Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(1): 81-86
Received: 12-11-2017
Accepted: 15-12-2017

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Effect of application of the sulphur (S), boron (B) and zinc (Zn) on soil fertility status and crop productivity under bhoo-chetana programme in selected villages of devaduraga taluk

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Abstract
A study was conducted during rabi 2014 to assess the impact of 'Bhoochetana', a soil test-based fertilizer management in Karnataka, to know the Effect of application of the Sulphur (S), Boron (B) and zinc (Zn) on soil fertility status and crop productivity in selected villages of Devadurga taluk, Raichur district, soil samples and crop yield data were collected from farmers' fields having farmer practice (FP) as well as improved practice (IP) of soil test-based application of N, P and K along with deficient sulphur (S), boron (B) and zinc (Zn) as recommended under 'Bhoochetana'. After five years (since 2010) of 'Bhoochetana' in Raichur district, significant improvement in soil health is noted in IP adopted plots. Results showed that there was soil organic carbon under IP increased to medium in both the villages (0.55% to 0.71%) levels as compared with low (0.26% to 0.43%) levels observed under FP. Soil fertility under IP improved in terms of both macro and micro nutrients like N, P, K, S, B and Zn. Increase in crop yield and also nutrient concentrations in seeds of sorghum and sunflower crops. Yield was increased in sorghum (16%), and sunflower (14.5%) was observed under IP.

Keywords: Sulphur, boron and zinc and soil productivity

Introduction
Sulphur (S) is being recognized as the fourth major nutrient in addition to nitrogen, phosphorus and potassium. It is highly reactive, existing in six oxidation states and moving among the lithosphere, hydrosphere and atmosphere. Within the biosphere, it is found in numerous chemical combinations and serves multiple biochemical functions. As a result, the pathways of S in any ecosystem are complex and intert wined with other elements.

Micronutrients in present day agriculture play an important role to enhance the agricultural productivity. Zinc (Zn) is essential micronutrient required for optimum crop growth. Zinc plays an important role in auxin metabolism, preferential accumulation of chlorophyll, protein synthesis, starch metabolism and activation of many enzymes. Therefore, deficiency of zinc in soil adversely affects the growth and development of crop plants. Zinc deficiency is the most common nutrient disorder constraining rice productivity.

Boron (B) is another essential micronutrient and is known to promote flowering, pollen germination and grain filling. Boron deficiency mainly occurs in high rainfall areas of coarse textured sandy soils, acid soils and calcareous soils. It can immediately move to the site of maximum demand and used by plant leaves during the critical times of seed production when movement from soil to root may be inadequate and root activity is declining.

Micronutrient deficiencies are becoming serious because of escalated nutrient demand from more intensive and exploitative agriculture coupled with use of single-nutrient fertilizers and low amounts of organic manures. It has been reported that Indian soils are deficient about 41, 12, 47, 04, 12 and 13 per cent in S, Fe, Zn, Mn, Cu and B, respectively.

Based on the stratified soil sampling methodology adopted by the ICRISAT to draw the 92,409 soil samples across the Karnataka, it was observed that soils in Karnataka are largely deficient in S (52%), Zn (55%) and B (60%). Similarly Hydrabad-Karnataka region soils are also largely deficient in S, Zn and B. The Northern Eastern dry zone of Karnataka (Zone-2) comprising part of Raichur district has widespread deficiency of sulphur, zinc and boron in soil (Wani *et al*. 2011) [14]. The Raichur district soils were deficient in S by 64%, in Zn by 79% and B by 39%. This paper presents the results of effect of application of the Sulphur (S), Boron (B) and zinc (Zn) on soil fertility status and crop productivity under Bhoo-chetana programme in the farmers' fields that show improvement of the soil fertility status.

Materials and methods

Site description

The study area comprised of Gabbur and Sunkeshwarhal villages in Devadurga taluk. The sampling locations were marked by using GPS.

Soil sampling and analysis

The survey work was conducted during r*abi* (2014) season before sowing. The surface (0 to 15cm) soil samples were collected randomly from Gabbur and Sunkeshwarhal villages from Devadurga taluk of Raichur district under farmer practice (not adopted Bhoo-chetana programme) and improved practice (adopted Bhoo-chetana programme).

