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Effect of different levels of gypsum and boron on yield, nutrient content and uptake by potato (*Solanum tuberosum* L.)

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Abstract
A field experiment was conducted during *kharif* 2018 farmers field to study the effect of different levels of gypsum and boron on yield and nutrient content and uptake by potato with twelve treatments and replicated thrice using RCBD. The study revealed that significantly higher number of tubers per plant (4.78 plant^{-1}) and tuber weight per plant (536.12 g plant^{-1}) and tuber yield per hectare (28.91 t ha^{-1}) recorded with the application of 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron along with RDF +FYM. Significantly lower tuber yield was found in absolute control (12.08 t ha^{-1}). The nitrogen (1.65% and 1.64% respectively), phosphorus (0.29% and 0.46% respectively) and potassium(2.79% and 2.28% respectively) content in haulm and tuber increased significantly with T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron and was on par T_6 (T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}.Significantly lower nitrogen (1.22% and 1.02% respectively), phosphorus (0.20% and 0.24%) and potassium 1.36% and 1.48% respectively) content in haulm and tuber recorded in absolute control. As regard to uptake of nutrients significantly higher uptake nitrogen, phosphorus and potassium by haulm and tuber was recorded due to application of 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron along with RDF + FYM. Significantly lower uptake of nitrogen, phosphorus and potassium by haulm and tuber recorded in absolute control. The highest protein (10.28%) and starch content (79.47%) in tubers was recorded in treatment T10 (RDF + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5%) Boron over other treatments. The highest B:C ratio (4.51) was recorded in T10 over other treatments and lowest B:C ratio was recorded in absolute control.

Keywords: gypsum, boron, yield, nutrient content, potato, *Solanum tuberosum* L.

Introduction
The potato is an annual herbaceous plant that grows up to 100 cm (40 inches) tall and produces tubers, which are botanically thickened stems that are so rich in starch that rank as the world's fourth most important food crop, after maize, wheat and rice. The potato belongs to the family Solanaceae, and shares the genus *Solanum* with at least 1,000 other species, including tomato, chillies and eggplant. Potato is recommended to grow in medium and light texture soils to avoid difficulties in harvesting. Recommended pH of soil is 5.5 and pH below 4.8 results in impaired potato growth. Too alkaline conditions can induce micronutrients deficiencies and will adversely affect skin quality of tubers. Potato plants deficient in boron usually have reduced biomass. With severe deficiencies the leaves near the growing tip appear stunted. Lack of boron reduces both tuber quality and quantity Boron stabilizes calcium in the cell wall and acts in synergy with calcium to improve plant resistance to disease, pest and environmental stresses. In this respect, it can help minimize apical necrosis of sprouts.In potato calcium is the key in cell wall strength and cellular adherence. Deficiency in potatoes is most severe in acid (pH<5) sandy soil. Vine symptoms include spindle stems and small, upward rolling, crinkled leaflets. Leaflets have yellow margins that may turn brown. In severe cases, leaves are wrinkled and have a rosette appearance, and roots don't grow. The optimal pH range for calcium availability is 7.0 to 8.5. There is a gradual decrease as pH becomes less than 7.0, acidifies, and also as pH increases above 8.5, more alkaline. This pH affects on the availability of calcium as well as magnesium. In this context present investigation on the effect of gypsum and boron on the yield, soil properties, quality and economics in potato crop.

Material and Methods
A field experiment was conducted during kharif 2018 at Doddachakanahalli village in Hassan taluk and Hassan district to study the ”Effect of different levels of gypsum and boron on soil properties, growth and yield of potato (*Solanum tuberosum* L.)”. The experimental site is geographically situated in the Southern Transitional Zone (Zone -7) of Karnataka and located

between 12^0 13' and 13° 333'N Latitude and 750 33' and 760 38'E Longitude at an altitude of 827 m above Mean Sea Level. The initial soil properties of experimental site was analysed using standard methods (Table 1) as described by Jackson (1973) and Lindsay and Norwel (1978) [4]. The experiment was layed out in Randomised block design with twelve treatments and replicated thrice. The gross plot size of experimental plot was 5m X5m and net plot size was 3mX4.2 m. The twelve treatments were imposed as per the treatments detailed as below.

