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Effect of graded levels of borax and gypsum on growth and yield attributes of irrigated finger millet (*Eleusine Corocana* L.) in southern dry zone of Karnataka

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Abstract
A field experiment was conducted during *Kharif* 2016 on sandy loam soil deficient in Boron at College of Agriculture, V. C. Farm, Mandya to study the effect of graded levels of borax and gypsum on growth and yield attributes of irrigated finger millet (*Eleusine corocana* L.) in Southern Dry Zone of Karnataka. The experiment was laid out in RCBD with fifteen treatments including four levels of borax (5, 10, 15 and 20 kg ha^{-1}), two levels of gypsum (100 and 200 kg ha^{-1}) and their combination along with RDF + FYM and replicated thrice. Results revealed that growth and yield parameters *viz.,* plant height, number of tillers per hill, leaf area index, number of ear heads per meter square and number of fingers per ear head (94.37cm, 6.18, 4.82, 310.67 and 7.61, respectively) were recorded higher in treatment 15 kg borax ha^{-1} +100 kg gypsum ha^{-1} + RDF + FYM (T_{12}) over RDF + FYM (T_1) (80.38cm, 4.93, 3.32, 241.67 and 6.05, respectively). Significantly higher grain yield of 45.95 q ha^{-1} (17.56% higher over control) and B:C ratio of 3.06 was also recorded in T_{12} when compared to RDF + FYM (T_1). 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)

Keywords: *Eleusine Corocana*, Karnataka, borax and gypsum

1. Introduction

Finger millet (*Eleusine coracana* (L.) Gaertn.) ranks third in importance among millets in the country in both area (1.38 million ha) and production (2.03 million tonnes). Karnataka state shares 60.8 per cent of the area and two third of its production (68.4%). (Anon., 2007) [1]. Finger millet is the main dietary component in Southern Karnataka particularly in districts of Bangalore rural, Tumkur, Mysore, Hassan, Mandya and Chitradurga. Further, finger millet is also an ideal food for patients suffering from diabetes. It has a high amount of calcium (0.38%), protein (6-8%), fibre (18%), phenolic compounds (0.3-3%), and sulphur containing amino acids.

Calcium is a major cation in middle lamella of cellwall, 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) [4]. Boron plays an important role in growth and nutrition of the crop plants and it promotes cell division, cell elongation, cell wall strength, flowering, pollination, seed set and sugar translocation. Calcium boron play a pivotal role in increasing the yields of cereals, but combined application of boron with calcium can affect the availability and utilisation of boron by plants (Kanwal *et al.* 2008).

Recent studies have reported an antagonistic relationship between boron (B^+) and calcium (Ca^{2+}) concentration at plant-soil interface. An enhanced boron deficiency symptom in plants by increased calcium supply has been reported. Similarly, boron deficiency altered calcium translocation to the shoot and fruit. It indicates the requirement of a balanced supply of calcium and boron for normal growth and development of plants.

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 millet also 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 growth and yield attributes of irrigated finger millet (*Eleusine corocana* L.) in Southern Dry Zone of Karnataka".

2. Material and methods

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 12^0 32' N latitude and 76^0 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 Table 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 2.

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. Seedlings of twenty two days age were transplanted by maintaining 20 cm space between two rows and 10 cm between two hills. 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

The growth parameters like plant height (cm), number of leaves per hill, number of tillers per hill, leaf area and yield parameters like number of ear heads per square metre, number of fingers per ear head, test weight, grain yield and straw yield were recorded at 30 and 60 days after transplanting.