Before analyses, the soil samples were air dried and powdered with wooden hammer and pass through 2 mm sieve. For organic carbon, the soil samples were finely powdered to pass through a 0.25 mm sieve. Processed soil samples were analyzed in the laboratory. The soil pH was measured by a glass electrode using a soil to water ratio of 1:2.5; electrical conductivity (EC) was determined by an EC meter using a soil to water ratio of 1:2. Organic carbon was determined using by Walkley-Black method (Jackson, 1973) [6]. Available nitrogen in the soil samples was determined by alkaline potassium permanganate method as outlined by (Subbaiah and Asija, 1956) [13]. Available phosphorous was extracted with 0.5 M sodium bicarbonate at pH 8.5 (Olsen's reagent) method as outlined by (Jackson, 1973) [6]. Available potassium in soil was extracted by neutral normal ammonium acetate (Jackson, 1973) [6]. Available S was extracted by 0.15% calcium chloride ($CaCl_2$) solution as an extractant (Black, 1965) [2], available Zn was extracted by DTPA reagent (Lindsay and Norvell, 1978) [7] and available B by hot water (Berger and Truog 1939) [1].

Yield estimation

At the time of harvesting the crops (sorghum, and sunflower), Crop samples were randomly collected from both farmer practice and improved practice, harvested area was 25 m^2. Thus crop plants covering a total area of about 25 m^2 were harvested, and the harvested plants were pooled. Economic parts of the plants were separated from the vegetative parts and weighed separately. Grain or pods and stover or haulm weights were taken separately, then yield per 25m^2 areas were converted into yield per ha^{-1}.

Results and Discussions

The result revealed that the soils of Devadurga taluk were slightly saline to alkaline in reaction. In the soils under FP, the pH values ranged between 7.20 to 8.90 with a mean of 8.35. Whereas, in the soils of IP pH values varied from 7.30 to 8.75 with a mean of 8.24.

The electrical conductivity of the soils from Devadurga taluk under FP ranged from 0.12 to 1.06 dS m^{-1} with a mean of 0.36 dS m^{-1}. Similarly, IP samples recorded an electrical conductivity of 0.11 to 1.02 dS m^{-1} with a mean of 0.30 dS m^{-1} respectively. The organic carbon content of the soils was low to medium in status. The organic carbon content of the soils under FP varied from 0.30 to 0.50 per cent with a mean of 0.41 per cent in Devadurga taluk. Whereas, the organic carbon content of soils of IP varied from 0.56 to 0.74 per cent, with a mean of 0.66 per cent, respectively. (Table.1)

The available nitrogen content of soils under FP in Devadurga taluk ranged between 224 and 336 kg ha^{-1} and that in IP sample ranged between 252 and 336 kg ha^{-1}. The soils in study area were low to medium in available nitrogen. The available phosphorus content of soils under FP in Devadurga taluk ranged from 10.3 to 26.9 kg ha^{-1} and in IP samples, it ranged between 11.8 and 39.6 kg ha^{-1}. Nitrogen contents under FP were comparatively (Table.2) lower than the IP. It might be due to the lower organic carbon content under FP and imbalanced application of fertilizers. Both the IP and FP soils recorded medium to high potassium status. The results are on line with the findings of Sahrawat *et al*. (2010) [11] and Srinivasarao *et al*. (2006) [12].

The available potassium contents of soils under FP ranged between 188 to 330 kg ha^{-1} and 246 to 333 kg ha^{-1} in IP samples of Devadurga taluk. The available sulphur content in the soils of study area was low to high and ranged between 9.62 to 25.5 mg kg^{-1} under FP in the taluk of Devadurga, whereas in the IP samples, sulphur content ranged between 21.3 to 32.1 mg kg^{-1}, mg kg^{-1} with a mean of 25.8 mg kg^{-1}. The highest available sulphur status under FP and IP were observed in Sunkeshwarhal with a mean of 15.8 and 27.9 mg kg^{-1}. Whereas lowest were observed in Gabbur with a mean of 13.3 and 23.7 mg kg^{-1}. All the samples were medium to high in available sulphur status. This might be due to the balanced application of nutrients under improved practice leading to higher organic C and apparently higher microbiological activity. The role of organic matter in reducing P-fixation is well known. Similarly, apparently higher microbial activity is expected to convert more of insoluble-P into soluble-P. results collaborate with the finding of Chander *et al*. (2014b) [4].

