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Comparative Efficiency of Soil and Foliar Application of Boron on Growth and Yield of Finger Millet (*Eleusine coracana*)

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Abstract

Field experiments were conducted at AICRP for Dryland Agriculture, University of Agricultural Sciences, GKVK, Bengaluru for three seasons to study the efficiency of boron as foliar spray and soil application on performance of finger millet. In the present investigation, the average yield of finger millet over three years revealed that foliar application of boron @ 0.5 kg ha^{-1} recorded significantly higher grain yield (3498 kg ha^{-1}) and straw yield (4640 kg ha^{-1}) as compared to control (3083 kg ha^{-1}, 4118 kg ha^{-1}, respectively) and it was on par with soil application of boron @ 0.5 kg ha^{-1} (3466 and 4529 kg ha^{-1}). The per cent increase in yield was 13.4 per cent with foliar application of boron @ 0.5 kg ha^{-1} as compared to control. The higher benefit cost ratio (1.46) as well as higher uptake of micronutrients (142, 2680 and 87 g ha^{-1} of Zn, Fe and B, respectively) was observed with the soil application of boron @ 1 kg ha^{-1}.

Keywords: Efficiency boron, finger millet and foliar application

Finger millet (*Eleusine coracana* L. Gaertn.) is the third most important millet crop in India, next to sorghum (*Sorghum bicolor* L.) and pearl millet (*Pennisetum glaucum* L.). It is grown on 1.27 million hectares (M ha) with an annual production of 1.89 million tons. It is an important crop of drought-prone regions because of its outstanding ability to withstand adverse weather conditions and grow in marginal and poor soils. The most striking feature, which made finger millet an important dry land crop, is its resilience and ability to withstand adverse weather conditions when grown in soils having poor water holding capacity. Integrated nutrient management is the maintenance of soil fertility and supply of plant nutrients at an optimum level for sustenance of desired crop production as well as minimizes nutrient losses to the environment (Singh and Balasubraman, 1986). Soil productivity declines through leaching, erosion and crop harvest. These losses are even exacerbated by tropical rainfall and anthropogenic forces. Unless the soil nutrients are replenished through use of organic wastes, crop residues, fallow and reconstruction of soil organic matter, soil fertility loss would continue unabated (Donova and Crassey, 1998). Intensification of use of mineral fertilizer has been reported to cause soil acidity and environmental health hazard. This situation renders use of inorganic fertilizer in sustainable soil productivity counterproductive.

Boron plays an important role in the physiological process of plants, such as cell elongation, cell maturation, meristematic tissue development and protein synthesis (Mengel and Kirkby, 1982). The need for B application in finger millet is to increase the growth, development and yield of crop. The application of boron also promotes the absorption of nitrogen from soil and increases the plant height and dry weight (Jing *et al*., 1994). The information on boron nutrition on finger millet in Karnataka is meagre. Therefore, the present investigation was aimed to study the effect of graded doses of boron on the growth and yield of finger millet, which is an important staple food crop of Eastern Dry Zone of Karnataka. Although various studies have been carried out in isolation, a comprehensive repeated experiment in different regions of Karnataka are necessary to assess the accurate response.

Material and Methods

A field experiment was conducted at AICRP for Dryland Agricultural Project, University of Agricultural Sciences, GKVK, Bengaluru for 3 years during *kharif* seasons to study the efficiency of boron both as foliar spray and soil application on growth and yield of finger millet. The Centre is located at 77^0 39’ 22.1” East longitude, 13^0 05’13.0” N latitude and 929 MSL altitude. The experimental area receives an average annual rainfall of 929.9 mm. Pre monsoon thunder showers are received right from February and terminated during May-June. The monsoon sets in two peaks, one during the month of May (100.8 mm) and other peek at September (211.9 mm). April (33.8^{0}C) is the hot month, while January (13.9^{0}C) is the coldest month of the year. It was 37 rainy days during second year while 19 rainy days in first year. The rainfall was very poor during cropping period. During the early 60 days, there was very scanty rainfall and the total rainfall during crop growth period was 293 mm. This was mainly responsible for lower productivity during first year. During second year, the rainfall distribution was optimum. The experiments were laid out in RCBD with three replications in a red sandy loam soil with pH 6.25, low in available nitrogen (250 kg ha^{-1}), low in available phosphorus (9 kg ha^{-1}) and medium in available potassium (160 kg ha^{-1}) with deficient in zinc (0.33 ppm) and boron (0.16 ppm). The treatments comprised of 2 methods of boron application (soil and foliar) at 3 levels (0.5, 1.0 and 2.0 kg ha^{-1}) along with a control (only RDF). The micronutrient boron in the form of borax (H_2BO_3) was applied basally at the time of sowing in soil application and sprayed on foliage at tillering stage. In addition to recommended dose of fertilizers (50:40:25 kg ha^{-1}) and FYM. At maturity, grain yield, straw yield, 1000 seed weight, ear head length and number of fingers / ear head were recorded by adopting the standard procedure. The soil samples were collected after the harvest of crops and analyzed for pH, EC, OC, available N, P, K and micronutrients. The soil pH was determined in 1:2.5 soil: water suspension by potentiometric method using glass electrode (Jackson, 1973). Electrical conductivity (1:2.5 soil-water extract) was determined using conductivity bridge and expressed as dSm^{-1} (Jackson, 1973). The soil organic carbon of a soil finely ground and sieved through 0.2 mm was determined by Walkely and Black wet-oxidation method as described by Jackson (1973), Available nitrogen was determined by macro distillation following alkaline permanganate method as suggested by Subbaiah and Asija (1956), Available phosphorus was determined by using a spectrophotometer (Jackson, 1973), available potassium was determined by flame photometer as described by Page *et al.*, (1982) and available micronutrients in soils was determined with DTPA extractant as described by Lindsay and Norwell (1978) and estimated using Atomic Absorption Spectrometer (AAS).