Table 1: Meteorological data indicating mean monthly normal, actual and deviation of weather parameters for the experimental period (2016) at College of Agriculture, V. C. Farm, Mandya

Month	Rainfall (mm)			Relative humidity (%)						Mean air temperature (°C)						Mean daily sunshine hours		
				Maximum			Minimum			Maximum			Minimum					
	N	A	D	N	A	D	N	A	D	N	A	D	N	A	D	N	A	D
July	56.3	65.6	-9.3	87.0	87.1	-0.1	29.8	63.0	-33.2	20.1	30.9	-10.8	18.5	20.7	-2.2	6.5	4.6	1.9
August	75.9	104.1	-28.2	88.1	92.3	4-.2	53.1	55.6	-2.5	29.5	32.2	-2.7	19.8	20.3	-0.5	4.8	5.3	-0.5
September	153.7	68.2	85.5	88.1	91.9	-3.8	54.2	60.5	-6.3	29.6	33.3	-3.7	19.8	19.1	0.7	5.0	2.5	2.5
October	149.8	65.0	84.8	89.9	86.2	3.7	58.9	54.6	4.3	29.4	34.5	-5.1	19.3	17.3	2.0	5.1	6.7	-1.6
November	55.7	4.4	51.3	83.3	89.0	-5.7	43.2	42.8	0.4	29.1	31.9	-2.8	17.1	15.8	1.3	5.9	8.8	-2.9

Note: N= Normal (1973 to 2015), A = Actual, D = Deviation

Table 2: Physico - chemical properties of soil at the experimental site

S. No	Soil property	Value
1.	Particle size analysis	
	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
3.	Electrical conductivity (dSm^{-1})	0.13
4.	Organic carbon (g kg^{-1})	3.90
5.	Available nitrogen (kg ha^{-1})	175.6
6.	Available phosphorus (kg ha^{-1})	25.25
7.	Available potassium (kg ha^{-1})	231.16
8.	Exchangeable calcium (cmol kg^{-1})	5.70
9.	Exchangeable magnesium (cmol kg^{-1})	2.40
10.	Available sulphur (mg kg^{-1})	8.50
11.	Available boron (mg kg^{-1})	0.28

After measuring leaf area of individual leaves, leaf area index per hill was worked out using fallowing relation.

LAI= (length x width x correction factor (CF=0.75) x number of leaves $hill^{-1}$)/(land area or spacing)

3. Results and Discussion

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°C was recorded in the month of October and the minimum air temperature of 19.3°C 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) (Table. 1).

Average data of five plants on growth and yield parameters of finger millet viz., plant height, number of leaves per hill, number of tillers per hill, leaf area index, number of ear heads per square meter, number of fingers per ear head, 1000 grain weight as influenced by different levels of borax and gypsum under low boron soils are presented below.

3.1 Growth parameters

The data on plant height (cm), number of leaves per hill, number of tillers per hill, leaf area index of finger millet as influenced by different levels of borax and gypsum at different growth stages are presented in Table 3. The growth parameters differed significantly at all the growth stages with different treatments. Growth parameters increased progressively with increase in age of the crop up to 60 days after transplanting and thereafter increase was not much.

Significantly higher plant height, number of leaves per hill, number of tillers per hill, leaf area index recorded in T_{12} (94.37 cm, 39.70, 6.18 and 4.82 respectively) which received 15 kg ha^{-1} borax + 100 kg ha^{-1} gypsum + RDF + FYM compared to RDF + FYM (T_1) applied treatment (80.38 cm, 28.92, 4.93, 3.32, respectively) at 60 DAT. However, it was on par with T_4 (T_1 + 15 kg borax ha^{-1}), T_3 (T_1 + 10 kg borax ha^{-1}), T_{13} (T_4+ 200 kg gypsum ha^{-1}), T_{11} (T3 + 200 kg gypsum ha^{-1}) and T_{10} (T_3 + 100 kg gypsum ha^{-1}). The other treatments recorded non significantly higher values when compared to control.

3.2 Yield parameters

The yield parameters differed significantly with different treatments except test weight as influenced by gypsum and borax application were presented in Table 4. 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. 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.