The exchangeable calcium content in the soils of FP ranged between 11.9 and 19.5 c mol (p^+) kg^{-1} with a mean of 15.3 c mol (p^+) kg^{-1}, while in IP samples it ranged between 13.4 and 19.9 c mol (p^+) kg^{-1} with a mean of 16.8 c mol (p^+) kg^{-1}, respectively. The lowest exchangeable calcium content in FP and IP samples were observed in Sunkeshwarhal with a mean of 14.9 and 16.4 c mol (p^+) kg^{-1}, highest were observed in Gabbur with a mean of 15.6 and 17.3 c mol (p^+) kg^{-1}. The exchangeable magnesium in the soils of FP ranged between 0.70 to 4.80 c mol (p^+) kg^{-1}. The mean value was 2.50 c mol (p^+) kg^{-1}, whereas, in the soils of IP it ranged between 1.30 to 5.30 c mol (p^+) kg^{-1} with a mean of 3.08 c mol (p^+) kg^{-1}. The lowest exchangeable magnesium content in FP and IP samples were observed in Sunkeshwarhal with a mean of 1.66 and 2.61 c mol (p^+) kg^{-1}. Similarly, highest content were observed in Gabbur with a mean of 3.28 and 3.55 c mol (p^+) kg^{-1}. The soils were deficient to sufficient in available boron status.

The available boron content of FP soils ranged between 0.60 to 2.24 mg kg^{-1} with a mean of 1.20 mg kg^{-1}, while that of IP samples ranged between 1.10 to 4.10 mg kg^{-1} with a mean of 2.13 mg kg^{-1}. The lowest available boron contents under FP and IP were observed in Gabbur and Sunkeshwarhal with a mean of 1.03 and 1.62 mg kg^{-1}, respectively. Similarly, highest was observed in Sunkeshwarhal and Gabbbur with a mean of 1.37 and 2.65 mg kg^{-1}, respectively. The available copper content of FP soils ranged between 0.02 to 0.57 mg kg^{-1} with a mean of 0.12 mg kg^{-1}, while that of IP samples ranged between 0.15 to 1.21 mg kg^{-1} with a mean of 0.36 mg kg^{-1}. The lowest available copper contents under FP and IP were observed in Sunkeshwarhal and Gabbur with a mean of 0.10 and 0.23 mg kg^{-1}, respectively. Similarly, highest were observed in Gabbur and Sunkeshwarhal with a mean of 0.13 and 0.48 mg kg^{-1}, respectively.

The available iron content of the soils was low to medium in status. The available iron content of the FP soils ranged between 0.03 to 1.79 mg kg^{-1} with a mean of 0.55 mg kg^{-1},

while that of IP samples ranged between 0.32 to 3.19 mg kg^{-1} with a mean of 1.30 mg kg^{-1}. The lowest available iron in FP and IP samples were observed in Sunkeshwarhal and Gabbur with a mean of 0.50 and 0.61 mg kg^{-1} respectively. Similarly, while highest were observed in Gabbur and Sunkeshwarhal with a mean of 0.78 and 1.81 mg kg^{-1}, respectively. The available zinc content of the FP soils ranged between 0.19 and 0.63 mg kg^{-1} with a mean of 0.34 mg kg^{-1}, while that of IP samples ranged between 0.32 and 0.68 mg kg^{-1} with a mean of 0.46 mg kg^{-1}. The lowest available zinc in FP and IP samples were observed in Sunkeshwarhal and Gabbur with a mean of 0.25 and 0.44 mg kg^{-1}, respectively. Similarly, the highest were observed in Gabbur and Sunkeshwarhal with a mean of 0.42 and 0.48 mg kg^{-1}, respectively. The extensive widespread deficiency of zinc, boron and sulphur under FP was apparently due to the poor organic carbon status of soil (Srinivasarao *et al*., 2006) [12] and depletion under continuous cropping without application of these nutrients (Rego *et al*.,2007) [9]. The results of present study are in line with the findings by Chander *et al*. (2014b) [4], Of the higher levels of zinc, boron and sulphur in soils under IP are on expected lines due to the application of S, B, Zn fertilizers along with N, P, and K Major portion of the study area was having sufficient levels of available copper and only some area was found deficient in it (Table.2).

