www.ThePharmaJournal.com
The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(8): 742-751

www.thepharmajournal.com
Received: 25-06-2022
Accepted: 29-07-2022

Govinda K
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, University of Agricultural Science, GKVK, Bangalore, Karnataka, India

Prakash SS
Dean (Agri.), College of Agriculture, V.C. Farm, UAS, Bangalore, Karnataka, India

Jagadeesha GS
Research Scholar, Department of Soil Science and Agricultural Chemistry, University of Agricultural Science, GKVK, Bangalore, Karnataka, India

Sagar R
Research Scholar, Department of Soil Science and Agricultural Chemistry, KSNUAHS, Shivamogga, Karnataka, India

Corresponding Author:
Govinda K
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, University of Agricultural Science, GKVK, Bangalore, Karnataka, India

Effect of graded levels of borax and gypsum on yield, nutrient content and uptake in irrigated finger millet (*Eleusine coracana* L.) under southern dry zone of Karnataka

Govinda K, Prakash SS, Jagadeesha GS and Sagar R

Abstract
A field experiment was conducted during *Kharif* 2016 on sandy loam soil deficient in B at College of Agriculture, V. C. Farm, Mandya to study the effect of graded levels of borax (5, 10, 15 and 20 kg ha^{-1}) and gypsum (100 and 200 kg ha^{-1}) on yield, nutrient content and uptake in irrigated finger millet (*Eleusine coracana* L.). Significantly higher grain yield of 45.95 q ha^{-1} (17.56% higher than the control) and a B:C ratio of 3.06 were also recorded at T_{12} compared with RDF + FYM (T_1). The Ca, Mg content in grain was higher in T_{12} (0.63 and 0.30% respectively) which received T_4 + 100 kg gypsum ha^{-1} when compared to control (0.50 and 0.23% respectively). The boron concentration in grain was significantly higher (34.38 mg kg^{-1}) in T_5 (T_1+ 20 kg borax ha^{-1}) followed by 32.38 mg kg^{-1} inT_{12} (T_4 + 100 kg gypsum ha^{-1}) when compared to T_1 (20.49 mg kg^{-1}). Higher total uptake of nitrogen, phosphorous, potassium, calcium and sulphur (166.82, 28.63, 184.54, 67.48 and 30.91 kg ha^{-1} kg ha^{1}, respectively) was observed in T_{12} (T_4 +100 kg gypsum ha^{-1}) which were significantly higher than control (T_1). As a result of these findings, applying 15 kg borax ha^{-1} + 100 kg gypsum ha^{-1} + RDF + FYM is the optimum dose for increasing yield.

Keywords: Boron, calcium, nutrient content and nutrient uptake, finger millet yield, economics

Introduction
In both, areas (1,38 million ha) and productivity, the finger millet (*Eleusine coracana* (L.) Gaertn.) is the third largest of all millets in the country (2.03 million tonnes). In India, finger millet is cultivated mainly in the states of Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Jharkhand, Uttaranchal, Maharashtra, and Gujarat occupying an area of 1.27 million hectares with a production of 2.61 million tonnes and average productivity of 1489 kg ha^{-1} (Agriculture Statistics at a Glance 2017). The State of Karnataka has 60.8% of the land and 2/3 of its output (68.4 percent). (Anon 2007) [2]. The principal food component in Southern Karnataka is finger millet, especially in the rural areas of Tumkur, Mysore, Hassan, Mandya and Chitradurga districts of Bangalore. In addition, finger millet is an appropriate nutrition for diabetic patients. It possesses high calcium amounts (0,38%), a high protein content (6-8%), fibre (18%) and amino acid phenolic compounds (0,3-3%).
Calcium is a major cation in middle lamella of cell wall, involves in protein synthesis and cell division. Finger millet is a crop rich in Ca (up to 450 mg /100 g). It also increases plant growth rapidly and maintains structural integrity of stems .The quality of grains produced is strongly related to calcium availability to crop plant (Easterwood, 2002) [9].
Boron plays an important role in plant growth and nutrition and it promotes cell division, cell elongation, cell wall resistance, flowering, pollination, fruit set and sugar translocation. The main function of boron in plant growth and development is its ability to form complexes with compounds with the cisdiol configuration. It has been observed that in most plant species, the boron requirement for reproductive development is much higher than the boron requirement for vegetative growth (Matoh *et al*., 1992) [21]. This is especially true for grasses that have the lowest cell wall pectin and the lowest boron requirements to maintain normal vegetative growth, but require as much boron as other species during the reproductive stage. The availability of B is influenced by dynamic soil properties including organic matter, texture, cultivation, drought, and microbial activity and $CaCo_3$ content (Mengel and Kirkby, 2001) [22]. According to some studies, B sorption heightens due to elevated levels of calcite in soil and liming diminished the water-soluble B content of soils (Goldberg and Forster, 1991; Lehto and

Malkonen, 1994) [10, 18]. This B adsorption is due to the bonding of B with CaCO3 which results into precipitation of Ca-borate or substitution of Carbon by B in CaCO3 or simple surface adsorption of B on CaCO3 (Goldberg and Forster, 1991; Cox and Reid, 1964; Keren and Ben-Hur, 2003) [10, 7, 16]. Calcium and boron both play important roles in enhancing grain yields, however combining boron and calcium can alter boron availability and use by plants (Kanwal *et al*. 2008) [15]. The availability or need of boron and calcium for proper plant growth and development are influenced by the proportion of each. Increased calcium supply has been shown to improve boron deficient symptoms in plants. Boron deficiency, on the other hand, altered calcium translocation to the shoot and fruit. It denotes the need for a balanced supply of calcium and boron for appropriate plant growth and development. Most of the farmers are growing finger millet by applying less amount of NPK with or without addition of secondary and micro nutrients, but research studies show finger mill*et al*so responds well to Ca, S and micronutrients like B, Zn and Fe. Secondary nutrients like calcium and sulphur in the form of gypsum and micronutrient boron in the form of borax have been recommended by Karnataka state department of agriculture under Bhoochetana scheme along with N, P, K fertilizers.

In view of above facts, the experiments were undertaken with an objective to study the " Effect of graded levels of borax and gypsum on yield, nutrient content and uptake in irrigated finger millet (*Eleusine coracana* L.) under Southern Dry Zone of Karnataka."

Material and Methods

The experimental site and soil

The field experiment was carried out during Kharif–2016 at College of Agriculture, V. C. Farm, Mandya, Karnataka. Mandya is situated in the Southern Dry Zone (Zone no.6) of Karnataka. It is located between 120 32' N latitude and 760 53' E longitude and at an altitude of 695 metres above mean sea level. The climatic conditions that prevailed during crop growth period are presented in Fig. 1.

Soils of the farm belong taxonomically to *Typic Rhodustalfs*. A composite soil sample was drawn from the experimental site by collecting samples from 0-15 cm depth before initiation of experiment. The soil was air-dried, powdered and passed through 2 mm sieve and was analyzed for physical and chemical properties. The results of soil analysis are furnished in Table 1.

Treatment

The experiment was laid out in RCBD (p=0.05) with fifteen treatments and replicated thrice with net plot size is 3.8 m x 2.1 m. The variety used in the experiment was KMR 301 with recommended doses of nitrogen, phosphorus and potassium were applied at the rate of 100: 50: 50 kg, N: P_2O_5: K_2O kg ha^{-1} in the form of urea, single super phosphate (SSP) and muriate of potash respectively and FYM at 10 t ha^{-1} to all the plots. Borax ($Na_2B_4O_7.10H_2O$ containing 11% B) as source of boron and gypsum ($CaSO_4$. $2H_2O$), containing 29 per cent of Ca as source of calcium were also mixed with the soil at the required dosage as per treatment, before transplanting of the seedlings.