Results and Discussion

Significantly higher grain (2242 kg ha^{-1}) and straw yield (3544 kg ha^{-1}) were recorded with foliar application of NPK+ boron @0.5 kg ha^{-1} as compared to control. It is followed by soil application of NPK+ boron @0.5 kg ha^{-1} (Table-1). The significant effect that B had on seed yield indicates that B plays an important role in seed formation. Foliar application of boron can have a direct effect on seed yield. Since boron is immobile, it will require during flowering and seed development stage from direct uptake through roots (Brown and Shelp, 1997).

During second year of the experimentation, significantly higher grain yield (4242 kg ha^{-1}) and straw yield (5433 kg ha^{-1}) were recorded in foliar spray of boron @ 0.5 kg ha^{-1} as compared to control [grain yield (3775 kg ha^{-1}) and straw yield (4829 kg ha^{-1}]. Similarly, higher grain and straw yield were recorded in the treatment receiving soil application of boron @0.5 kg ha^{-1} (4172 and 5258 kg ha^{-1}). However, it was found on par with soil application of boron @ 0.5 kg ha^{-1} and foliar spray of boron @ 1 kg ha^{-1}. The results clearly indicated that the application of boron @ 0.5 kg ha^{-1} either as through soil and foliar of same level did not vary significantly. Also higher doses of boron application either through soil or foliar decreases the yield attributes and yields of finger millet. The 1000 seed weight and number of fingers recorded with the same level of boron either through foliar or soil was on par with each other and they differ over other treatments.

During third year of experimentation, the effect of boron application on grain yield, straw yield, ear head length and number of finger millet per head were found to be significant except for 1000 seed weight. Significantly higher grain yield (4184 kg ha^{-1}), straw yield (5244 kg ha^{-1}) and benefit cost ratio (1.46) was recorded in the treatment receiving soil application of boron @ 1 kg ha^{-1} as compared to control (3683 and 4711 kg ha^{-1}) and it was on par with foliar application boron @ 1 kg ha^{-1} (4122 and 5183 kg ha^{-1}) or boron @ 2 kg ha^{-1} (3970 and 4835 kg ha^{-1}) and soil application of boron @ 0.5 kg ha^{-1} (4054 and 4975 kg ha^{-1}). The 1000 seed weight and number of fingers recorded with

TABLE I

Influence of Boron application on grain and straw yield (Kg Ha^{-1}) and B:C ratio of finger millet over three years

Treatments	Grain yield				Straw yield				B:C Ratio		
	Ist Year	IInd Year	IIIrd Year	Pooled	Ist Year	IInd Year	IIIrd Year	Pooled	Ist Year	IInd Year	IIIrd Year
Control (No boron application)	1793	3775	3682	3083	2816	4829	4711	4118	-0.04	0.95	1.21
Boron @0.5 kg ha^{-1} (soil application)	2171	4172	4054	3466	3356	5258	4975	4529	0.15	1.13	1.40
Boron @1.00 kg ha^{-1} (soil application)	2041	4032	4184	3419	3243	4998	5224	4495	0.08	1.03	1.46
Boron @ 2.00 kg ha^{-1} (soil application)	1916	3905	3864	3228	3083	4835	4743	4220	0.00	0.93	1.23
Boron @0.5 kg ha^{-1} (Foliar spray)	2242	4242	4012	3498	3544	5433	4943	4640	0.19	1.17	1.38
Boron @1.00 kg ha^{-1} (Foliar spray)	2018	4085	4122	3429	3289	5181	5183	4551	0.10	1.07	1.43
Boron @ 2.00 kg ha^{-1} (Foliar spray)	1966	3970	3916	3284	3136	4905	4813	4285	0.02	0.96	1.26
S. Em.±	55.2	51.5	68.2	40.2	72.9	31.2	96.2	76.3	-	-	-
C.D at 5%	170.1	158.8	210.2	123.7	224.7	96.2	296.5	235.1	NS	NS	NS