Nutrient concentration in sorghum and sunflower seeds
Sorghum
The nitrogen content under FP ranged from 1.28 to 1.38 per cent and from 1.39 and 1.96 per cent in IP samples. The phosphorus content under FP ranged between 0.16 to 0.20 per cent and 0.18 to 0.26 per cent in IP samples. The potassium content ranged between 0.54 to 0.58 per cent in FP samples and 0.53 to 0.58 per cent in IP samples. The sulphur content ranged from 0.09 and 0.11 per cent in FP and 0.09 to 0.11 per cent in IP samples. Boron content under FP ranged between 1.37 to 1.83 mg kg^{-1} and 1.28 and 2.31 mg kg^{-1} in IP samples. The zinc content under FP was ranged between 18.0 to 19.0 mg kg^{-1} and 18.6 to 19.9 mg kg^{-1} under IP. (Table 3).

Sunflower
The total nitrogen content under FP ranged from 2.95 to 3.47 per cent and from 3.13 and 3.89 per cent in IP samples. The total phosphorus content under FP ranged between 0.62 and 0.74 per cent, 0.57 and 0.83 per cent in IP samples. The potassium content ranged from 1.06 to 1.11 per cent in FP samples and from 1.07 to 1.17 per cent in IP samples. The sulphur content ranged between 0.221 and 0.24 per cent in FP and 0.23 and 0.26 per cent in IP samples. Boron content under FP ranged between 14.7 to 15.9 mg kg^{-1} and 14.9 and 15.8 mg kg^{-1} in IP samples. The zinc content under FP ranged between 47.8 to 60.5 mg kg^{-1} and 53.8 to 63.7 mg kg^{-1} under IP. The highest zinc content in FP and IP samples were observed in Gabbur with a mean of 53.8 and 57.2 mg kg^{-1} respectively (Table 3).

Productivity of sorghum and sunflower
Sorghum
The average grain yield of sorghum under FP 2003 kg ha^{-1} (Table. 4), while that under IP, it ranged between 2283 kg ha^{-1}, respectively. The average straw yield under FP and IP was 2083 and 2567 kg ha^{-1} respectively. The per cent increase in grain yield under IP plots over FP was 16 per cent and in stover yield, it was 18.8 per cent. The per cent increase in yield over FP was apparently due to the combined and balanced application of S, B, Zn and N, P, K (Sahrawat *et al*., 2008b, Chander *et al*. 2014a,b) [3, 4].

Sunflower
The grain yield of sunflower under FP ranged between 950 and 1150 kg ha^{-1}, while that under IP, it ranged between 1020 and 1450 kg ha^{-1} with a mean of 998 and 1156 kg ha^{-1}, respectively. The straw yield under FP ranged between 2100 and 3000 kg ha^{-1}, while that under IP, it ranged between 2340 and 4500 kg ha^{-1} with a mean of 2580 and 3248 kg ha^{-1}, respectively. The per cent increase in pod yield under IP plots over FP was 14.5 per cent and in case of stover yield, it was 20.6 per cent. The percent yield increase over the farmer practice was apparently due to application of deficient Zn, B and S along with N, P (Srinivasarao *et al* 2008, Ghosh *et al*. 2000, Nayak *et al*. 2009 and Sahrawat *et al*. 2010) [5, 8, 11].

Table 1: Physico-chemical properties of soils from the villages of Devadurga taluk

Locations/ Village	Sample No.	Clay (%)	Silt (%)	Sand (%)	Textural Class	pH (1:2.5)		EC (dS m^{-1})		OC (%)	
						FP	IP	FP	IP	FP	IP
Gabbur	1	52.5	30.0	17.5	Clay	7.65	8.73	0.27	0.26	0.44	0.70
	2	54.2	27.5	18.2	Clay	8.77	8.75	0.51	0.31	0.38	0.66
	3	43.6	45.7	10.7	Silty clay	8.30	8.50	0.27	0.11	0.50	0.70
	4	53.4	27.0	19.6	Clay	8.20	8.10	1.06	0.32	0.50	0.56
	5	56.0	31.5	12.5	Clay	8.37	8.20	0.43	0.26	0.30	0.66
	6	57.4	28.6	14.0	Clay	8.30	8.50	0.26	0.12	0.35	0.66
	7	55.0	25.1	19.8	Clay	8.20	7.30	0.12	1.02	0.44	0.70
	8	38.5	28.5	33.0	Clay loam	7.60	8.30	0.34	0.25	0.38	0.66
	9	38.5	27.4	34.1	Silty clay	8.90	8.40	0.32	0.31	0.50	0.56
	10	39.2	26.9	33.9	Silty clay	7.20	8.30	0.42	0.25	0.50	0.66
Average		48.8	29.8	21.3		8.15	8.30	0.40	0.32	0.43	0.65