Treatment details

Treatments	Details
T_1	Absolute Control
T_2	RDF + FYM (POP)
T_3	T_2 + 75 kg Gypsum ha^{-1}
T_4	T_2 + 150 kg Gypsum ha^{-1}
T_5	T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}
T_6	T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}
T_7	T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron
T_8	T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron
T_9	T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron
T_{10}	T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron
T_{11}	T_2 + 0.25% Foliar sprayof Boron
T_{12}	T_2 + 0.5% Foliar spray of Boron

1. RDF: Rec. Dose of Fertilizer for potato (75:75:100 $N:P_2O_5:K_2O$)kg ha
2. FYM @ 25 t ha applied commonly to all treatments (except absolute control)
3. CF : Conventional fertilizers (Urea, DAP, SOP)
4. T_3 to T_{10}: Calcium and sulphur were applied from external source as Gypsum.
5. T_5 to T_{12} :Boron was applied through Solubor

Certified seed tubers (cv. Kufri Jyothi) of stage II obtained from National seed Corporation, Jalandar, Punjab were used for planting which were procured from regulated seed market of Hassan. The whole tubers were air dried for 15 days in room for subrization. The whole subrized tubers were cut into two or three pieces weighing approximately 30 – 40 grams and were soaked into a solution of Dithane M-45 (2.0 g in one litre of water) for 20 minutes and dried in shade before planting to prevent the decay of seed tubers. The growth and yield parameters were recorded at harvest in selected plants in each treatments and replications. The plant samples at harvest were collected and analysed for major (N, P &K) and micronutrients (Zn, Cu, Mn and B) using standard procedure as described by Jackson (1973) and Lindsay and Norwel (1978) [4] for nutrient uptake studies macro nutrients after harvest of crop. Experimental data obtained were subjected to statistical analysis adopting Fisher's method of analysis of variance as out lined by Gomez and Gomez (1984) [2]. The level of significance used in F" test was given at 5 per cent. Critical difference (CD) values are given in the table at 5 per cent level of significance, wherever the F" test was found significant at 5 per cent level.

Results and Discussion

Yield parameters of potato

Yield parameters of potato differ significantly due application of different levels of gypsum and boron

Tuber weight per plant (g $plant^{-1}$)

Significantly higher tuber weight per plant at harvest was observed in treatment T_{10} (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron) (536.12 g $plant^{-1}$) followed by T_6 (T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}) (521.66 g $plant^{-1}$) and T_9 (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron) (508.74 g $plant^{-1}$) which were significantly superior over treatments T_8 (T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron) (477.30 g $plant^{-1}$) and T_5(T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}) (474.06 g $plant^{-1}$). Whereas, absolute control recorded significantly lowest tuber weight per plant (196.83 g $plant^{-1}$).

Number of tubers per plant

Significantly higher number of tubers per plant at harvest were observed in treatment T_{10} (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron) (4.78 $plant^{-1}$) followed by T_6 (T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}) (4.62 $plant^{-1}$) and T_9 (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron) (4.46 $plant^{-1}$) which were almost similar to the treatments T_8 (T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron) (4.33 $plant^{-1}$) and T_5(T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}) (4.32 $plant^{-1}$). Whereas, absolute control recorded significantly lowest number of tuber per plant (2.54 $plant^{-1}$).

Tuber yield (tonnes per hectare)

Significantly higher tuber yield at harvest was observed in treatment T_{10} (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron) (28.91 t ha^{-1}) followed by T_6 (T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg $ha^{-1)}$ (28.03 t ha^{-1}) and T_9 (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron) (27.49 t ha^{-1}) which were almost similar to the treatments T_8 (T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron) (26.48 t ha^{-1}) and T_5(T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}) (26.46 t ha^{-1}) Where, absolute control recorded significantly lowest tuber weight per plant (12.08 t ha^{-1}).

