7.5 kg ha^{-1}	19.14	27.60
T_9	T2 + Boron @ 1.0 kg ha^{-1}+ Zinc @ 2.5 kg ha^{-1}	20.79	31.60
$T_{1}0$	T2 + Boron @1.5 kg ha^{-1}+ Zinc @ 5.0 kg ha^{-1}	21.67	32.10
T_{11}	T2 + Boron @1.5 kg ha^{-1} + Zinc @ 7.5 kg ha^{-1}	22.51	33.50
SE (m) ±		0.469	1.625
CD at 5 %		1.382	4.793

Table 4: Nitrogen, phosphorus and potassium content in stover at different growth stages and seed of cowpea as influenced by application of boron and zinc

Tr. No.	Treatments	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
		Stover		Seed	Stover		Seed	Stover		Seed
		At 45 DAS	At harvest		At 45 DAS	At harvest		At 45 DAS	At harvest	
T1	Control (No NPK)	2.28	1.66	2.20	0.232	0.110	0.205	1.46	0.93	0.83
T2	25:60:40 N:P205:K20 kg ha^{-1} + Rhizobium and PSB @ 25g kg^{-1}seed	3.11	2.16	2.60	0.294	0.141	0.239	1.73	1.47	0.94
T3	T2 + B @ 1.0 kg ha^{-1}	3.16	2.38	2.65	0.306	0.152	0.259	1.93	1.57	1.01
T4	T2 + B @ 1.5 kg ha^{-1}	3.27	2.42	2.69	0.311	0.166	0.282	2.21	1.59	1.04
T5	T2 + B @ 2.0 kg ha^{-1}	3.39	2.47	2.73	0.334	0.178	0.303	2.37	1.65	1.11
T6	T2 + Zn @ 2.5 kg ha^{-1}	3.22	2.34	2.61	0.297	0.157	0.267	2.24	1.59	0.97
T7	T2 + Zn @ 5.0 kg ha^{-1}	3.29	2.35	2.66	0.324	0.164	0.278	2.31	1.64	1.05
T8	T2 + Zn @ 7.5 kg ha^{-1}	3.38	2.39	2.73	0.345	0.173	0.294	2.47	1.69	1.11
T9	T2 + B @ 1.0 kg ha^{-1} + Zn @ 2.5 kg ha^{-1}	3.21	2.43	2.52	0.289	0.145	0.246	2.26	1.67	1.13
T10	T2 + B @ 1.5 kg ha^{-1} + Zn @ 5.0 kg ha^{-1}	3.30	2.50	2.69	0.329	0.166	0.283	2.36	1.72	1.17
T11	T2 + B @ 2.0 kg ha^{-1} + Zn @ 7.5 kg ha^{-1}	3.55	2.57	2.77	0.336	0.183	0.311	2.52	1.77	1.20
	S.E±	0.101	0.081	0.095	0.011	0.009	0.013	0.033	0.053	0.057
	C.D (P=0.05)	0.297	0.240	0.280	0.032	0.026	0.038	0.097	0.156	0.168

Table 5: Nitrogen, phosphorus and potassium uptake by stover and seed of cowpea as influenced by application of boron and zinc

Tr. No	Treatments	Nitrogen Uptake (kg ha-1)			Phosphorus Uptake (kg ha-1)			Potassium Uptake (kg ha-1)		
		Stover	Seed	Total	Stover	Seed	Total	Stover	Seed	Total
T1	Control (No NPK)	27.55	23.09	50.64	1.87	2.15	4.02	15.56	8.79	24.35
T2	25:60:40 N:P205:K20 kg ha^{-1} + Rhizobium and PSB @ 25g kg^{-1}seed	53.46	41.84	95.29	3.45	3.86	7.31	36.33	15.21	51.54
T3	T2 + B @ 1.0 kg ha^{-1}	60.76	44.31	105.06	3.88	4.32	8.20	39.90	16.86	56.76
T4	T2 + B @ 1.5 kg ha^{-1}	65.64	47.09	112.73	4.51	4.93	9.44	42.88	18.18	61.06
T5	T2 + B @ 2.0 kg ha^{-1}	69.77	50.64	120.41	5.01	5.64	10.65	46.60	20.58	67.18
T6	T2 + Zn @ 2.5 kg ha^{-1}	56.95	39.32	96.27	3.84	4.05	7.89	38.93	14.74	53.67
T7	T2 + Zn @ 5.0 kg ha^{-1}	59.20	44.77	103.98	4.11	4.69	8.80	41.35	17.74	59.08
T8	T2 + Zn @ 7.5 kg ha^{-1}	65.95	52.36	118.30	4.78	5.62	10.41	46.66	21.19	67.85
T9	T2 + B @ 1.0 kg ha^{-1} + Zn @ 2.5 kg ha^{-1}	76.56	52.38	128.93	4.58	5.11	9.70	52.97	23.59	76.56
T10	T2 + B @ 1.5 kg ha^{-1} + Zn @ 5.0 kg ha^{-1}	80.66	58.30	138.96	5.32	6.13	11.45	55.30	25.27	80.57
T11	T2 + B @ 2.0 kg ha^{-1} + Zn @ 7.5 kg ha^{-1}	85.93	62.34	148.27	6.08	6.98	13.06	59.33	27.24	86.57
	S.E±	4.48	1.83	4.76	0.26	0.24	0.41	3.52	1.42	3.90
	C.D (P=0.05)	13.21	5.40	14.05	0.78	0.72	1.21	10.38	4.19	11.50

Conclusion

On the basis of the findings of the present investigation, it can be concluded that the N, P and K contents in stover at flowering, stover at harvest and seed and their uptake in stover at harvest, seed at harvest and Total uptake was significantly increased due to application of 25:60:40 N:P205:$K_2$0 kg ha^{-1} + Rhizobium and PSB @ 25g kg^{-1}seed + B @ 2.00 + Zn @ 7.5 kg ha^{-1}.

Acknowledgement

Financial assistance from the College of Agriculture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Daploi, Dist Ratnagiri (Maharashtra) for conducting the study is duly acknowledged.

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