FP: Soil samples from field which have not adopted Bhoo-chetana programme (N + P + K)
IP: Soil samples from field which have adopted Bhoo-chetana programme (N + P + K + S + B + Zn)

Conti... Physico-chemical properties of soils from the villages of Devadurga taluk

Locations/ Village	Sample No.	Clay (%)	Silt (%)	Sand (%)	Textural Class	pH (1:2.5)		EC (dS m^{-1})		OC (%)	
						FP	IP	FP	IP	FP	IP
Sunkeshwarhal	11	52.8	33.3	13.9	Clay	8.53	8.25	0.60	0.43	0.36	0.74
	12	53.0	32.5	14.5	Clay	8.20	8.15	0.25	0.26	0.40	0.62
	13	54.7	29.4	15.9	Clay	8.51	8.23	0.19	0.15	0.50	0.70
	14	54.6	31.9	13.4	Clay	8.46	8.18	0.58	0.22	0.40	0.66
	15	39.5	49.5	11.0	Silty lay	8.33	8.30	0.40	0.37	0.34	0.70
	16	41.6	47.63	10.8	Silty lay	8.42	8.20	0.20	0.43	0.30	0.70
	17	36.5	27.9	35.6	Silty lay	8.50	8.10	0.21	0.12	0.50	0.65
	18	34.3	25.6	40.1	Silty lay	8.20	7.90	0.12	0.24	0.40	0.62
Average		45.8	34.7	19.4		8.39	8.16	0.32	0.28	0.40	0.67
Overall range		34.3-57.4	25.1-49.5	10.70-40.10		7.20-8.90	7.30-8.75	0.12-1.06	0.11-1.02	0.30-0.50	0.56-0.74
Average		47.3	32.3	20.3		8.35	8.24	0.36	0.30	0.41	0.66
SD±		8.16	7.56	9.96		0.49	0.8	0.22	0.2	0.07	0.05

FP: Soil samples from field which have not adopted Bhoo-chetana programme (N + P + K)
IP: Soil samples from field which have adopted Bhoo-chetana programme (N + P + K + S + B + Zn)

Table 2: Available nutrient status of soils of Devadurga taluk

Location/ Village	Sample No.	N		P_2O_5		K_2O		S		Exch.Ca^{++}		Exch.Mg^{++}		B		Cu		Fe		Mn		Zn	
		(kg ha^{-1})						(mg kg^{-1})		(c mol (P^+) kg^{-1})				(mg kg^{-1})									
		FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP
Gabbur	1	308	308	11.1	18.3	188	333	11.6	22.1	13.6	19.3	2.10	3.00	0.90	3.91	0.08	0.26	0.39	0.59	0.79	1.29	0.52	0.50
	2	308	280	25.2	13.0	254	327	16.6	21.5	11.9	19.9	2.50	4.60	1.45	3.80	0.57	0.25	0.43	0.32	0.01	1.36	0.63	0.32
	3	308	308	26.9	11.8	304	270	9.62	24.1	19.2	13.4	3.60	3.50	1.32	4.10	0.09	0.32	1.79	1.04	1.74	2.19	0.34	0.68
	4	252	252	12.5	27.2	279	282	11.6	24.8	18.0	18.5	4.20	2.70	0.61	4.10	0.08	0.22	0.40	1.02	1.34	0.95	0.40	0.41
	5	280	252	20.5	18.3	308	323	16.6	21.3	17.5	15.8	1.90	2.80	1.20	3.80	0.20	0.22	0.63	1.04	2.04	1.51	0.28	0.40
	6	252	308	13.0	18.3	304	304	11.6	24.5	13.5	17.5	2.10	3.50	1.30	1.45	0.07	0.24	0.03	0.61	0.69	1.50	0.30	0.42
	7	308	252	17.5	17.8	254	282	16.6	26.5	11.9	18.2	3.60	4.50	0.90	1.65	0.04	0.21	0.81	0.50	0.05	0.91	0.40	0.49
	8	280	308	18.3	22.0	246	333	11.1	21.5	19.5	18.9	4.80	2.90	1.10	1.10	0.08	0.24	0.67	1.04	0.90	1.10	0.60	0.35
	9	252	336	22.0	23.5	223	270	16.6	24.8	17.9	16.5	3.20	3.50	0.60	1.20	0.02	0.21	0.50	1.02	1.02	1.90	0.31	0.42
	10	308	280	23.5	25.0	304	252	11.6	25.9	13.5	15.2	4.80	4.50	0.90	1.40	0.04	0.15	0.42	0.60	1.50	2.21	0.40	0.42
Average		286	288	19.0	19.5	267	298	13.3	23.7	15.6	17.3	3.28	3.55	1.03	2.65	0.13	0.23	0.61	0.78	1.01	1.49	0.42	0.44