The increase in tuber yield and number of tubers per plant were due to application of gypsum that influenced of sulphur released from the gypsum on availability of other nutrients from the soil and their extraction by the plant seems to have provided congenial nutritional environment for the plants. Further, calcium plays an important role in the reproductive growth of the crop, thereby increased the tuber yield. These results are in agreement with the findings of Rao and Shaktawat (2005), Sreelatha *et al.* (2004) and Ismail *et al.* (1998) [8, 9, 3].

Application of different levels of gypsum and boron influenced significantly on major (N.P &K), secondary (Ca, Mg &S) and micronutrient (Zn &B) content in haulm and tuber of potato. The nitrogen (1.65% and 1.64% respectively), phosphorus (0.29% and 0.46% respectively) and potassium

(2.79% and 2.28% respectively) content in haulm and tuber increased significantly (Table 3) with T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron and was on par with T_6 (T_2 +150 kg Gypsum ha^{-1} +Soil application of Boron @5kg ha^{-1}. With respect to nitrogen (1.62 &1.61%), phosphorus (0.28 &0.43%) and potassium content (2.71 &2.22%) in haulm and tuber respectively. Significantly lower nitrogen (1.22% and 1.02% respectively), phosphorus (0.20% and 0.24%) and potassium 1.36% and 1.48% respectively) content in haulm and tuber recorded in absolute control.

Effect of gypsum and boron application on secondary and micronutrient content in haulm and tuber of potato

Application of gypsum and boron influenced significantly on concentration of secondary and micronutrient in haulm and tuber of potato (Table 4 & Table 5).

Significantly higher content of Calcium (1.56% 1.02%), magnesium (1.24 &0.47%), Sulphur (0.69 & 0.60%), zinc (19.27 ppm & 11.32 ppm) and boron (20.92 ppm & 23.08 ppm) recorded in haulm and tuber respectively with T10 (T_2 + 150 kg Gypsum ha^{-1} + foliar spray of Boron @ 0.5%) and significantly lowest content of Calcium (0.98 &0.54%), magnesium (0.41% & 0.21%), Sulphur (0.31% & 0.35%), zinc (15.42 ppm & 8.09 ppm) and boron (10.21 ppm & 10.69 ppm). As regard to content and uptake of secondary (Ca, Mg and S) and micronutrients (Zn and Boron). Significantly higher content of Calcium (1.56% 1.02%), magnesium (1.24 &0.47%), Sulphur (0.69 & 0.60%), zinc (19.27 ppm & 11.32 ppm) and boron (20.92 ppm & 23.08 ppm) recorded in haulm and tuber respectively with T10 (T_2 + 150 kg Gypsum ha^{-1} + foliar spray of Boron @ 0.5%) and significantly lowest content of Calcium (0.98 & 0.54%), magnesium (0.41% & 0.21%), Sulphur (0.31% & 0.35%), zinc (15.42 ppm & 8.09 ppm) and boron (10.21 ppm & 10.69 ppm).

As regard to uptake of nutrients (Table 6), significantly higher uptake nitrogen (36.17, 71.44 & 107.61 kg/ha), phosphorus (6.42, 20.04 and 26.46 kg/ha) and potassium (61.17, 99.32 & 160.49 kg/ha) was recorded by haulm, tuber and total uptake, respectively with T10 (T2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron). Significantly lower uptake of nitrogen (7.56, 16.99 & 24.56 kg/ha), phosphorus (1.22, 4.00 & 5.22 kg/ha) and potassium (8.43, 24.66 & 33.09 kg/ha) by haulm, tuber and total uptake, respectively in absolute control.

The uptake of secondary (Ca, Mg and S) followed similar trend (Table 7) as observed in major nutrients uptake by haulm and tuber of potato as influenced by application of gypsum and boron at different levels. Significantly higher uptake of calcium (34.2, 44.43 & 78.63 kg/ha), magnesium (27.18, 20.33 & 47.51 kg/ha) and sulphur (15.13, 25.99 & 41.12 kg/ha) was recorded in haulm, tuber and total uptake, respectively with T10 (T_2 + 150 kg Gypsum ha^{-1} + foliar spray of Boron @ 0.5%) and the lowest uptake of calcium (6.08, 9.00 &15.07 kg/ha), magnesium (2.54, 3.50 & 6.04 kg/ha) and sulphur (1.92, 5.85 & 7.77 kg/ha) recorded in absolute control.