the same level of boron application @ 1 kg ha^{-1} either through foliar or soil was on par with each other and they differ over other treatments.

The effect of boron application on average grain and straw yield, 1000 seed weight, ear head length and number of fingers per head was found significant over three years. Second year was a good year in relation to weather. First year was a drought year and recorded lower yield and yield attributes in all the treatments. Over the years, higher grain yield (4242 kg ha^{-1}) was recorded during second year (Table-I) with the foliar application of boron @ 0.5 kg ha^{-1} and lower with NPK only (1793 kg ha^{-1}). This may be due to variation in the rainfall received during crop growth period. Better moisture availability associated with good rainfall hastened the root growth, nutrient absorption and biomass production (Basaveshwari *et al.*, 2008). Because of the congenial environment, the productivity was maximum during second and third year of the experimentation. These results are in conformity with Govinda Bhandari, 2013.

Significantly higher pooled (over 3 years) grain yield (3498 kg ha^{-1}), straw yield (4640 kg ha^{-1}), 1000 gain weight (2.78 g), ear head length (7.53 cm) and number of fingers per head (6.63) was noticed in foliar application of boron @ 0.5 kg ha^{-1}as compared to control (3083 and 4118 kg ha^{-1}, 2.29 g, 6.29 cm and 5.21, respectively) and it was on par with soil application of boron @ 0.5 kg ha^{-1} (3466 and 4529 kg ha^{-1}, 2.72g, 7.55 cm and 6.60) and foliar spray of boron @ 1 kg ha^{-1} (3429 and 4551 kg ha^{-1}, 2.75g, 7.6 cm and 6.60) (Table- I and II). Significantly lower grain yield (3083 kg ha^{-1}) with control *i.e.,* without boron application might be associated with poor pollination due to lower pollens exertion. While, boron treated plots noticed higher yield due to boron, might have enhanced pollen tube germination, pollination and improvement of grain setting. Boron application has a

TABLE II

Influence of boron application on 1000 seed weight, ear length and number of fingers per ear in finger millet

Treatments	1000 seed weight (g)				Ear length (cm)				No. of fingers / ear head			
	Ist year	IInd year	IIIrd year	Pooled	Ist year	IInd year	IIIrd year	Pooled	Ist year	IInd year	IIIrd year	Pooled
Control (No Boron application)	2.11	2.35	2.42	2.29	6.26	6.56	6.05	6.29	4.96	5.01	5.65	5.21
Boron @0.5kg/ha (soil application)	2.71	2.78	2.68	2.72	7.67	7.82	7.15	7.55	6.50	6.67	6.62	6.60
Boron @1.00kg/ha (soil application)	2.5	2.66	3.02	2.73	7.49	7.56	7.65	7.57	6.17	5.89	7.52	6.53
Boron @ 2.00kg/ha (soil application)	2.34	2.43	2.51	2.43	7.13	6.89	6.21	6.74	5.41	5.41	5.89	5.57
Boron @0.5kg/ha (Foliar spray)	2.79	2.92	2.63	2.78	7.72	8.02	6.85	7.53	6.58	6.85	6.45	6.63
Boron @1.00kg/ha (Foliar spray)	2.66	2.73	2.87	2.75	7.63	7.76	7.42	7.60	6.34	6.20	7.25	6.60
Boron @ 2.00kg/ha (Foliar spray)	2.41	2.52	2.58	2.50	7.33	7.34	6.62	7.10	5.93	5.70	6.12	5.92
S. Em.±	0.06	0.23	0.14	0.07	0.27	0.14	0.49	0.14	0.08	0.38	0.47	0.20
C.D at 5%	0.19	NS	NS	0.22	0.83	0.45	1.48	0.43	0.25	1.18	1.47	0.63

key role in plant metabolism and root growth through its influence on utilization of nitrogen and synthesis of carbohydrates, proteins besides efficient use of water. The higher B:C ratio (1.46) was noticed with the soil application of boron @ 1 kg ha^{-1}, which may be ascribed to higher grain and straw yield besides the lower cost of application.