The treatment details are as follows

T_1= RDF+FYM, $T_2 = T_1$ + 5 kg ha^{-1} borax, $T_3 = T_1$ + 10 kg ha^{-1} borax, $T_4 = T_1$ + 15 kg ha^{-1} borax, $T_5 = T_1$ + 20 kg ha^{-1} borax, $T_6 = T_1$ + 100 kg ha^{-1} gypsum, $T_7 = T_1$ + 200 kg ha^{-1} gypsum, $T_8 = T_2$ +100 kg ha^{-1} gypsum, $T_9 = T_2$ + 200 kg ha^{-1} gypsum, $T_{10} = T_3$ + 100 kg ha^{-1} gypsum, $T_{11}= T_3$ + 200 kg ha^{-1} gypsum, $T_{12} = T_4$ +100 kg ha^{-1} gypsum, $T_{13} = T_4$ +200 kg ha^{-1} gypsum, $T_{14}= T_5$ + 100 kg ha^{-1} gypsum, $T_{15}= T_5$ + 200 kg ha^{-1} gypsum

Soil and plant studies

Soil samples will be collected separately from each plot after layout of experiment, at flowering stage and after the harvest of crop. The samples will be processed and used for determination of pH, EC, OC, N, P, K, Ca, Mg, S and B status.

During the harvesting of crop, five plants from each plot which were randomly selected and labelled were collected by cutting the entire plant. The plant samples were first washed with tap water, later with detergent solution and finally with distilled water to remove the adhering soil and dusts. Samples were dried at 65 ºC in a hot air oven and powdered by using a grinder with stainless steel blades and preserved in polythene covers for further chemical analysis. Nitrogen was determined by Kjeldahls method using conc H_2SO_4 in the presence of digestion mixture (Piper, 1966). Phosphorus content in the digested plant sample was estimated by vanadomolybdo phosphoric yellow colour method in nitric acid medium and the colour intensity was measured at 460 nm wave length as given by Jackson (1973) [14]. Potassium in the digested plant sample was estimated by atomizing the diluted acid extract in a flame photometer as described by Jackson (1973) [14]. Calcium and magnesium in the digested plant sample were estimated by titrating against standard versenate solution using murexide and EBT indicators respectively for calcium and calcium plus magnesium, whereas magnesium was determined by difference between concentration of calcium plus magnesium and calcium (Jackson, 1973) [14]. Sulphur content of the plant sample was estimated by using an aliquot of digested plant extract by turbidimetric method by using barium chloride as outlined by Black (1965) [4]. The plant samples were dry ashed using muffle furnace at a temperature of 550 ºC for a period of four hours. Then dried samples were treated with two ml of concentrated sulphuric acid and evaporated to dryness on hot plate. Then samples were made to volume of 100 ml. Boron in the extracted material was determined by Colorimetry using Azomethane-H reagent (Page *et al*., 1982) [4].

Nutrient uptake for all the major, secondary and micronutrients (boron) was calculated by the formula mentioned below.

$$\text{Uptake (kg ha}^{-1}) = \frac{\text{Nutrient concentration (\%) x Biomass (kg ha}^{-1})}{100}$$

Benefit: cost (B:C) ratio

Benefit cost ratio was worked out by using the following formula,

$$\text{B: C Ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

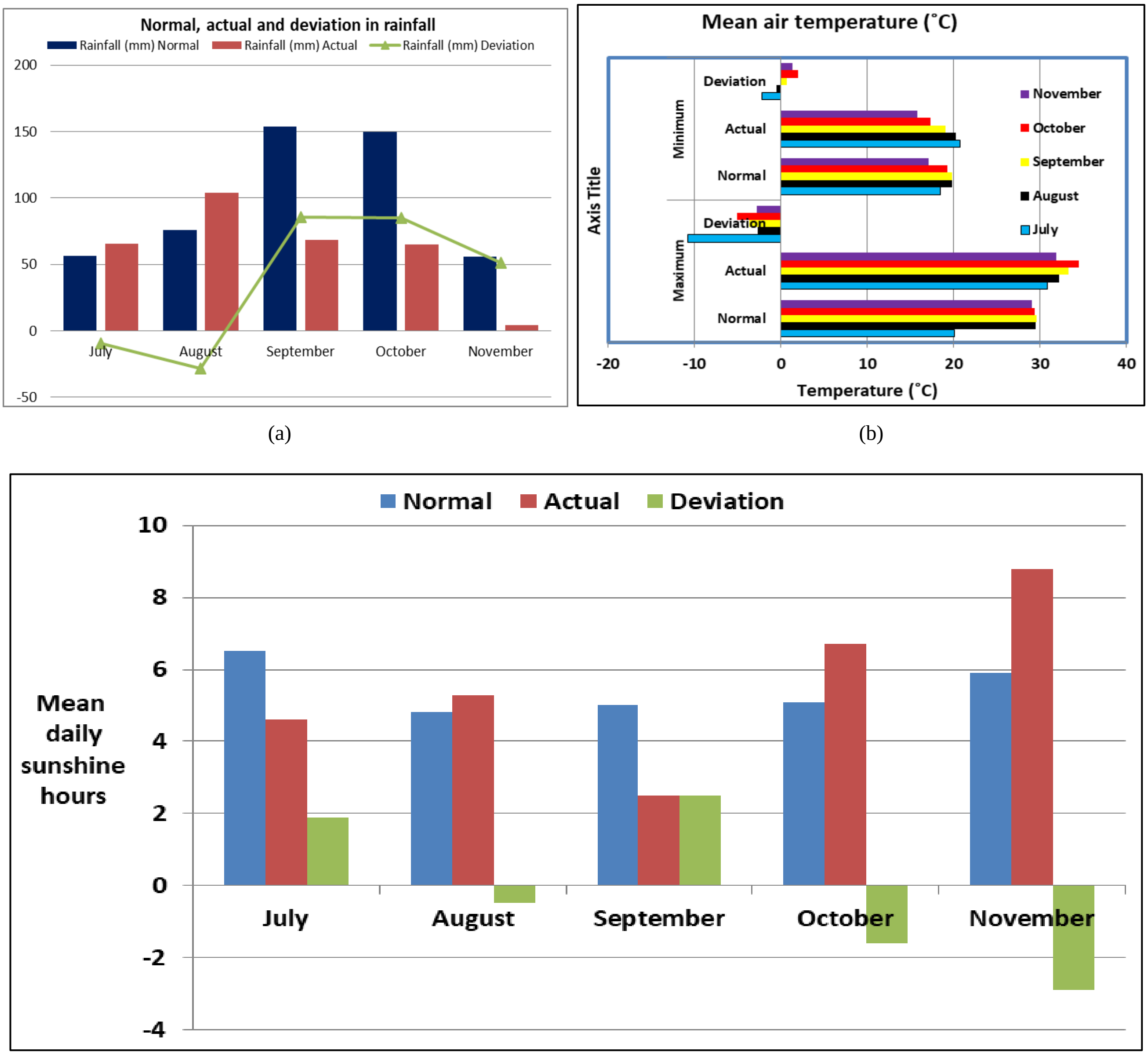
Statistical analysis

The data collected from the experiment at different growth stages were subjected to statistical analysis as described by Gomez and Gomez (1984) [11]. The level of significance used in ›F› and ›t› test was P = 0.05. Critical difference (CD) values were calculated for the P = 0.05 whenever ›F› test was found to be significant.