FP: Soil samples from field which have not adopted Bhoo-chetana programme (N + P + K)
IP: Soil samples from field which have adopted Bhoo-chetana programme (N + P + K + S + B + Zn)

Table 2: Conti… Available nutrient status of soils of Devadurga taluk

Location/ Village	Sample No.	N		P_2O_5		K_2O		S		Exch.Ca^{++}		Exch.Mg^{++}		B		Cu		Fe		Mn		Zn	
		(kg ha^{-1})						(mg kg^{-1})		(c mol (P^+) kg^{-1})				(mg kg^{-1})									
		FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP
Sunkeshwarhal	11	308	308	17.8	39.6	238	318	15.4	22.5	13.2	17.5	1.80	3.50	1.13	1.60	0.05	0.76	0.34	2.35	2.03	5.06	0.27	0.40
	12	280	308	13.5	18.3	246	328	25.5	23.5	14.5	17.2	2.00	3.50	0.68	1.90	0.10	1.21	0.87	1.16	1.80	2.64	0.20	0.42
	13	308	308	18.5	26.4	330	307	12.5	23.6	14.8	17.5	0.70	2.40	0.77	1.70	0.14	0.17	0.46	1.05	1.64	1.97	0.31	0.60
	14	280	308	18.3	20.2	248	303	11.6	26.5	14.9	17.2	1.90	5.30	1.17	1.70	0.14	0.43	0.45	2.28	1.37	3.35	0.19	0.55
	15	252	308	10.3	13.5	318	298	16.6	31.5	14.6	17.4	1.10	2.10	1.50	1.50	0.09	0.30	0.42	1.09	2.40	2.68	0.19	0.45
	16	308	280	17.3	17.0	307	246	11.6	32.0	16.9	13.9	1.50	1.30	2.00	1.60	0.11	0.20	0.42	3.19	1.55	4.22	0.39	0.51
	17	336	336	18.3	24.5	303	303	16.6	31.6	14.5	14.5	2.50	1.30	1.50	1.45	0.04	0.18	0.49	1.16	1.61	2.65	0.25	0.48
	18	224	336	13.0	20.2	265	302	16.6	32.1	15.9	15.8	1.80	1.50	2.24	1.50	0.14	0.60	0.51	2.23	1.72	2.50	0.21	0.39
Average		287	311	15.9	22.5	282	301	15.8	27.9	14.9	16.4	1.66	2.61	1.37	1.62	0.10	0.48	0.50	1.81	1.76	3.13	0.25	0.48
Overall range		224-336	252-336	10.3-26.9	11.8-39.6	188-330	246-333	9.62-25.5	21.3-32.1	11.9-19.5	13.4-19.9	0.70-4.80	1.30-5.30	0.60-2.24	1.10-4.10	0.02-0.57	0.15-1.21	0.03-1.79	0.32-3.19	0.01-2.40	0.91-5.06	0.19-0.63	0.32-0.68
Average		286	300	17.5	21.0	274	299	14.5	25.8	15.3	16.8	2.50	3.08	1.20	2.13	0.12	0.36	0.55	1.30	1.39	2.31	0.34	0.46
SD±		29.7	27.1	4.79	6.46	38.5	26.9	3.77	3.78	2.35	1.83	1.21	1.15	0.45	1.13	0.12	0.27	0.36	0.77	0.65	1.12	0.13	0.09