Table 3: Influence of graded levels of borax and gypsum at different stages of growth parameters in irrigated finger millet

Treatments	Plant height (cm)		Number of leaves $hill^{-1}$		No. of tillers per hill		LAI	
	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT
T_1 : RDF+FYM	52.01	80.38	24.25	28.92	3.50	4.93	2.70	3.32
T_2 : T_1 + 5 kg ha^{-1} borax	56.82	86.27	28.07	33.35	3.70	5.64	3.63	4.25
T_3 : T_1 + 10 kg ha^{-1} borax	62.47	90.12	32.33	37.51	4.34	5.87	4.11	4.61
T_4 : T_1 + 15 kg ha^{-1} borax	64.33	93.74	34.20	39.32	4.46	6.09	4.30	4.75
T_5 : T_1 + 20 kg ha^{-1} borax	52.15	79.55	24.61	30.06	3.14	4.87	3.00	3.64
T_6 : T_1 + 100 kg ha^{-1} gypsum	60.31	84.39	26.75	33.53	3.61	5.18	3.22	3.72
T_7 : T_1 + 200 kg ha^{-1} gypsum	60.70	86.10	27.77	34.38	3.71	5.28	3.16	3.97
T_8 : T_2 +100 kg ha^{-1} gypsum	56.69	86.54	26.59	32.89	4.11	5.61	3.58	4.24
T_9 : T_2 + 200 kg ha^{-1} gypsum	55.55	85.70	25.68	31.97	3.90	5.52	3.45	4.18
T_{10}: T_3 + 100 kg ha^{-1} gypsum	64.47	90.19	31.08	36.56	4.31	5.82	4.11	4.64
T_{11}: T_3 + 200 kg ha^{-1} gypsum	63.25	88.62	28.95	34.75	4.02	5.58	3.93	4.57
T_{12}: T_4 +100 kg ha^{-1} gypsum	66.06	94.37	34.38	39.70	4.57	6.18	4.45	4.82
T_{13}: T_4 +200 kg ha^{-1} gypsum	63.42	92.51	30.99	37.52	4.32	5.94	4.06	4.68
T_{14}: T_5 + 100 kg ha^{-1} gypsum	53.95	82.16	26.78	30.32	4.03	5.42	3.38	4.12
T_{15}: T_5 + 200 kg ha^{-1} gypsum	53.61	81.46	24.75	29.71	3.87	5.10	3.37	3.51
S.Em±	3.34	3.30	2.34	2.42	0.24	0.24	0.35	0.33
CD (p=0.05)	9.67	9.57	6.77	7.01	0.69	0.71	1.03	0.95

Table 4: Influence of graded levels of borax and gypsum at different stages of yield parameters in irrigated finger millet

Treatments	No. of fingers per ear head	No. of ear heads per m^2	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	B:C ratio
T_1 : RDF + FYM	6.05	241.67	2.47	37.88	53.45	2.69
T_2 : T_1 + 5 kg ha^{-1} borax	6.53	275.67	2.44	39.41	56.27	2.76
T_3 : T_1 + 10 kg ha^{-1} borax	7.40	288.00	2.52	43.24	62.68	2.98
T_4 : T_1 + 15 kg ha^{-1} borax	7.47	303.17	2.52	44.58	64.85	3.02
T_5 : T_1 + 20 kg ha^{-1} borax	6.27	246.67	2.51	38.81	56.09	2.57
T_6 : T_1 + 100 kg ha^{-1} gypsum	6.33	258.83	2.46	40.24	56.34	2.84
T_7 : T_1 + 200 kg ha^{-1} gypsum	6.43	263.86	2.49	40.62	56.46	2.84
T_8 : T_2 +100 kg ha^{-1} gypsum	6.63	275.83	2.56	40.67	56.43	2.81
T_9 : T_2 + 200 kg ha^{-1} gypsum	6.47	267.33	2.50	38.93	56.40	2.7
T_{10}: T_3 + 100 kg ha^{-1} gypsum	7.17	291.17	2.52	42.45	62.16	2.92
T_{11}: T_3 + 200 kg ha^{-1} gypsum	7.05	280.17	2.50	40.33	58.88	2.75
T_{12}: T_4 +100 kg ha^{-1} gypsum	7.61	310.67	2.51	45.95	65.42	3.08
T_{13}: T_4 +200 kg ha^{-1} gypsum	7.30	290.67	2.49	42.90	62.56	2.87
T_{14}: T_5 + 100 kg ha^{-1} gypsum	6.95	271.17	2.54	41.36	57.19	2.7
T_{15}: T_5 + 200 kg ha^{-1} gypsum	6.82	255.00	2.38	39.97	55.32	2.59
S.Em±	0.32	13.83	0.10	1.55	2.64	-
CD (p=0.05)	0.92	40.06	NS	4.50	7.64	-