Results and discussion

Soil of the experimental site was sandy loam in texture and neutral in soil reaction (pH, 7.44). Electrical conductivity was normal (0.13 dSm^{-1}) and organic carbon content was low (3.9 g kg^{-1}). Available N content of the soil was low (175.6 kg ha^{-1}), that of K_2O and available P_2O_5 content was medium (231.16 and 25.25 kg ha^{-1}, respectively). Available B and S content were low (0.28 and 8.5 mg kg^{-1} respectively).

The crop received more than normal rainfall during the month of August, whereas in the month of September and October there was nearly 85 mm deficit rainfall. Maximum mean air temperature of 34.5 ºC was recorded in the month of October and the minimum air temperature of 19.3 ºC was also recorded in the month of October during crop growth. Thus at the ear head formation stage of crop growth during October the crop suffered with extreme differences in temperature. The crop growth suffered at tillering stage due to lower mean sun shine hours recorded during the month of September (2.5 hours) (Fig. 1). Plant sample will be collected at harvest stage and analysed for major and secondary nutrients and boron content.



(a) (b)

(c)

Fig 1: Meteorological data indicating mean monthly normal, actual and deviation of (a) Rainfall (b) Temperature (c) Daily sunshine hours for the experimental period (2016) at College of Agriculture, V. C. Farm, Mandya

Effect of application of graded levels of borax and gypsum on grain and straw yield in irrigated finger millet

Application of 15 kg borax ha^{-1} + 100 kg gypsum ha^{-1}+ RDF + FYM recorded significantly higher grain and straw yield (45.95 q ha^{-1} , 65.42q ha^{-1} respectively) followed by T_4 (44.58 q ha^{-1} , 64.85 q ha^{-1} respectively) when compared to T_1 (37.88 q ha^{-1} , 53.45 q ha^{-1} respectively with RDF + FYM only (Table 2). However, treatments like T_3 (T_1+5 kg borax ha-1), T_{13} (T_4 + 200 kg gypsum ha^{-1}) and T_{10} (T_3+100 kg gypsum ha^{-1}) recorded on par yield. The other treatments recorded statistically non-significant when compared to T_1. The other yield parameters like number of fingers per ear head and number of ear heads per meter square recorded significantly higher in T_{12} treatment when compare to control (T_1). More tillers per hill, ear heads per square metre, and fingers per ear head all contributed to a significant rise in grain output in T_{12}. Under optimal borax and gypsum fertilisation, finger millet has a significant potential to generate more tillers per hill, particularly in low B soils. The use of boron, which has improved pollen tube germination and grain setting, may be responsible for the increased grain production. The application of boron during the booting stage satisfied the anthers' boron needs for effective fertilisation, and grain production was greater than control (Tahir *et al*. 2009) [34]. Mishra *et al*. (1989) [23] and Ramachandrappa *et al*. (1990) [32] both achieved similar findings. Ramachandrappa *et al*. (2014) [32]. Chitralekha *et al*. (1987) [6] also observed that when both calcium and boron were applied, calcium did not bring about desired changes, but application of boron to the deficient soil resulted in a good response.

The T_5 treatment, which received 20 kg borax ha^{-1} along with prescribed NPK and FYM, had considerably lower grain and straw yields, which may be ascribed to the detrimental effect of excess B on plant development. Excess B has been linked to lower vigour, slowed plant growth, delayed development, decreased quantity, size, and weight of fruits, and leaf discolouration (Lovatt and Bates 1984; Nable *et al*. 1997) [20, 28]. However, in the current investigation, treatments T_{14} and T_{15}, which received 20 kg borax ha^{-1} combined with 100 kg gypsum ha^{-1} and 200 kg gypsum ha^{-1}, respectively, yield decreases owing to boron toxicity are smaller than when 20 kg borax ha^{-1} is applied alone because plants can withstand larger levels of boron without being toxic if they have enough calcium, they can endure higher levels of boron without becoming hazardous (Chitralekha *et al.* 1987) [6].

Effect of application of graded levels of borax and gypsum on nutrient content of grain and straw in finger millet.

Nitrogen

Nitrogen content in straw and grain of irrigated finger millet at harvest did not differ significantly due to application of gypsum and borax in treatments (Table 3). Higher nitrogen content of 1.97 per cent was recorded in grain in T_{12} (T_4 + 100 kg gypsum ha^{-1}) followed by 1.96 per cent in T_7 (T_1+ 200 kg gypsum ha^{-1}) as compared to control (1.85%). However, these were on par with all other treatments. It was observed that varied combinations of gypsum and borax treatment had a substantial influence on phosphorus concentration in finger millet grain and straw at harvest. when compared to T_1, the phosphorus content in grain was 0.32 percent, which was substantially higher in T_{12}, which received T_4 + 100 kg gypsum ha^{-1}, and 0.31 percent in T_{11} (T_3 + 200 kg gypsum ha^{-1}) (0.27 percent).

Table 1: Physico - chemical properties of soil at the experimental site

Sl. No	Soil property	Value	Method
1.	Particle size analysis		International pipette method (Piper 1966)
	a. Sand (%)	84.03	-
	b. Silt (%)	2.00	-
	c. Clay (%)	13.55	-
	Texture	Sandy loam	-
2.	pH (1:2.5 soil : water suspension)	7.44	Jackson, 1973 [14]
3.	Electrical conductivity (dSm^{-1})	0.13	Jackson, 1973 [14]
4.	Organic carbon (g kg^{-1})	3.90	Walkley and Black wet oxidation method (Jackson, 1973) [14]
5.	Available nitrogen (kg ha^{-1})	175.6	Alkaline permanganate method by Subbaiah and Asija (1956)
6.	Available phosphorus (kg ha^{-1})	25.25	Jackson, 1973 [14]
7.	Available potassium (kg ha^{-1})	231.16	Jackson, 1973 [14]
8.	Exchangeable calcium (cmol kg^{-1})	5.70	Jackson, 1973 [14]
9.	Exchangeable magnesium (cmol kg^{-1})	2.40	Jackson, 1973 [14]
10.	Available sulphur (mg kg^{-1})	8.50	Turbidometry (Black, 1965) [4].
11.	Available boron (mg kg^{-1})	0.28	Azomethine-H method (Page *et al*., 1982) [30]

Table 2: Influence of graded levels of borax and gypsum on grain and straw yield of finger millet

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1 : RDF+FYM	37.88	53.45
T_2 : T_1 + 5 kg ha^{-1} borax	39.41	56.27
T_3 : T_1 + 10 kg ha^{-1} borax	43.24	62.68
T_4 : T_1 + 15 kg ha^{-1} borax	44.58	64.85
T_5 : T_1 + 20 kg ha^{-1} borax	38.81	56.09
T_6 : T_1 + 100 kg ha^{-1} gypsum	40.24	56.34
T_7 : T_1 + 200 kg ha^{-1} gypsum	40.62	56.46
T_8 : T_2 +100 kg ha^{-1} gypsum	40.67	56.43
T_9 : T_2 + 200 kg ha^{-1} gypsum	38.93	56.40
T_{10}: T_3 + 100 kg ha^{-1} gypsum	42.45	62.16
T_{11}: T_3 + 200 kg ha^{-1} gypsum	40.33	58.88
T_{12}: T_4 +100 kg ha^{-1} gypsum	45.95	65.42
T_{13}: T_4 +200 kg ha^{-1} gypsum	42.90	62.56
T_{14}: T_5 + 100 kg ha^{-1} gypsum	41.36	57.19
T_{15}: T_5 + 200 kg ha^{-1} gypsum	39.97	55.32
S.Em±	1.55	2.64
CD (p=0.05)	4.50	7.64

The phosphorus concentration in straw was significantly higher in T_{13} (0.24%) which received T_4 + 200 kg gypsum ha^{-1} followed by T_{10} (0.23%) when compared to control (0.19%). However, T_{13} was on par with T_{12} (T_4+ 100 kg gypsum ha^{-1}), T_7 (T_1+200 kg gypsum ha^{-1}) and T_4 (T_1+15 kg borax ha^{-1}) recorded 0.21 per cent, T_8, T_{15} (0.19%) and T_{14} (0.20%). All other treatments are on par with control (0.19%).

