J. Hortl. Sci.
Vol. 5 (1): 57-60, 2010

Response of beet root tubers to gypsum, P levels, boron and iron sulphate in salt-affected soils

N. Sunitha, P.K. Basavaraja and B.N. Dhananjaya
Department of Soil Science and Agricultural Chemistry
University of Agricultural Sciences
Gandhi Krishi Vigyan Kendra, Bangalore – 560 065 India
E-mail: pujarikbraj@gmail.com

ABSTRACT

A field-experiment was conducted in salt-affected soils of Dodda Seebi tank command area of Tumkur district, Karnataka during *rabi* season of 2007 to study effect of gypsum, P level, borax and iron sulphate on beet root tuber yield and nutrient uptake. Treatments included two main-plot treatments, viz., M0: Control (without gypsum) and M_1: gypsum application @ 9.0 t ha^{-1} and eight sub-plot treatments, *viz*., S_1: Phosphorus @ 100 kg P_2O_5 ha^{-1}, S_2: Phosphorus @ 150 kg P_2O_5 ha^{-1}, S_3: S_1 + Borax @ 5 kg ha^{-1}, S_4: S_2 + Borax @ 5 kg ha^{-1}, S_5: S_1 + $FeSO_4$ @ 25 kg ha^{-1}, S_6: S_2 + $FeSO_4$ @ 25 kg ha^{-1}, S_7: S_3 + $FeSO_4$ @ 25 kg ha^{-1} and S_8: S_4 + $FeSO_4$ @ 25 kg ha^{-1}. Recommended N and K were applied to all treatments. The experiment was laid out in split plot design with three replications. Beet root, a salt-tolerant crop, was sown for testing its performance in salt-affected soils. Significantly higher tuber yield of 12.70 t ha^{-1} was realized when the crop received gypsum @ 9.0 t ha^{-1} compared to control (7.73 t ha^{-1}), besides higher nutrient uptake by the tubers. Among the nutrients, application of P at higher level (150 kg P_2O_5 ha^{-1}) plus recommended NK along with borax and iron sulphate realized higher tuber yield (15.72 t ha^{-1}) as well as nutrients uptake by tubers. Crop that received gypsum in combination with P at a higher level plus recommended NK, along with borax and iron sulphate, resulted in highest tuber yield (19.72 t ha^{-1}) and nutrient uptake.

Key words: Salt-affected soil, beet root, gypsum, tuber yield, nutrient uptake

Most salt-affected soils are deficit in available P due to varying amounts of lime ($CaCO_3$), whereby phosphorus gets fixed as $CaPO_4$. These soils are dominated by silt and clay-sized carbonate fractions, which provide enhanced surface area for P-fixation (Srinivasa Rao *et al*, 1991). On the contrary, available potassium content of most salt-affected soils is higher due to predominance of K-rich micaceous minerals in arid and semi-arid regions (Kapoor *et al*, 1980). Also, dissolution of muscovite saturated units releases large amounts of K in sodic soil environments (Pal, 1985). Besides, higher volatilization losses of available nitrogen occur under highly alkaline conditions (Rao and Batra, 1983). However, gypsum application results in decreased pH and ESP, possibly due to replacement of exchangeable Na^+ by calcium of the gypsum. So it can be expected that net negative charge will increase marginally, resulting in higher CEC. Also, most salt-affected soils are deficit in available- micronutrient content. Therefore, application of gypsum and growing salt-resistant crop are important features for successful management of salt-affected soils. Some salt-tolerant crops are rice, sugarcane, barley, sugar beet and beet root. Beet root or garden beet (*Beta vulgaris* L.), belonging to the family Chenopodiaceae, is an important root vegetable crop grown in almost all states of the country. In Karnataka, it is cultivated in an area of 2,693 hectares with production of 50,493 tons (*Anon*, 1995). It is generally grown during the winter season because good-quality tubers rich in sugar with intense red colour are obtained during cool weather, when temperatures vary between 18.3 and 21.1^{0}C. However, at temperatures below 10^{0}C, the plants start wilting before attaining marketable root size (Nath *et al*, 1987). The crop grows well under fairly-deep, friable, well-drained loamy soil. However, high yields are obtained from deep, rich alluvial or silt-loam soils. The plant is sensitive to soil-acidity and yields get adversely affected at soil pH below 5.8. Even though soil pH of 6 to 7 is considered to be ideal for the beet root crop, it does well in alkali soil with pH as high as 9 to 10. Keeping all these points in view, the present study was undertaken to study effect of gypsum, P level, boron and iron sulphate on beet root tuber yield and nutrient uptake.