Increase in content and uptake of nutrients was attributed to application of gypsum improved the physical properties of soil there by providing favourable environment for the microbial process and mineralization and enhancing the supply of nitrogen, phosphorus and potassium from the native pools. These results are in agreement with the findings of Sreelatha *et al*. (2004) [9].

Uptake of micronutrient by haulm and tuber of Potato

The uptake of zinc and boron (Table 8) followed similar trend as recorded with respect to major and secondary nutrients.

Uptake of Zinc by potato haulm and tuber

Higher zinc uptake by haulm, tuber and total uptake (41.76, 49.31 and 91.08 g ha^{-1} respectively) was recorded in T_{10} which was received with (T_2 + 150 kg gypsum ha^{-1} + foliar spray of 0.5% boron) which was on par with treatment T_6 (T_2 + 150 kg gypsum ha^{-1} + soil application of boron @ 5 kg ha^{-1}) (38.08, 44.23 and 82.31g ha^{-1}respectively). Lower zinc uptake by haulm, tuber and total uptake (9.56, 13.48 and 23.04 g ha^{-1}respectively) was recorded inT_1 that is absolute control. The increase in the uptake of micronutrients might be attributed to increased availability of micronutrients due to their increased solubility by the acids produced by oxidation of sulphur released from gypsum. These findings are in agreement with the findings of Sreelatha *et al*. (2004) [9].

Uptake of Boron by potato haulm and tuber

The data boron uptake revealed that (Table 8) significantly higher boron uptake by haulm, tuber and total uptake (43.01, 97.03 and 140.05 g ha^{-1} respectively) was recorded in T_6 (T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}). It was followed by T_5 (T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha-1) (26.59, 84.69 and 111.24 g ha $^{-1}$ respectively). Uptake of boron in haulm, tuber and total uptake (6.33, 17.81 and 24.14 g ha $^{-1}$ respectively) was found significantly lower in T_1 that is absolute control.

B applied through foliar spray was recognized as an effective means of enhancing B concentrations of the reproductive organs resulting in higher crop yields (Johnson *et al*. 1995) [5]. The increase in B uptake could also be attributed to foliar application of B to plants, resulting in greater absorption of B (Ali, Singh, and Singh 2013) [1]

Effect of different levels of gypsum and boron application on starch content of Potato

The starch and protein content of potato differed significantly (Table 9) due to application of gypsum and boron. The data revealed that T_{10}(T_2 + 150 kg Gypsum ha^{-1} + foliar spray of Boron @ 0.5%) recorded significantly higher starch content of 79.47%, it was on par with (T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron@ 5 kg ha $^{-1}$) (T_6) which recorded 74.85%. Lower total soluble solids of 58.65% was recorded in T_1 that is absolute control.

The data on protein content reveals that T_{10}(T_2 + 150 kg Gypsum ha^{-1} + foliar spray of Boron @ 0.5%) recorded significantly higher protein of 10.28%, it was on par with T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1} (T_6) which recorded 10.06%. Lower protein content of 6.38% was recorded in T_1 that is absolute control. Sulphur being a component of sulphur containing amino acids as well as involved in sulpho – hydral bonds in polypeptides, also component of protein enzyme involved in chlorophyll, starch and protein synthesis. Involvement of sulphur in these biochemical processes in plant metabolism might be the cause for increased starch content and production of large sized tubers (Lalitha *et al*., 2002) [6].

Economics of crop

The higher gross returns and net returns were recorded (Table 10) in Treatment T_{10} with T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron which is followed by T_6 with T_2 + 150 kg Gypsum ha^{-1} + soil application of Boron @ 5 kg ha^{-1}. The highest B: C ratio was found in T_{10} (4.51) followed by T_9 (4.38) compared to all other treatments (Table 7). The higher B: C ratio obtained with these treatments was mainly due to higher yield obtained. The lowest B:C ratio was recorded in absolute control.