Numerically higher K concentration of 1.51 per cent in grains was found in T_4 which received T_1+ 15 kg borax ha^{-1} followed by the treatment T_5 (T_1+ 20 kg borax ha^{-1}) recorded 1.44 per cent. The lower K concentration of 1.37 per cent was recorded in T_{10} which received T_3 + 100 kg gypsum ha^{-1}. The potassium concentration in straw ranges from 1.51 to 1.83 per cent. The higher concentration was observed in T_7 (1.83%) due to 200 kg gypsum ha^{-1}+ RDF + FYM application followed by T_{12} (1.82%). The lower K concentration of 1.47 per cent was recorded in T_{14} which received 20 kg borax ha^{-1}+ 100 kg gypsum ha^{-1}+ RDF + FYM. Application of borax did not influence the N, K content of the kernels and haulm (Nadaf and Chidanandappa, 2015 and Lopez *et al.*, 2002) [29, 19]. Presence of higher calcium and potassium contents in grain due to application of gypsum helps plants to attain more calcium, potassium and sulfur to avoid sodium uptake (Muhammad., 2013) [25].

Table 3: Nitrogen, phosphorous and potassium content in grain and straw of finger millet as influenced by graded levels of borax and gypsum application

Treatments	N (%)		P (%)		K (%)	
	Grain	Straw	Grain	Straw	Grain	Straw
T_1 : RDF+FYM	1.85	1.04	0.27	0.19	1.42	1.71
T_2 : T_1 + 5 kg ha^{-1} borax	1.87	1.07	0.29	0.18	1.40	1.57
T_3 : T_1 + 10 kg ha^{-1} borax	1.73	1.12	0.29	0.19	1.39	1.70
T_4 : T_1 + 15 kg ha^{-1} borax	1.91	1.08	0.30	0.21	1.51	1.76
T_5 : T_1 + 20 kg ha^{-1} borax	1.77	1.03	0.28	0.17	1.44	1.76
T_6 : T_1 + 100 kg ha^{-1} gypsum	1.68	1.03	0.28	0.18	1.40	1.77
T_7 : T_1 + 200 kg ha^{-1} gypsum	1.96	1.07	0.28	0.21	1.39	1.83
T_8 : T_2 +100 kg ha^{-1} gypsum	1.73	1.12	0.28	0.19	1.41	1.63
T_9 : T_2 + 200 kg ha^{-1} gypsum	1.87	0.97	0.28	0.22	1.43	1.63
T_{10}: T_3 + 100 kg ha^{-1} gypsum	1.73	1.03	0.29	0.23	1.37	1.61
T_{11}: T_3 + 200 kg ha^{-1} gypsum	1.87	0.98	0.31	0.17	1.40	1.69
T_{12}: T_4 +100 kg ha^{-1} gypsum	1.97	1.17	0.32	0.21	1.38	1.82
T_{13}: T_4 +200 kg ha^{-1} gypsum	1.68	1.07	0.29	0.24	1.39	1.57
T_{14}: T_5 + 100 kg ha^{-1} gypsum	1.59	0.94	0.29	0.20	1.40	1.47
T_{15}: T_5 + 200 kg ha^{-1} gypsum	1.77	0.93	0.28	0.19	1.42	1.51
S.Em±	0.08	0.07	0.01	0.01	0.04	0.08
CD (p=0.05)	NS	NS	0.02	0.04	NS	NS

Secondary nutrients (Ca, Mg and S) and Boron

The data presented in Table 4 indicates that the secondary nutrients like calcium, magnesium, sulphur and boron in grain and straw of finger millet as influenced by application of different levels of borax and gypsum.

Calcium and magnesium content in grain and straw showed a significant difference due to treatments. The calcium and magnesium content in grain was higher in T_{12} (0.63 and 0.30%, respectively) which received T_4+ 100 kg gypsum ha^{-1} when compared to control (0.50 and 0.23%, respectively). In straw, significantly higher concentration of calcium was observed in T_{11} (T_3 + 200 kg gypsum ha^{-1}) (0.71%) when compared to T_1 (0.46%) but incase of magnesium, significantly higher in T_{13} (0.54%) which received T_4+ 200 kg gypsum ha^{-1} followed by T_5 (T_1+ 20 kg borax ha^{-1}) (0.45%) when compared to T_1 (0.36%).

The data on sulphur and boron contents in grain and straw of finger millet as influenced by application of different levels of borax and gypsum are presented in Table 4. The sulphur concentration in grain was significantly higher (0.28%) in T_{13} (T_4 + 200 kg gypsum ha^{-1}) followed by 0.27 per cent in T_{12} (T_4 + 100 kg gypsum ha^{-1}) when compared to RDF and FYM only (0.17%). However, T_{13} was on par with T_9 (T_2 + 200 kg gypsum ha^{-1}), T_6 (T_1 + 100 kg gypsum ha^{-1}) recorded 0.23 per cent, T_{11} (T_3 + 200 kg gypsum ha^{-1}) and T_{14} (T_5 + 100 kg gypsum ha^{-1}) (0.25%) and T_{15} (T_5 + 200 kg gypsum ha^{-1}) (0.22%). Lowest sulphur content was recorded in T_8 (0.13%) treatment and other treatments are on par with T_1 (0.17%). The sulphur content in straw 0.30 per cent was significantly higher in T_{11} (T_3 + 200 kg gypsum ha^{-1}) when compared to T_1 (0.24%). However T_{11} was on par with other treatments except T_4 (T_1+15 kg borax ha^{-1}), T_5 (T_1+20 kg borax ha^{-1}) and T_{15} (T_5 + 200 kg gypsum ha^{-1}) which recorded 0.25, 0.23 and 0.23 percent, respectively.

Boron content in grain and straw showed a significant difference due to treatments effect (Table 4). The boron concentration in grain was significantly higher (34.38 mg kg^{-1}) in T_5 (T_1+ 20 kg borax ha^{-1}) followed by 32.38 mg kg^{-1} inT_{12} (T_4 + 100 kg gypsum ha^{-1}) when compared to T_1 (20.49 mg kg^{-1}). However, T_{12} was on par with T_{14} (T_5 + 100 kg gypsum ha^{-1}), T_{15} (T_5 + 200 kg gypsum ha^{-1}) and T_4 (T_1+15 kg borax ha^{-1}) (31.34, 31.83 and 31.76 mg kg^{-1}, respectively) and other treatments except in T_6 (21.62 mg kg^{-1}) and T_7 (22.35 mg kg^{-1}) treatments which received T_1+ 100 kg gypsum $ha^{-1}$and T_1+ 200 kg gypsum ha^{-1}.