A field-experiment was conducted in salt-affected soils of Dodda Seebi tank command area, Tumkur district of Karnataka, during the *rabi* season of the year 2007 under irrigated conditions. Soils at this experimental site are alkaline in reaction (pH 8.5) with high soluble- salt content (EC 1.42 dS m^{-1}), and, low in organic carbon (3.01g kg^{-1}); and available nitrogen content (145kg ha^{-1}); whereas, available phosphorus, potassium and sulphur content in the soil were medium. The soils are sufficient with respect to exchangeable calcium [13.02 cmol(p^+) kg^{-1}] and magnesium [2.92 cmol(p^+) kg^{-1}] content, whereas, DTPA extractable iron (4.20 ppm), manganese (1.16 ppm), zinc (0.56 ppm) and copper (0.30 ppm), including hot water soluble boron (0.41 ppm) content of the soil are below the critical level with an ESP of 35.20. It is a typical, salt-affected soil and particularly, alkali or sodic soil.

The treatments included two main plot treatments, viz., M0: Control (without gypsum) and M_1: gypsum @ 9.0 t ha^{-1} and eight sub-plot treatments, viz., S_1: Phosphorus @ 100 kg P_2O_5 ha^{-1}, S_2: Phosphorus @ 150 kg P_2O_5 ha^{-1}, S_3: S_1 + Borax @ 5 kg ha^{-1}, S_4: S_2 + Borax @ 5 kg ha^{-1}, S_5: S_1 + $FeSO_4$ @ 25 kg ha^{-1}, S_6: S_2 + $FeSO_4$ @ 25 kg ha^{-1}, S_7: S_3 + $FeSO_4$ @ 25 kg ha^{-1} and S_8: S_4 + $FeSO_4$ @ 25 kg ha^{-1}. The experiment was laid out in a split-plot design with three replications. Beet root, a salt-tolerant crop, was sown for testing its performance in salt-affected soils. Recommended dose of nitrogen (63 kg N ha^{-1}) and potassium (63 kg K_2O ha^{-1}) were applied in all treatments, whereas, phosphorus was applied at two different levels (100 and 150 kg P_2O_5 ha^{-1}). Beet root was spaced at 30 cm between rows and 22.5 cm between plants and the crop was raised as per recommended management practices under irrigated conditions.

Apart from taking tuber yield observations, tubers were analyzed for nutrient composition. Nutrient uptake by tubers was worked out using the following formula:

$$\text{Nutrient uptake by tubers (kg or g ha}^{-1}\text{)} = \frac{\text{Nutrient concentration in tubers (\% or ppm)}}{100} \times \text{Dry weight of tubers in kg ha}^{-1}$$

Tuber samples from four plants were collected from each plot at harvest and washed with clean water, cut into small pieces and dried in an oven. Dry weight of the samples was recorded. The samples were powdered and analyzed for major (NPK), secondary (S) nutrients and micronutrients (Fe, Mn, Zn, Cu and B). One gram of powdered sample was pre-digested with 5 ml of concentrated nitric acid and kept overnight. This was digested on a hot-plate with diacid mixture (HNO_3:$HClO_4$ in 10:4 ratio) until a snow white residue was formed which was cooled and made up to a known volume with distilled water. This extract was used for analysis of major nutrients (except nitrogen), secondary nutrients and micronutrients, as described by Piper (1966). For determination of nitrogen, plant sample (0.5 g) was digested with concentrated sulphuric acid in presence of the digestion mixture by boiling, till a bluish green residue was formed. Nitrogen in the digested sample was determined by micro-Kjeldahl distillation method (Piper, 1966). Tuber yield and nutrient uptake by tubers was statistically analyzed by procedures outlined by Sundararaj *et al* (1972).

Tuber-yield data (Table 1) indicated that application of gypsum @ 9.0 t ha^{-1} (M_1) recorded significantly higher tuber yield (12.70 t ha^{-1}) over control (7.73 t ha^{-1}), irrespective of the nutrients applied. Similarly, application of P at a higher level (150 kg P_2O_5 ha^{-1}) plus recommended NK along with borax @ 5 kg ha^{-1} and $FeSO_4$ @ 25 kg ha^{-1} (S_8) recorded significantly higher tuber-yield (15.72 t ha^{-1}) over all the other treatments, irrespective of the gypsum applied. However, treatment S_6 consisting of application of P at a higher level plus recommended NK along with $FeSO_4$, and, S_7 consisting of application of recommended NPK along with borax and $FeSO_4$ were found to be on par with treatment S_8. Application of gypsum in combination with P at the higher level plus recommended NK along with borax and $FeSO_4$ recorded significantly higher tuber-yield (19.72 t ha^{-1}) over all the other treatment combinations, except M_1 X S_6 (17.65 t ha^{-1}) and M_1 X S_7 (15.83 t ha^{-1}). Increased yield here may also be due to higher availability of nutrients in the soil (Prakash *et al*, 1994).