Table 1: Initial physical and chemical properties of soil at the experimental site

Sl. No.	Parameter	Value
Physical parameters		
1	Sand%	73.20
2	Silt%	12.25
3	Clay%	13.60
	Soil texture	Sandy
Chemical properties		
1	pH $_{1:2.5}$	7.25
2	EC $_{1:2.5}$(dSm^{-1})	0.37
3	CEC[c mol (p+) kg $^{-1}$]	6.68
4	Organic carbon(g kg $^{-1}$)	5.30
5	Available N(kg ha^{-1})	299.25
6	Available P_2O_5(kg ha $^{-1}$)	47.68
7	Available K_2O(kg ha $^{-1}$)	173.54
8	Exchangeable Ca(c mol (p+) kg^{-1})	3.45
9	Exchangeable Mg(c mol(p+) kg-^{1})	1.86
10	Available sulphur (kg ha $^{-1}$)	11.83
11	DTPA Fe (mg kg^{-1})	8.83
12	DTPA Mn (mg kg^{-1})	11.49
13	DTPA Zn (mg kg^{-1})	0.74
14	DTPA Cu (mg kg^{-1})	0.61
15	Hot water soluble boron (mg kg^{-1})	0.45

Table 2: Effect of different levels of Gypsum and Boron on yield components, tuber yield of potato

Treatments	Tuber yield plant $^{-1}$ (g)	No. of tubers plant^{-1}	Tuber yield (t ha^{-1})
T_1 : Absolute control	196.83	2.54	12.08
T_2 : RDF + FYM (POP)	344.80	3.18	20.49
T_3 : T_2 + 75 kg Gypsum ha^{-1}	423.35	3.69	23.98
T_4 : T_2 + 150 kg Gypsum ha^{-1}	436.23	3.87	24.56
T_5 : T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}	474.06	4.32	26.46
T_6 : T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}	521.66	4.62	28.03
T_7 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	473.50	4.19	25.58
T_8 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	477.30	4.33	26.48
T_9 : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	508.74	4.46	27.49
T_{10} : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	536.12	4.78	28.91
T_{11} : T_2 + 0.25% Foliar spray of Boron	385.73	3.39	21.45
T_{12} : T_2 + 0.5% Foliar spray of Boron	397.33	3.56	22.34
S.Em.±	22.43	0.12	0.85
CD @ 5%	65.78	0.36	2.51

Note: RDF: Rec. Dose of Fertilizer for potato (75: 75: 100 kg ha $^{-1}$ NPK); FYM: Farm Yard Manure @ 25 t ha^{-1}

Table 3: Effect of different levels of Gypsum and Boron on N, P and K content (%) in haulm and tuber of potato at harvest

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Haulm	Tuber	Haulm	Tuber	Haulm	Tuber
T_1 : Absolute control	1.22	1.02	0.20	0.24	1.36	1.48
T_2 : RDF + FYM (POP)	1.39	1.36	0.21	0.28	1.85	1.64
T_3 : T_2 + 75 kg Gypsum ha^{-1}	1.52	1.54	0.22	0.36	2.24	1.89
T_4 : T_2 + 150 kg Gypsum ha^{-1}	1.60	1.61	0.27	0.41	2.59	2.11
T_5 : T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}	1.55	1.56	0.23	0.38	2.40	2.01
T_6 : T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}	1.62	1.61	0.28	0.43	2.71	2.22
T_7 : T_2 + 75 kg Gypsum ha^{-1}+ Foliar spray of 0.25% Boron	1.54	1.52	0.24	0.40	2.32	1.90
T_8 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	1.58	1.57	0.25	0.42	2.48	2.07
T_9 : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	1.61	1.59	0.28	0.44	2.64	2.10
T_{10} : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	1.65	1.64	0.29	0.46	2.79	2.28
T_{11} : T_2 + 0.25% Foliar spray of Boron	1.38	1.38	0.21	0.24	1.89	1.57
T_{12} : T_2 + 0.5% Foliar spray of Boron	1.41	1.39	0.22	0.28	1.93	1.51
S.Em.±	0.05	0.04	0.01	0.01	0.07	0.05
CD @ 5%	0.14	0.12	0.02	0.03	0.21	0.15

Note: RDF: Rec. Dose of Fertilizer for potato (75: 75: 100 kg ha $^{-1}$ NPK); FYM: Farm Yard Manure @ 25 t ha $^{-1}$