The boron concentration in straw was significantly higher in T_5 (37.33 mg kg^1) which received T_1+20 kg borax ha^{-1}followed by T_{15} (36.16 mg kg^{-1}) when compared to T_1 (24.95 mg kg^{-1}). However, T_5 was on par with T_{12} (33.36 mg kg^{-1}) and T_4 (32.37 mg kg^{-1}) and other treatments except T_6 (T_1+ 100 kg gypsum ha^{-1}), T_7 (T_1 + 200 kg gypsum ha^{-1}), and T_9 (T_2 + 200 kg gypsum ha^{-1}) (24.48, 25.22 and 25.15mg kg^{-1}, respectively).

Table 4: Calcium, magnesium sulphur and boron content in grain and straw of finger millet as influenced by graded levels of borax and gypsum application

Treatments	Ca (%)		Mg (%)		S (%)		B (mg kg^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1 : RDF+FYM	0.50	0.46	0.23	0.36	0.17	0.24	20.49	24.95
T_2 : T_1 + 5 kg ha^{-1} borax	0.56	0.50	0.25	0.37	0.19	0.27	25.92	30.87
T_3 : T_1 + 10 kg ha^{-1} borax	0.54	0.40	0.23	0.42	0.20	0.26	27.40	31.97
T_4 : T_1 + 15 kg ha^{-1} borax	0.56	0.41	0.27	0.39	0.18	0.25	31.76	32.37
T_5 : T_1 + 20 kg ha^{-1} borax	0.52	0.42	0.25	0.45	0.21	0.23	34.38	37.33
T_6 : T_1 + 100 kg ha^{-1} gypsum	0.54	0.51	0.27	0.29	0.23	0.27	21.62	24.48
T_7 : T_1 + 200 kg ha^{-1} gypsum	0.58	0.59	0.25	0.35	0.19	0.27	22.35	25.22
T_8 : T_2 +100 kg ha^{-1} gypsum	0.52	0.68	0.23	0.28	0.13	0.26	26.90	29.42
T_9 : T_2 + 200 kg ha^{-1} gypsum	0.60	0.67	0.24	0.31	0.23	0.27	24.82	25.15
T_{10}: T_3 + 100 kg ha^{-1} gypsum	0.54	0.68	0.24	0.30	0.14	0.26	30.10	27.33
T_{11}: T_3 + 200 kg ha^{-1} gypsum	0.59	0.71	0.26	0.32	0.25	0.30	29.04	31.37
T_{12}: T_4 +100 kg ha^{-1} gypsum	0.63	0.62	0.30	0.43	0.27	0.29	32.38	33.36
T_{13}: T_4 +200 kg ha^{-1} gypsum	0.56	0.69	0.28	0.54	0.28	0.29	28.79	32.87
T_{14}: T_5 + 100 kg ha^{-1} gypsum	0.62	0.64	0.23	0.40	0.25	0.26	31.34	34.68
T_{15}: T_5 + 200 kg ha^{-1} gypsum	0.58	0.70	0.24	0.31	0.22	0.23	31.83	36.16
S.Em±	0.02	0.04	0.01	0.02	0.01	0.01	1.13	1.05
CD (p=0.05)	0.07	0.12	0.03	0.04	0.02	0.02	3.26	3.06

Boron has synergistic effect on Ca uptake by maize crop (Adem *et al,* 2011) [1]. They have reported that increased levels of boron application increased shoot and leaf Ca, Mg, and P concentration. Magnesium concentration in straw (0.54%) and S concentration in grain (0.28%) were significantly higher in T_{13} (T_4 + 200 kg gypsum ha^{-1}). Leandro *et al.* (2014) [17] noticed that yield of Barley increased linearly with gypsum application, indicating no problem with Mg status in the leaves since gypsum is a source of these nutrients. In present study boron content was numerically lesser in treatments where gypsum and borax was applied in combination compared to B alone treated plots. This could be due to higher calcium application to soil through gypsum may reduced B content in finger millet plant. Kanwal *et al*. (2008) [15] have reported that application of excess calcium reduces the boron concentration in shoots and suggested to consider Ca/B ratio for optimization of yields. Similar findings were reported by Murat *et al*. (2009) [27], Tariq and Mott (2007) [35] and Chitralekha *et al* (2012) [6].

Effect of application of graded levels of borax and gypsum on total nutrient uptake by finger millet

NPK uptake

The total uptake of NPK by finger millet as influenced by application of borax and gypsum fertilizers along with RDF and FYM is presented in Fig 2. The total uptake of NPK were significantly higher in T_{12} (166.82, 28.63 and 184.54 kg ha^{-1} respectively) with 15 kg borax ha^{-1} + 100 kg gypsum ha^{-1}+ FYM + RDF when compare to T_1 (126.18, 19.61 and 145.18 kg ha^{-1} respectively) and T_{12} was on par with T_4 (T_1+15 kg borax ha^{-1}) which recorded 155.62, 27.52 and 181.76 kg ha^{-1} respectively.

The higher uptake of nutrients due to application of gypsum and boron may be attributed to improvement in growth. This helped in higher nutrient uptake, (Fig. 4, 5 and 6). Hythum and Nasser (2012) and Soomro *et al.* (2011) have reported higher grain and stover dry matter accumulation due to application of boron.

NPK uptake by the crop was positively influenced by B treatment. The variation in nutrient uptake was influenced by seed yield and nutrient concentration Hossain *et al*. (2011) [12]. Nadaf and Chidanandappa (2015) [29] reported that total uptake of NPK by groundnut was significantly increased due to the application of borax. This may be attributed to the increase in haulm and kernel yield levels due to increased availability of boron in soil. Similar findings were obtained by Adem *et al,* (2011) [1]. boron nutrition has marked effects on proton secretion and creation of an electrical potential gradient across the membranes. Boron supply enhances the activity of membrane bound ATPase and subsequently causes hyperpolarization of plasma membrane by stimulating ion uptake. e.g. K+ uptake). The pumping activity of the membranes with subsequent membrane hyperpolarization, results in an increased driving force for K+ influx (Schon *et al*., 1990).

Secondary nutrients and boron uptake

The total uptake of secondary nutrients and boron as influenced by application of borax and gypsum fertilizers along with RDF and FYM is presented in Fig 3

The Fig 3 indicates that total uptake of calcium was found to be higher in T_{12} (T_4 + 100 kg gypsum ha^{-1}) (67.48 kg ha^{-1}) which was significantly higher than T_1 (43.83 kg ha^{-1}) and it was on par with T_{13} (T_4 + 200 kg gypsum ha^{-1}), T_{14} (T_5+ 100 kg gypsum ha^{-1}), T_{11} (T_3 + 200 kg gypsum ha^{-1}), T_7 (T_1+ 100 kg gypsum ha^{-1}), T_8 (T_2 + 100 kg gypsum ha^{-1}), T_9 (T_2 + 200 kg gypsum ha^{-1}), T_{15} (T_5 + 200 kg gypsum ha^{-1}) and T_{10} (T_3 + 100 kg gypsum ha^{-1}) treatments which recorded 65.51, 61.87, 66.02, 56.22, 59.33, 61.39, 61.74 and 62.93 kg ha^{-1} , respectively. Other treatments were on par with T_1.