Table 1. Beet root tuber yield (t ha^{-1}) as influenced by gypsum, P level, borax and iron sulphate

Treatment	Tuber yield (t ha^{-1})		
	M0: Control (no gypsum)	M_1: Gypsum 9.0 t ha^{-1}	Mean
S_1: Rec. NK + P @ 100 kg P_2O_5 ha^{-1}	5.03	6.66	5.84
S_2: Rec. NK + P @ 150 kg P_2O_5 ha^{-1}	6.03	8.37	7.19
S_3: S_1 + Borax @ 5 kg ha^{-1}	5.71	9.52	7.61
S_4: S_2 + Borax @ 5 kg ha^{-1}	7.93	13.33	10.62
S_5: S_1 + $FeSO_4$ @ 25 kg ha^{-1}	7.16	10.55	8.85
S_6: S_2 + $FeSO_4$ @ 25 kg ha^{-1}	9.84	17.65	13.74
S_7: S_3 + $FeSO_4$ @ 25 kg ha^{-1}	8.37	15.83	12.09
S_8: S_4 + $FeSO_4$ @ 25 kg ha^{-1}	11.74	19.72	15.72
Mean	7.73	12.70	
	M	S	M X S
SEm ±	0.95	1.61	2.23
CD *(P=0.05)*	1.76	4.57	6.04

Data on major and secondary nutrient uptake by tubers as influenced by gypsum and other nutrients presented in Table 2 revealed that application of gypsum @ 9.0 t ha^{-1} recorded significantly higher N, P and K uptake (39.08, 9.44 and 24.47 kg ha^{-1}, respectively) over control (20.34, 4.26 and 13.10 kg ha^{-1} for N, P and K, respectively). Among the nutrients, treatment S_8 recorded significantly higher N, P and K uptake irrespective of gypsum application (44.96, 11.66 and 30.22 kg ha^{-1}, respectively), followed by the treatment S_6. However, treatment S_7 was found to be on par with treatment S_8 with respect to N and P uptake. Application of gypsum (M_1) in combination with S_6 recorded significantly higher N uptake (56.90 kg ha^{-1}) by the tubers over all the other treatment combinations, except M_1 X S_8 and M_1 X S_7; whereas, M_1 X S_8 recorded significantly higher P and K uptake (15.87 and 39.11 kg ha^{-1}, respectively) by the tubers over all the other treatment combinations, except M_1 X S_6 and M_1 X S_7. Increased N uptake by beet root tubers could be due to higher content of mineralized nitrogen in the soil (Chawla, 1969).Increased uptake of phosphorus may be attributed to acidulation of native P and reduction in fixation of added P due to gypsum application and, thus, subsequent enhancement in dry matter production (Verma and Singh, 1996). Increased uptake of potassium may be due to greater root growth, enabling the plant to explore wider areas for uptake (Jaggi *et al*, 1995). Significantly higher uptake of sulphur (8.41 kg ha^{-1}) by the tubers was recorded by application of gypsum, over control (3.78 kg ha^{-1}), irrespective of the different nutrients applied. Similarly, treatment S_8, irrespective of gypsum application, recorded significantly higher S uptake (10.11 kg ha^{-1}) over all the other treatments (3.03 to 8.01 kg ha^{-1}). Application of gypsum in combination with S_8 recorded significantly higher S uptake (13.53 kg ha^{-1}) compared to other treatment combinations (2.15 to 11.20 kg ha^{-1}). Increased sulphur content in soil by gypsum application may have resulted in increased S-uptake by the tubers. These results are in conformity with findings of Nagaich *et al* (1998).