Table 4: Effect of different levels of Gypsum and Boron on Ca, Mg and S content (%) in haulm and tuber of potato at harvest

Treatments	Calcium (%)		Magnesium (%)		Sulphur (%)	
	Haulm	Tuber	Haulm	Tuber	Haulm	Tuber
T_1 : Absolute control	0.98	0.54	0.41	0.21	0.31	0.35
T_2 : RDF + FYM (POP)	1.11	0.71	0.86	0.27	0.46	0.41
T_3 : T_2 + 75 kg Gypsum ha^{-1}	1.31	0.84	1.05	0.36	0.58	0.49
T_4 : T_2 + 150 kg Gypsum ha^{-1}	1.43	0.89	1.15	0.41	0.64	0.56
T_5 : T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}	1.35	0.86	1.10	0.38	0.62	0.52
T_6 : T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}	1.54	0.98	1.21	0.45	0.68	0.57
T_7 : T_2 + 75 kg Gypsum ha^{-1}+ Foliar spray of 0.25% Boron	1.33	0.81	1.09	0.38	0.60	0.50
T_8 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	1.38	0.79	1.12	0.39	0.62	0.51
T_9 : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	1.49	0.96	1.18	0.43	0.66	0.57
T_{10} : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	1.56	1.02	1.24	0.47	0.69	0.60
T_{11} : T_2 + 0.25% Foliar spray of Boron	1.14	0.74	0.88	0.29	0.48	0.43
T_{12} : T_2 + 0.5% Foliar spray of Boron	1.18	0.75	0.89	0.31	0.51	0.45
S.Em.±	0.03	0.02	0.02	0.01	0.01	0.01
CD @ 5%	0.09	0.06	0.07	0.03	0.04	0.04

Note: RDF: Rec. Dose of Fertilizer for potato (75: 75: 100 kg ha^{-1} NPK); FYM: Farm Yard Manure @ 25 t ha^{-1}

Table 5: Effect of different levels of Gypsum and Boron on B and Zn content (mg kg^{-1}) in haulm and tuber of potato at harvest

Treatments	Zinc (mg/kg)		Boron (mg/kg)	
	Haulm	Tuber	Haulm	Tuber
T_1 : Absolute control	15.42	8.09	10.21	10.69
T_2 : RDF + FYM (POP)	18.35	11.02	12.17	14.84
T_3 : T_2 + 75 kg Gypsum ha^{-1}	17.98	11.16	11.28	12.81
T_4 : T_2 + 150 kg Gypsum ha^{-1}	19.02	10.56	10.97	12.06
T_5 : T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}	17.96	11.24	16.27	21.96
T_6 : T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}	18.52	10.52	20.92	23.08
T_7 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	19.12	11.18	13.02	14.36
T_8 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	18.42	10.84	15.11	16.40
T_9 : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	19.05	11.24	13.28	14.01
T_{10} : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	19.27	11.32	13.92	14.82
T_{11} : T_2 + 0.25% Foliar spray of Boron	18.62	10.94	14.03	15.22
T_{12} : T_2 + 0.5% Foliar spray of Boron	18.84	10.96	15.08	16.35
S.Em.±	0.49	0.29	0.35	0.40
CD @ 5%	1.44	0.85	1.03	1.17

Note: RDF: Rec. Dose of Fertilizer for potato (75: 75: 100 kg ha^{-1} NPK); FYM: Farm Yard Manure @ 25 t ha^{-1}

Table 6: Effect of different levels of Gypsum and Boron on N, P and K uptake (kg ha^{-1}) in haulm and tuber of potato at harvest