The total magnesium uptake was significant between the treatments. Higher total magnesium uptake by grain was observed in T_{13} (46.24 kg ha^{-1}) with 15 kg borax ha^{-1}+ 200 kg gypsum ha^{-1}+ FYM + RDF which was significantly higher than control (27.92 kg ha^{-1}).

Total uptake of sulphur was found to be higher in T_{12} (T_4 + 100 kg gypsum ha^{-1}) (30.91 kg ha^{-1}) which was significantly higher than T_1 (19.08 kg ha^{-1}) and it was on par with other treatments except T_{15} (T_5 + 200 kg gypsum ha^{-1}), T_5 (T_1+ 15 kg borax ha^{-1}), T_8 (T_2 + 100 kg gypsum ha^{-1}) and T_{10} (T_3 + 100 kg gypsum ha^{-1}) (21.54, 21.11, 20.11 and 22.04 kg ha^{-1}, respectively).

The Fig 3 indicated that the boron uptake by finger millet differed significantly due to different levels of borax and gypsum application. Significantly higher total B uptake of 367.03 g ha^{-1} was observed in treatment T_{12} (T_4 + 100 kg gypsum ha^{-1}) compared to T_1 (210.60 g ha^{-1}) and it was on par with all other treatment except T_6 (225.70 g ha^{-1}), T_7 (233.09 g ha^{-1}) and T_9 (238.46 g ha^{-1}).

Secondary nutrients uptake by the crop was positively influenced by B treatment. The variation of nutrient uptake was influenced by seed yield and nutrient concentration (Hossain *et al*. 2011) [12]. Adem *et al.* (2011) [1] have reported that increased levels of boron application increased shoot and leaf Ca concentration. These are in conformity with the results of Kanwal *et al.* (2008) [15] and Murat *et al.* (2009) [27]. Sulphur uptake significantly increased as the levels of gypsum application increased from 100 to 200 kg ha^{-1} with no effect of borax application. This might be due to the additional supply of sulphur through gypsum as supported by increased availability of sulphur in soil and in the grain and straw yield of finger millet. Muhammad *et al.* (2013) [25] have reported that application of gypsum helps plants to attain more sulphur uptake. Similar observations were reported by Caires *et al.* (2004), Muhammad *et al.* (2006) [26], Prystupa *et al.* (2005) and Dechassa *et al*. (2013). The higher uptake of B due to application of borax may be attributed to improvement in growth and yield of finger millet and increased levels of B in soil, which helps in higher B uptake. There was a linear correlation between B content in the soil and B uptake by the plants. Hossain *et al*. (2011) [12] reported that B uptake by the crop was positively influenced by B treatment. Hu and Brown (1994) reported that growth of cells in newly emerging shoot and root tips is one of the basic functions of B in many plants which helps in uptake of nutrients. The variation of nutrient uptake was influenced by seed yield and nutrient concentration. Similar results are obtained by Nadaf and Chidanandappa (2015) [29], Mohamed *et al.* (2015) and Chitralekha *et al.* (1987) [6].

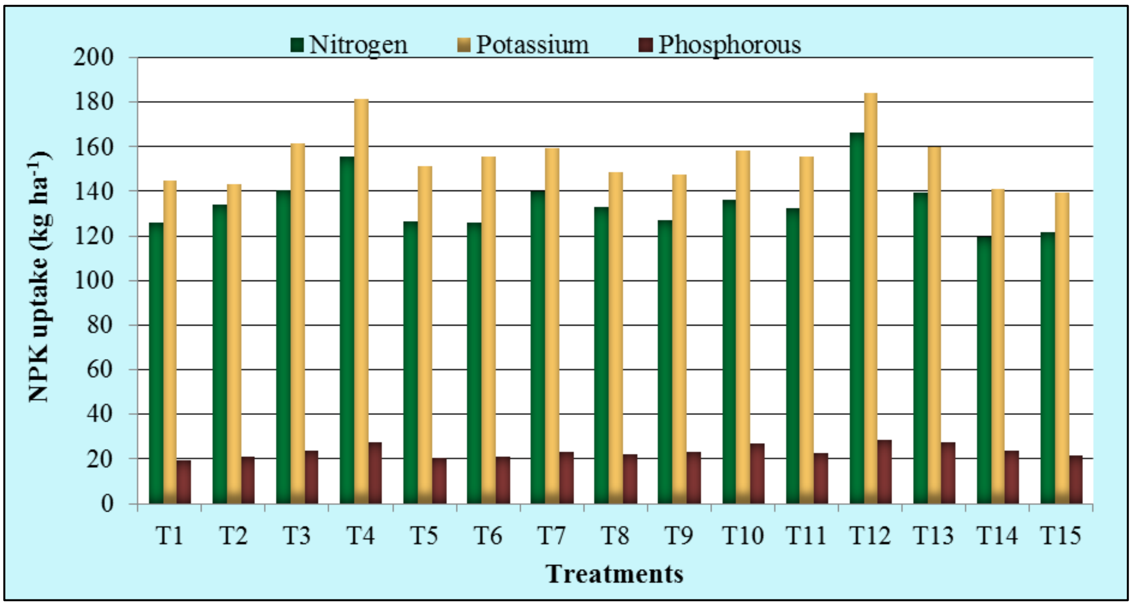


Fig 2: Uptake of N, P and K by finger millet as influenced by graded levels of borax and gypsum application

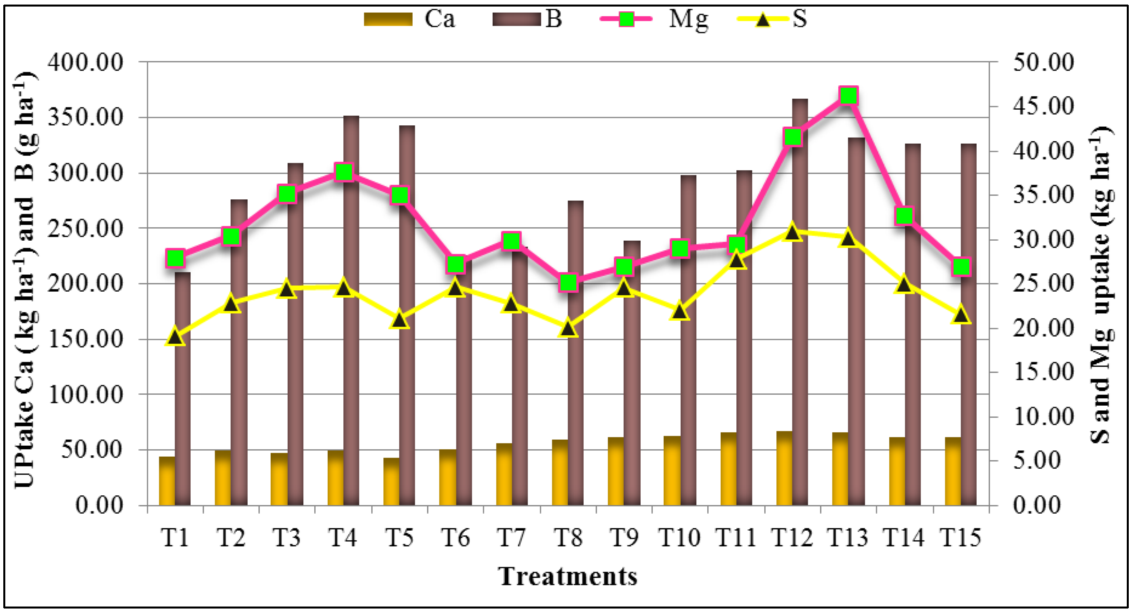


Fig 3: Total uptake of Ca, Mg, S and B in finger millet as influenced by graded levels of borax and gypsum application
Note

Economics of finger millet production

Economics of irrigated finger millet production as influenced by graded levels of borax and gypsum application, analysis was carried out by considering the cost prevailed during the cropping period of 2016 and also by considering the cost of FYM, inorganic fertilizers and plant protection chemicals Table 5. The cost incurred and profits derived are calculated (Appendix-1).