FP: Soil samples from field which have not adopted Bhoo-chetana programme (N + P + K)
IP: Soil samples from field which have adopted Bhoo-chetana programme (N + P + K + S + B + Zn)

Table 3: Nutrient concentration in sorghum and sunflower seeds

Location/ Village	Sample No.	N		P		K		S		B		Cu		Fe		Mn		Zn	
		%								(mg kg^{-1})								
		Sorghum																	
		FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP	FP	IP
Sunkeshwarhal	1	1.38	1.39	0.16	0.18	0.54	0.53	0.11	0.09	1.83	1.28	0.93	1.01	22.0	23.1	9.81	10.0	18.0	18.7
	2	1.31	1.88	0.20	0.26	0.58	0.55	0.09	0.11	1.37	2.09	0.87	1.59	24.7	26.2	10.8	12.7	18.9	18.6
	3	1.28	1.96	0.19	0.28	0.56	0.58	0.11	0.11	1.80	2.31	0.83	1.90	26.2	28.5	10.3	13.0	19.0	19.9
Average		**1.32**	**1.74**	**0.18**	**0.24**	**0.56**	**0.55**	**0.10**	**0.10**	**1.67**	**1.89**	**0.88**	**1.50**	**24.3**	**25.9**	**10.3**	**12.0**	**18.7**	**19.0**
Sunflower																			
Gabbur		**FP**	**IP**	**FP**	**IP**	**FP**	**IP**	**FP**	**IP**	**FP**	**IP**	**FP**	**IP**	**FP**	**IP**	**FP**	**IP**	**FP**	**IP**
	1	3.21	3.13	0.68	0.57	1.06	1.11	0.24	0.26	15.7	15.0	19.0	21.8	53.0	51.6	20.5	22.0	59.0	57.7
	2	2.95	3.53	0.62	0.71	1.08	1.17	0.24	0.25	15.9	14.9	20.8	21.0	54.1	46.6	21.4	20.7	60.5	53.8
	3	3.18	3.89	0.66	0.83	1.10	1.12	0.22	0.23	15.3	15.8	17.7	18.3	45.6	51.6	18.0	19.9	49.7	54.0
	4	3.47	3.38	0.74	0.73	1.10	1.07	0.22	0.24	15.1	15.8	17.5	24.1	55.1	53.8	18.7	21.1	50.4	63.7
	5	3.34	3.22	0.65	0.70	1.11	1.07	0.24	0.24	14.7	15.7	19.7	18.7	43.0	51.0	18.8	20.5	47.8	56.7
Average		3.23	3.43	0.67	0.71	1.1	1.1	0.23	0.24	15.3	15.4	19.0	20.8	50.2	50.9	19.5	20.8	53.5	57.2

FP: Soil samples from field which have not adopted Bhoo-chetana programme (N + P + K)
IP: Soil samples from field which have adopted Bhoo-chetana programme (N + P + K + S + B + Zn)

Table 4: Productivity of sorghum and sunflower in different villages of Devadurga taluk

Taluk	Village	Sl. No.	Variety	Grain/Pod yield (kg ha^{-1})		Straw yield (kg ha^{-1})		% increase in grain of IP over FP yield	% increase in Straw yield of IP over FP
				FP	IP	FP	IP		
Sorghum									
Devadurga	**Sunkeshwarhal**	1	M-35-1	1950	2200	1900	2600	11.4	26.9
		2	M-35-1	1960	2300	2100	2200	14.8	4.55
		3	M-35-1	2100	2650	2250	2900	20.8	22.4
Average				2003	2383	2083	2567	16.0	18.8
Sunflower									
Devadurga	Gabbur	1	RSFH-130	960	1087	2200	2340	11.7	5.98
		2	RSFH-130	950	1050	2100	2600	9.52	19.2
		3	RSFH-130	1150	1450	2700	4500	20.7	40.0
		4	RSFH-130	900	1173	3000	3600	23.3	16.7
		5	RSFH-130	980	1020	2900	3200	3.92	9.38
Average				988	1156	2580	3248	14.5	20.6

Acknowledgement
I thank International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Patancheru, Hyderbad, Telangana, for awarding me the scholarship during my M.Sc (Agri) research study.

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