Treatments	Nitrogen (kg ha-^{1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	Haulm	Tuber	Total	Haulm	Tuber	Total	Haulm	Tuber	Total
T_1 : Absolute control	7.56	16.99	24.56	1.22	4.00	5.22	8.43	24.66	33.09
T_2 : RDF + FYM (POP)	17.53	37.63	55.16	2.65	7.75	10.40	23.33	45.38	68.71
T_3 : T_2 + 75 kg Gypsum ha^{-1}	23.27	51.28	74.55	3.37	11.99	15.36	34.29	62.93	97.23
T_4 : T_2 + 150 kg Gypsum ha^{-1}	29.09	55.39	84.48	4.91	14.11	19.01	47.08	72.59	119.68
T_5 : T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}	25.33	60.13	85.46	3.76	14.65	18.41	39.22	77.48	116.70
T_6 : T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}	33.31	67.69	101.00	5.76	18.08	23.84	55.72	93.33	149.05
T_7 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	25.74	60.05	85.79	4.01	15.80	19.81	38.77	75.06	113.84
T_8 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	28.99	62.64	91.62	4.59	16.76	21.34	45.50	82.59	128.08
T_9 : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	30.06	66.19	96.25	5.23	18.32	23.54	49.29	87.42	136.71
T_{10} : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	36.17	71.44	107.62	6.42	20.04	26.46	61.17	99.32	160.49
T_{11} : T_2 + 0.25% Foliar spray of Boron	19.54	42.11	61.65	2.97	7.32	10.30	26.77	47.91	74.67
T_{12} : T_2 + 0.5% Foliar spray of Boron	20.66	42.70	63.36	3.22	8.60	11.83	28.28	46.39	74.67
S.Em.±	0.62	1.34	1.97	0.11	0.38	0.49	0.99	1.75	2.74
CD @ 5%	1.83	3.94	5.77	0.33	1.10	1.43	2.91	5.14	8.05

Note: RDF: Rec. Dose of Fertilizer for potato (75: 75: 100 kg ha^{-1} NPK); FYM: Farm Yard Manure @ 25 t ha^{-1}

Table 7: Effect of different levels of Gypsum and Boron on Ca, Mg and S uptake (kg ha^{-1}) in haulm and tuber of potato at harvest

Treatments	Calcium (kg ha^{-1})			Magnesium (kg ha^{-1})			Sulphur (kg ha^{-1})		
	Haulm	Tuber	Total	Haulm	Tuber	Total	Haulm	Tuber	Total
T_1 : Absolute control	6.08	9.00	15.07	2.54	3.50	6.04	1.92	5.85	7.77
T_2 : RDF + FYM (POP)	14.00	19.65	33.65	10.85	7.47	18.32	5.80	11.35	17.15
T_3 : T_2 + 75 kg Gypsum ha^{-1}	20.05	27.97	48.03	16.07	11.99	28.06	8.88	16.32	25.20
T_4 : T_2 + 150 kg Gypsum ha^{-1}	26.00	30.62	56.62	20.91	14.11	35.01	11.63	19.27	30.90
T_5 : T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}	22.06	33.15	55.21	17.98	14.65	32.62	10.13	20.04	30.18
T_6 : T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}	31.66	41.20	72.86	24.88	18.78	43.66	13.98	23.96	37.95
T_7 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	22.23	32.00	54.23	18.22	15.01	33.23	10.03	19.75	29.78

T_8 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	25.32	31.52	56.84	20.55	15.56	36.11	11.37	20.35	31.72
T_9 : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	27.82	39.96	67.78	22.03	18.04	40.07	12.32	23.73	36.05
T_{10} : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	34.20	44.43	78.63	27.18	20.33	47.51	15.13	25.99	41.12
T_{11} : T_2 + 0.25% Foliar spray of Boron	16.14	22.58	38.72	12.46	8.85	21.31	6.80	13.12	19.92
T_{12} : T_2 + 0.5% Foliar spray of Boron	17.29	23.04	40.33	13.04	9.52	22.56	7.47	13.82	21.30
S.Em.±	0.64	0.80	1.44	0.45	0.35	0.79	0.27	0.46	0.73
CD @ 5%	1.87	2.34	4.21	1.32	1.01	2.33	0.79	1.35	2.14

Note: RDF: Rec. Dose of Fertilizer for potato (75: 75: 100 kg ha^{-1} NPK); FYM: Farm Yard Manure @ 25 t ha^{-1}

Table 8: Effect of different levels of Gypsum and Boron on Zn and B uptake (g ha $^{-1}$) in haulm and tuber of potato at harvest