Cost of cultivation

Higher cost of cultivation Rs. 41435.47 ha^{-1} was recorded in T_{15} treatment (T_5 + 200 kg gypsum ha^{-1}) followed by T_{14} (Rs. 41,200.47 ha^{-1}) with T_5 + 100 kg gypsum ha^{-1}. A lowest cost of cultivation was in T_1 (Rs. 37965.47 ha^{-1}) which received only RDF and FYM without borax and gypsum. The other treatments values were intermediate between T_1 and T_{15}.High cost of cultivation in T_{15} mainly due to higher amount of borax and gypsum application and also lower amount of economic yield was recorded.

Gross returns

Among the treatments, application of 15 kg borax ha^{-1} + 100 kg gypsum ha^{-1} + RDF + FYM in T_{12} treatment recorded higher gross returns (Rs. 124610.0 ha^{-1}) because higher economc yield. A lowest gross returns (Rs.1,02,485.00 ha^{-1}) was recorded in treatment T_1 (RDF + FYM).

Table 5: Cost of cultivation, gross returns, net returns and benefit cost ratio as influenced by the graded levels of borax and gypsum application

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1 : RDF+FYM	37965.47	102485	64519.53	2.69
T_2 : T_1 + 5 kg ha^{-1} borax	38715.47	106955	68239.53	2.76
T_3 : T_1 + 10 kg ha^{-1} borax	39465.47	117820	78354.53	2.98
T_4 : T_1 + 15 kg ha^{-1} borax	40215.47	121585	81369.53	3.02
T_5 : T_1 + 20 kg ha^{-1} borax	40965.47	105665	64699.53	2.57
T_6 : T_1 + 100 kg ha^{-1} gypsum	38200.47	108650	70449.53	2.84
T_7 : T_1 + 200 kg ha^{-1} gypsum	38435.47	109470	71034.53	2.84
T_8 : T_2 +100 kg ha^{-1} gypsum	38950.47	109555	70604.53	2.81
T_9 : T_2 + 200 kg ha^{-1} gypsum	39185.47	106060	66874.53	2.70
T_{10}: T_3 + 100 kg ha^{-1} gypsum	39700.47	115980	76279.53	2.92
T_{11}: T_3 + 200 kg ha^{-1} gypsum	39935.47	110100	70164.53	2.75
T_{12}: T_4 +100 kg ha^{-1} gypsum	40450.47	124610	84159.53	3.08
T_{13}: T_4 +200 kg ha^{-1} gypsum	40685.47	117080	76394.53	2.87
T_{14}: T_5 + 100 kg ha^{-1} gypsum	41200.47	111315	70114.53	2.70
T_{15}: T_5 + 200 kg ha^{-1} gypsum	41435.47	107600	66164.53	2.59

Net returns

The higher net return was recorded (Rs.84159.53 ha^{-1}) in treatment T_{12} (T_4 + 100 kg gypsum ha^{-1}) followed by T_4 (Rs. 81369.53 ha^{-1}) which received 15 kg borax ha^{-1} + RDF + FYM. The least net returns was recorded in T_1 (Rs. 64519.53 ha^{-1}) which received only RDF and FYM.

B:C ratio: The benefit cost ratio has been calculated to evaluate the economics of irrigated finger millet production under different treatments imposed. The higher B: C ratio of 3.08 was recorded in treatment T_{12} (T_4 + 100 kg gypsum ha^{-1}) and it was followed by treatment (T_4) received 15 kg borax ha^{-1}+ RDF + FYM (3.02) Whereas the least B:C ratio (2.57) was observed in the treatment (T_5) which received 20 kg borax ha^{-1}+ RDF + FYM followed by T_{15} (2.59) with 20 kg borax ha^{-1}+ 200 kg gypsum ha^{-1} + RDF + FYM. Higher B: C ratio (3.08) observed in T_{12} was due to more grain (45.95 q ha^{-1}) and straw yield (65.42 q ha^{-1}) due to application of 15 kg borax ha^{-1} + 100 kg gypsum ha^{-1} + RDF + FYM. The higher gross and net income was also recorded in the same treatment. This was due to the fact that optimum doses of borax and gypsum, improved vegetative growth and increased number of tillers and ear heads number which resulted in good grain and straw yield. These results are in line with Patil *et al.* (2008) reported that the higher benefit-cost ratio of 1.80 was obtained in tomato with the application of boron when compared to control (1.40). The results are in conformity with Sridhara *et al.* (2003) [33] who reported that maximum benefit-cost ratio was obtained in the treatment consisting of recommended NPK along with azatobacter, zinc sulphate and gypsum (2.48:1) when compared to application of recommended NPK only.

Conclusion

The finger millet yield was increased to 17.56 percent compared to RDF practice in boron deficient soils with a soil treatment of 15 kg borax ha^{-1}, and 100 kg gypsum ha^{-1} together with RDF and FYM. Application of 15 kg ha^{-1} of borax + 100 kg of gypsum ha^{-1}+ RDF + FYM was recorded significantly greater nutrient content and uptake of P, Ca, Mg, S, and B. High levels of borax treatments, i.e. T_5 (T_1+20 kg ha^{-1} borax) and T_{15} (T_5+200 kg ha^{-1} gypsum), recorded substantially greater B levels in plants at flowering and harvest stage compared to control. Treatment T_{12} (T_1+ 15 kg borax ha^{-1} + 100 kg gypsum ha^{-1}) had the highest gross and net yields, with a B: C ratio of 3.08. As a result of these findings, it is possible to conclude that applying 15 kg borax ha-1 + 100 kg gypsum ha-1 + RDF + FYM is the optimum dose for increasing yield levels of irrigated finger millet grown in low B soils, and that higher levels of gypsum application reduce boron uptake due to the antagonistic effect of calcium and boron.

References

1. Adem G, Nizamettin A, Aslihan E, Oguzha N, Sinan A, Metin T. Yield and chemical composition of corn (*Zea mays* L.) as affected by boron management. Int. J Pl. Animal. Environ. Sci. 2011;1(1):42-53.
2. Anonymous. Micronutrient management for enhancing the productivity of finger millet-pulse-oil based productivity system for Alfisols of Karnataka. Annual report of micronutrient project 2006-07, All India Coordinated Research Project for Dry land Agriculture, University of Agricultural Sciences, Bangalore, 2007, 39-52.