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).

The growth and yield parameters recorded higher in T_{12} (T_4 + 100 kg ha^{-1} gypsum) and T_4 (T_1 + 15 kg ha^{-1} Borax) treatments due to boron application which might have resulted in enhanced carbohydrate metabolism, sugar transport, cell wall structure, protein metabolism, root growth and stimulated other physiological processes of plant. These results are corroborated with findings of Ramachandrappa *et al.* (2014) [8], Ashour and Reda, (1972) [2]. This is in conformity with the results of Soomro *et al.* (2011) [9] who have reported that application of boron with NPK fertilizers recorded highest plant height, thicker stem girth and Tahir *et al*. (2012) [11] also reported that application of boron increased plant height, leaf area and stem diameter and sufficient calcium increases thickness of stem and rapid plant growth (Easterwood, 2002) [4].

Significant increase in grain yield in T_{12} was due to more number of tillers per hill, ear heads per square meter and number of fingers per ear head. Finger millet has considerable capacity to produce more number of tillers per hill under optimum borax and gypsum fertilization specially in low B soils. Grain yield increase may be due to the reason that the application of boron which has enhanced pollen tube germination and grain setting. Boron requirement in the anthers for successful fertilization was met by application of boron at booting stage and the grain yield was higher than control (Tahir *et al.* 2009). Similar results were obtained by Mishra *et al*. (1989) [6] and Ramachandrappa *et al.* (2014) [8]. Chitralekha *et al.* (1987) [3] also have 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 good response.

All growth and yield parameters, grain yield, straw yield were significantly reduced in T_5 treatment which received 20 kg borax ha^{-1} along with recommended NPK and FYM which might be attributed to the negative effect of excess B application on plant growth. (Lovatt and Bates 1984: Nable *et. al*. 1997) [5, 7] have reported that excess B resulted in reduced vigour, stunted plant growth, delayed development, decreased number, size and weight of fruits and discoloration of leaves. But in the present study treatments T_{14} and T_{15} which received 20 kg borax ha^{-1} along with 100 kg gypsum ha^{-1} and 200 kg gypsum ha^{-1} respectively, decrease in yield due to boron toxicity is less when compared to application of 20 kg borax ha^{-1} alone because plants can tolerate higher amount of boron without any toxic effect if they have adequate supply of calcium (Chitralekha *et al*. 1987) [3].

3.3 B:C ratio

The benefit cost ratio has been calculated to evaluate the economics of irrigated finger millet production under different treatments imposed (Table 4). 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

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. The results are in conformity with Sridhara *et al*. (2003) [10] 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.

4. Conclusion

Boron is unique among the essential elements in that a narrow range in concentration can mean the difference between plant deficiency and plant toxicity. Soil application of 15 kg borax ha^{-1} and 100 kg gypsum ha^{-1} along with RDF + FYM increased the finger millet yield by 17.56 per cent more when compared to RDF practices in boron deficient soil with a B: C ratio of 3.08. There is need to supply Ca and B in optimum quantity for normal growth and development of finger millet for getting higher yield.

5. References

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