The per cent increase in yield was to the tune of 13.4 per cent with foliar application of boron @ 0.5 kg ha^{-1} as compared to control. These results clearly indicated that application of boron @ 0.5 kg ha^{-1} either through soil or through foliar application at the same level did not vary significantly. The 1000 seed weight and number of fingers per head recorded with the same level of boron @ 0.5 kg ha^{-1} either through foliar or soil application was on par with each other. The higher yield may be due to overall growth parameters, higher plant biomass, which accumulated during early stage due to favoured and higher translocation of photosynthates to the sink (Bergmann, 1992).

The soil fertility status after the harvest of finger millet is presented in (Table-III). The pH, electrical conductivity (EC), organic carbon, macronutrients (P_2O_5 and K_2O) and micronutrient (Zn, Cu, Mn and Fe) contents were found to be non-significant. Further, boron content in soil varied significantly among the treatments, while other nutrient status remained non-significant. Soil and foliar application boron @ 1 kg ha^{-1} recorded significantly higher available boron content (0.27 ppm) compared to control (0.22 ppm). While the same treatment registered higher content of Zn, Cu, Mn & Fe of 1.76, 0.70, 19.50 and 23 ppm, respectively.

Higher uptake of nitrogen (73 kg ha^{-1}), phosphorus (14.5 kg ha^{-1}) and potassium (65 kg ha^{-1}) was observed in soil and foliar application of boron @ 1 kg ha^{-1} compared to control. Zinc (158 mg ha^{-1}) copper (44 mg ha^{-1}), manganese (154 mg ha^{-1}), iron (3904 mg ha^{-1}) and boron (96 mg ha^{-1}) showed higher values with the soil application of boron @ 1kg ha^{-1} (Table- IV).

TABLE III

Soil fertility status of the experimental plots after the harvest of finger millet

Treatments	pH	EC (dSm^{-1})	OC (%)	P_2O_5	K_2O	Zn	Cu	Mn	Fe	B
				kg ha^{-1}		-ppm-				
Control (No Boron application	5.8	0.06	0.52	76	189	1.64	0.6	18	21	0.22
Boron @0.5 kg ha^{-1} (soil application)	6.0	0.07	0.58	77	195	1.74	0.7	19	22	0.26
Boron @1.00 kg ha^{-1} (soil application)	6.1	0.07	0.62	78	200	1.76	0.7	19.50	23	0.27
Boron @ 2.00 kg ha^{-1} (soil application)	5.8	0.06	0.53	75	190	1.65	0.6	18	21	0.23
Boron @0.5 kg ha^{-1} (Foliar spray)	6.0	0.06	0.56	76	193	1.70	0.6	19	22	0.25
NPK+ boron @1.00 kg ha^{-1} (Foliar spray)	6.1	0.07	0.6	78	196	1.76	0.7	19.5	23	0.27
Boron @ 2.00 kg ha^{-1} (Foliar spray)	5.9	0.06	0.54	76	190	1.68	0.6	18.50	21	0.25
S. Em. ±	0.14	0.004	0.038	0.70	3.74	0.048	0.034	0.53	0.68	0.006
C.D at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.019

TABLE IV

Uptake of nutrients after the harvest of finger millet as influenced by boron application

Treatments	N	P_2O_5	K_2O	Zn	Cu	Mn	Fe	B
	kg ha-1		mg kg-1					
Control (No Boron application	69	12	60	143	38	148	3830	93
Boron @0.5 kg ha^{-1} (soil application)	72	14	64	156	42	152	890	95
Boron @1.00 kg ha^{-1} (soil application)	73	14.5	65	158	44	154	3904	96
Boron @ 2.00 kg ha^{-1} (soil application)	69	12	61	155	39	149	3850	94
Boron @0.5 kg ha^{-1} (Foliar spray)	71	14	63	155	41	151	3880	95
Boron @1.00 kg ha^{-1} (Foliar spray)	73	14.5	65	157	43	153	3900	96
Boron @ 2.00 kg ha^{-1} (Foliar spray)	70	13	62	154	40	150	3870	94
S. Em.±	1.38	0.88	1.71	5.10	2.11	2.08	24.88	0.41
C.D at 5%	NS	NS	NS	NS	NS	NS	NS	1.21

It can be concluded from present experiment that soil or foliar application of boron @ 0.5 kg ha^{-1} results in increased grain yield and yield components of finger millet. Thus foliar sprays of boron are suggested to be applied for better crop nutrition and increased crop growth, which will ensure higher yields.

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