Data on micronutrient uptake by tubers as influenced by gypsum and nutrients presented in Table 3 indicated that application of gypsum @ 9.0 t ha^{-1} recorded significantly higher Fe, Mn, Zn, Cu and B uptake (185, 196, 189, 164 and 0.12 g ha^{-1}, respectively) over control (80, 80, 83, 58 and 0.04 g ha^{-1} for Fe, Mn, Zn, Cu and B, respectively), irrespective of the nutrients applied. Similarly, treatment S_8 recorded significantly higher Fe, Mn, Zn, Cu and B uptake (238, 233, 230, 201 and 0.14 g ha^{-1}, respectively) over all the other treatments, irrespective of the gypsum applied. However, treatment S_6 was found to be on par with treatment S_8 with respect to Mn, Zn and B uptake. Besides, treatments S_7 and S_4 were also found to be on par with treatment S_8 with respect to B uptake by root tubers, irrespective of the gypsum applied. Application of gypsum (M_1) in combination with S_8 recorded significantly higher Fe, Mn, Zn, Cu and B uptake (332, 336, 311, 303 and 0.19g ha^{-1}, respectively) over all the other treatments combinations. However, application of gypsum (M_1) in combination with S_6 was found to be on par with M_1 X S_8 combination with respect to Mn, Zn and B uptake by tubers. Besides, treatment combinations M_1 X S_7 and M_1 X S_4 were also found to be on par with M_1 X S_8 with respect to B uptake. Higher uptake of iron by tubers may perhaps be due to higher availability of Fe in the soil as a result of improvement in soil conditions due to gypsum application, added $FeSO_4$ and its absorption by the crop. A plausible reason for higher uptake of Mn may be its increased availability in the soil as a result of nitrogen and sulphur application (as these are synergistically related) (Biswas *et al*, 1995). Similarly, increased uptake of Zn and Cu by tubers could be due to higher availability of these elements in the soil (as, the applied nitrogen, sulphur and

Table 2. Major and secondary nutrient uptake (kg ha^{-1}) by beet root tubers as influenced by gypsum, P level, borax and iron sulphate

Treatment	N			P			K			S		
	M0	M_1	Mean	M0	M_1	Mean	M0	M_1	Mean	M0	M_1	Mean
S_1	11.71	18.93	15.32	2.04	4.19	3.11	7.84	11.86	9.85	2.15	3.91	3.03
S_2	14.47	25.04	19.75	2.82	5.68	4.25	9.59	15.77	12.68	2.82	5.46	4.13
S_3	13.98	29.08	21.53	2.77	6.59	4.68	9.28	18.04	13.66	2.39	6.44	4.42
S_4	20.20	41.46	30.83	4.18	9.51	6.84	11.34	25.44	18.39	3.62	9.44	6.53
S_5	18.50	33.34	25.92	3.87	7.71	5.79	13.80	20.15	16.97	3.22	7.68	5.45
S_6	26.49	56.90	41.69	5.78	13.52	9.65	16.49	34.41	25.45	4.83	11.20	8.01
S_7	23.57	51.76	37.66	5.12	12.46	8.78	15.08	30.96	23.02	4.53	9.62	7.07
S_8	33.78	56.14	44.96	7.47	15.87	11.66	21.33	39.11	30.22	6.69	13.53	10.11
Mean	20.34	39.08		4.26	9.44		13.10	24.47		3.78	8.41	
	M	S	M x S	M	S	M x S	M	S	M x S	M	S	M x S
SEm ±	10.10	2.84	3.92	1.10	1.03	2.31	2.10	2.38	2.93	0.49	0.54	0.78
CD *(P=0.05)*	18.60	8.23	11.36	2.00	3.20	6.20	3.80	7.16	10.13	0.91	1.58	2.25

*treatment details, please see Table 1

Table 3. Micronutrient uptake (g ha^{-1}) by beet root tubers as influenced by gypsum, P level, borax and iron sulphate

Treatment	Fe			Mn			Zn			Cu			B		
	M0	M_1	Mean	M0	M_1	Mean	M0	M_1	Mean	M0	M_1	Mean	M0	M_1	Mean
S_1	46	82	64	44	80	62	42	86	64	31	64	48	0.02	0.05	0.04
S_2	56	107	82	54	109	82	52	116	84	39	92	66	0.03	0.07	0.05
S_3	51	126	89	58	137	98	54	136	95	40	105	73	0.03	0.09	0.06
S_4	73	183	128	84	196	140	81	194	138	58	151	105	0.05	0.13	0.09
S_5	69	146	108	75	162	119	75	157	116	53	128	91	0.03	0.09	0.06
S_6	102	256	179	107	286	197	112	264	188	77	238	158	0.05	0.16	0.11
S_7	100	245	173	91	258	175	102	244	173	71	233	152	0.06	0.16	0.11
S_8	144	332	238	130	336	233	148	311	230	98	303	201	0.08	0.19	0.14
Mean	80	185		80	196		83	189		58	164		0.04	0.12	
	M	S	M x S	M	S	M x S	M	S	M x S	M	S	M x S	M	S	M x S
SEm ±	12	14	19	7	14	19	7	13	18	17	14	17	0.03	0.02	0.02
CD *(P=0.05)*	35	47	66	19	42	58	22	44	62	49	42	59	0.07	0.07	0.07