3. Arya VS, Balraj D, Balwan S, Anoop S. Effect of boron in irrigation of different EC and SAR levels on yield and its concentration in wheat grain and straw. Haryana J Agron. 2009;25(1/2):39-42.
4. Black CA. Method of Soil Analysis part II Agronomy monograph No, 9, American Society of Agronomy, Madison, Wisconsin, 1965, 148.
5. Caires EF, Kusman MT, Barth G, Garbuio FJ, Padilh JM. Changes in soil chemical properties and corn response to lime and gypsum applications. Rev. Bras. Cienc. Solo. 2004;28:125-136.
6. Chitralekha C, Pratima S, Nirmala N, Shirish CA, Chandra PS. Metabolic changes associated with boron-calcium interaction in maize. Soil Sci. Pl. Nutr. 1987;33(4):607-617.
7. Cox FR, Reid PH. Calcium-boron nutrition as related to concealed damage in peanuts. Agron. J. 1964;56:173-176.
8. Dechassa H, Hunshal CS, Hiremath SM, Awaknavar JS, Wali MC, Nadagouda BT. Performance of maize (*Zea mays* L.) hybrids as influenced by different levels of nitrogen, phosphorus, potassium and sulphur application. Karnataka J Agric. Sci. 2013;26(2):194-199.
9. Easterwood GW. Calcium's role in plant nutrition. J Fluid. 2002;10:16-19.
10. Goldberg S, Forster HS. Boron sorption on calcareous soils and reference calcites. Soil Sci. 1991;152:304-310.
11. Gomez KA, Gomez AA. Statistical procedures for Agric. Res. 2nd Ed. John Wiley & Sons, New York, 1984.
12. Hossain MA, Jahiruddin M, Khatun F. Effect of boron on yield and mineral nutrition of mustard (*Brassica napus*). Bangladesh. J Agril. Res. 2011;36(1):63-73.
13. Hu H, Brown PH. Localisation of boron in the cell wall and its association with pectin. Evidence of a structural role of boron in the cell wall. Plant Physiol. 1994;105:681-689.
14. Jackson ML. Soil chemical Analysis. Prentice Hall India Pvt. Ltd., New Delhi, 1973.
15. Kanwal S, Rahmatullah Aziz T, Maqsood MA, Abbas N. Critical ratio of calcium and boron in maize shoot for optimum growth. J Pl. Nutri. 2008;31:1535-1542.
16. Keren R, Ben-Hur M. Interaction effects of clay swelling and dispersion and $CaCO_3$ content on saturated hydraulic conductivity. Aus. J Soil Res. 2003;41:979- 989.
17. Leandro M, Marcelo MLM, José SSF, Jackson K, Ronaldo DN, Luiz FMK. Soil fertility, nutrition and yield of maize and barley with gypsum application on soil surface in no-til. R. Bras. Ci. Solo. 2014;38:1496-1505.
18. Lehto T, Malkonen E. Effects of liming and boron fertilization on boron uptake of Picea abies. Plant Soil. 1994;163:55-64.
19. Lopez-Lefebre, Rivero Garci´ A, Sanchez PC, Ruiz EJM. Romero L. Boron effect on mineral nutrients of tobacco. J Pl. Nutr. 2002;25(3):509–522.
20. Lovatt CJ, Bates LM. Early effects of excess boron on photosynthesis and growth of Cucurbita pepo. J Exp. Bot. 1984;35:297-305.
21. Matoh T, Ishigaki KI, Mizutani M, Matsunaga W, Takabe K. Boron nutrition of cultured tobacco BY-2 cells: I. Requirement for and intracellular localization of boron and selection of cells that tolerate low levels of boron. Plant and cell physiology. 1992;33(8):1135-1141.
22. Mengel K, Kirkby EA. Boron. In: Principles of Plant Nutrition. 5th Edition, Kluwer Academic Publishers. Dordrecht/ Boston/ London, Netherlands. 2001, 621-638.
23. Mishra SS, Gulati JML, Nanda SS, Garnayk LM, Jana SN. Micronutrient studies in wheat. Orissa J Agri. Res. 1989;22(2):94-96.
24. Mohamed SH, Subbarayappa CT, Sarala Kumari J. Effect of graded levels of boron on growth and yield attributes of Maize in calcareous Soils. Trends in Biosciences. 2015;8(13):3291-3296.
25. Muhammad A, Syed IH, Arshad A, Imdad AM. Cumulative effect of sulphur and calcium on wheat growth and yield under saline-sodic soils. Pakistan J Agri. Res. 2013;26(1):46-53.
26. Muhammad JK, Muhammad HK, Riaz AK, Muhammad TJ. Response of maize to different levels of sulphur. Soil Sci. Pl. Analysis. 2006;37(1-2):41-52.
27. Murat AT, Nilgun T, Süleyman T. Effect of calcium on the alleviation of boron toxicity and localization of boron and calcium in cell wall of wheat. Not. Bot. Hort. Agrobot. 2009;37(2):99-103.
28. Nable RO, Ba˜Nuelos GS, Paull JG. Boron toxicity. Pl. Soil. 1997;193:181-198.
29. Nadaf SA, Chidanandappa HM. Content and uptake of macronutrients by groundnut (*Arachis hypogaea* L.) as influenced by soil application of zinc and boron in sandy loam soils of Karnataka, India. Leg. Res. 2015;38(3):363-366.
30. Page AL, Miller RH, Kenay DR. Methods of soil analysis part-2 soil science of America. Inc. Pubis. Madison, Wisconsin, USA, 1982.
31. Prystupa P, Flavio H, Gutierrez B, Fernando S, Gustavo F, Lucrecia C. Measuring corn response to fertilization in the northern Pampas. Better Crops Int. 2005;90:12-13.
32. Ramachandrappa BK, Sathish A, Dhanapal GN, Srikanth Babu PN. Nutrient management strategies for enhancing productivity of dry land crops in Alfisols. Indian J Dryl. Agric. Res & Dev. 2014;29(2):49-55.
33. Sridhara CJ, Narayan SM, Krishna NS. Yield maximization in ragi under rainfed condition. Karnataka J Agric. Sci. 2003;16(2):220-222.
34. Tahir M, Tanveer A, Tajamal HS, Naeem F, Allah W. Yield response of wheat (*Triticum aestivum* L.) to boron application at different growth stages. Pakistan J life soc. Sci. 2009;7(1):39-42.
35. Tariq M, Mott CJB. Effect of boron on the behaviour of nutrients in soil-plant systems. Asian J Pl. Sci. 2006;6:195-202.

Appendix-I

Cost of Inputs and Prices of Output

Particulars	Quantity	Per unit cost	Cost (Rs)
Variable cost			
Human labour (Mandays)	67	175	11725
Bullock labour (Inter cultivation, earthing up)	4	600	2400
Machine labour (hours)	10	600	6000
Seed (kgs)	8	30	240
FYM (tons)	10	750	7500
Fertilizer cost			
A. urea	5.75	217.5	1250.62
B, SSP	7.39	312.5	2309.37
MOP	15.74	83.33	1311.14
Gypsum	2.35	-	-
Borax	150	-	-
Herbicide (Londax powder)	8	891(4kg bag)	1782
Interest on working capital @ 10 per cent	-	-	3447.34
Total variable cost	-	-	37965.47
Returns per product			
Grain yield	1 q	2000	
Straw	1 q	500	
Total			

Appendix-II

Calendar of operations during growth period of finger millet

Sl. No.	Date	Particulars
1	12-07-2016	Sowing in nursery
2	17-07-2016	FYM application and land levelling
3	01-08-2016	Layout of the experiment
4	03-08-2016	Soil apllication of borax and gypsum along with full dose of P_2O_5, K_2O and half dose of N during transplanting of seedlings.
5	05-08-2016	Pre emergence herbicide Londax power is applied at 4kg/ acre .
6	03-09-2016	Weeding and intercultivation along with application of remaining dose of N.
7	02-11-2016	Harvesting.