*For treatment details, please see Table 1

iron increased availability of Zn and Cu in the soil since these are synergistically related) (Biswas *et al*, 1995). Increased uptake of B by tubers might be due to boron application, either alone or with $FeSO_4$, as these are synergistically related. These results are in conformity with findings of Vinay Singh and Dixit (1994).

From this study, it can be inferred that significantly higher tuber yield is realized when the crop receives gypsum @ 9.0 t ha^{-1}. In salt-affected soils, non-availability of nutrients to the crop plant is the main constraint. Application of gypsum as an amendment for reclamation resulted in increased nutrient availability in the soil due to enhanced nutrient uptake by tubers. Application of P at a higher level (150 kg P_2O_5 ha^{-1}) plus recommended NK along with borax @ 5 kg ha^{-1} and $FeSO_4$ @ 25 kg ha^{-1} also significantly increased tuber yield and nutrient uptake. Interaction between gypsum and nutrients also resulted in highest tuber yield and nutrient uptake. It can be concluded that combined application of gypsum and P at a higher level, plus recommended NK along with borax and $FeSO_4$, rather than applying these chemicals individually, is a better option for enhancing tuber yield and nutrient uptake in salt-affected soils.

REFERENCES

Anonymous. 1995. Statistical data on horticultural crops. Department of Horticulture, Lal Bagh, Bangalore, p. 13

Biswas, D.R., Ali, S.A. and Khera, M.S. 1995. Introduction on the uptake of P and Zn, Cu, Fe and Mn by gobhi sarson. *J. Ind. Soc. Soil Sci*., **43**:280-281

Chawla, V.K. 1969. Available N and P status of saline-sodic soils. *Agri. Water. Mgt*., **5**:41-50

Jaggi, R.C., Dixit, S.P. and Bhardwaj, S.K. 1995. Nutrient uptake and tuber yield of potato as influenced by phosphate and FYM in an acid alfisol. *J. Ind. Soc. Soil Sci*., **43**:391-394

Kapoor, B.S., Singh, H.B. and Goswami, S.C. 1980. Analcime in a sodic profile. *J. Ind. Soc. Soil Sci*., **28**:513-515

Nagaich, K.N., Tridevi, S.K. and Fajesh Lekhi. 1998. Effect of sulphur and potassium fertilization on onion (*Allium cepa* L.). *South Ind. Hort*., **45**:266-271

Nath, P., Velayudhan, S. and Singh, D.P. 1987. Vegetables for the tropical regions. ICAR, New Delhi

Pal, D.K. 1985. Potassium release from muscovite and biotite under alkaline conditions. *Pedology*, **35**:133-136

Piper, C.S. 1966. Soil and plant analysis. Hans Publishers, Bombay, p. 368

Prakash, V., Sharma, N.I. and Singh, R. 1994. Effect of soil amendment on soil properties and yield of rice and barley in salt affected soil. *Curr. Agri*., **18**:35-40

Rao, D.L.N. and Batra, L. 1983. Ammonia volatilization from applied nitrogen in alkali soils. *Pl. & Soil*, **70**:219

Srinivasa Rao, C.A., Subaiah, G.V. and Pillai, R.N. 1991. Nutrient status of black soils of Telugu Ganga Project Area in Nellore district of Andra Pradesh. *Andhra Agri. J*., **38**: 201-205

Sundararaj, N., Nagaraju, S. and Venkata Ramu, M.N. 1972. Design and analysis of field experiments. *Univ. Agri. Sci.,* Bangalore.

Verma, S.K. and Singh, S.S. 1996. Effect of N, P and S and their interaction on yield and uptake by linseed. *J. Ind. Soc. Soil Sci*., **43**:72-75

Vinay Singh and Dixit, H.C. 1994. Response of cauliflower to boron and iron application. *J. Ind. Soc. Soil Sci*., **39**:25-26

(MS Received 4 May 2009, Revised 17 March 2010)