Treatments	Zinc (g ha^{-1})			Boron(kg/ha)		
	Haulm	Tuber	Total	Haulm	Tuber	Total
T_1 : Absolute control	9.56	13.48	23.04	0.27	17.81	24.14
T_2 : RDF + FYM (POP)	23.14	31.32	54.47	1.33	41.06	56.41
T_3 : T_2 + 75 kg Gypsum ha^{-1}	27.53	37.16	64.69	2.00	42.65	59.92
T_4 : T_2 + 150 kg Gypsum ha^{-1}	34.58	36.33	70.91	2.48	41.49	61.43
T_5 : T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}	29.35	43.33	72.68	2.57	84.65	111.24
T_6 : T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}	38.08	44.23	82.31	3.49	97.03	140.05
T_7 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	31.96	44.17	76.12	2.74	56.73	78.49
T_8 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	33.79	43.25	77.04	3.03	65.43	93.15
T_9 : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	35.98	46.79	82.77	3.23	58.32	83.12
T_{10} : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	41.76	49.31	91.08	3.66	64.56	95.08
T_{11} : T_2 + 0.25% Foliar spray of Boron	26.37	33.38	59.75	1.72	46.44	66.31
T_{12} : T_2 + 0.5% Foliar spray of Boron	27.61	33.67	61.28	1.82	50.23	72.33
S.Em.±	0.83	1.05	1.88	0.63	1.52	2.15
CD @ 5%	2.43	3.08	5.51	1.83	4.47	6.30

Note: RDF: Rec. Dose of Fertilizer for potato (75: 75: 100 kg ha^{-1} NPK); FYM: Farm Yard Manure @ 25 t ha^{-1}

Table 9: Effect of different levels of Gypsum and Boron on quality parameters of potato

Treatments	Quality		
	Starch (%)	Protein (%)	TSS (º Brix)
T_1 : Absolute control	58.65	6.38	5.09
T_2 : RDF + FYM (POP)	61.24	8.50	5.36
T_3 : T_2 + 75 kg Gypsum ha^{-1}	68.34	9.63	5.56
T_4 : T_2 + 150 kg Gypsum ha^{-1}	68.56	10.06	5.59
T_5 : T_2 + 75 kg Gypsum ha^{-1} + soil application of Boron @ 2.5 kg ha^{-1}	70.68	9.75	5.63
T_6 : T_2 + 150 kg Gypsum ha^{-1} + soil application of Boron @ 5 kg ha^{-1}	74.85	10.06	5.93
T_7 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	70.12	9.50	5.70
T_8 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	71.81	9.81	5.79
T_9 : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	73.42	9.94	5.85
T_{10} : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	79.47	10.28	6.10
T_{11} : T_2 + 0.25% Foliar spray of Boron	62.75	8.63	5.39
T_{12} : T_2 + 0.5% Foliar spray of Boron	62.91	8.69	5.41
S.Em.±	3.18	0.25	0.14
CD @ 5%	9.32	0.72	0.40

Note: RDF: Rec. Dose of Fertilizer for potato (75: 75: 100 kg ha $^{-1}$ NPK); FYM: Farm Yard Manure @ 25 t ha^{-1}

Table 10: Economics of potato as influenced by application of different levels of gypsum and boron

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1 : Absolute control	62425	122920	60495	1.97
T_2 : RDF + FYM (POP)	84451	286860	202409	3.40
T_3 : T_2 + 75 kg Gypsum ha^{-1}	85201	335720	250519	3.94
T_4 : T_2 + 150 kg Gypsum ha^{-1}	85951	343840	257889	4.00
T_5 : T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}	88951	370440	281489	4.16
T_6 : T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}	93451	392467	299016	4.20
T_7 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	87076	358073	270997	4.11
T_8 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	88951	370720	281769	4.17
T_9 : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25% Boron	87826	384907	297081	4.38
T_{10} : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5% Boron	89701	404749	315048	4.51
T_{11} : T_2 + 0.25% Foliar spray of Boron	86326	300347	214021	3.48
T_{12} : T_2 + 0.5% Foliar spray of Boron	88201	312695	224494	3.55

Note: RDF: Rec. Dose of Fertilizer for potato (75: 75: 100 kg ha^{-1} NPK); FYM: Farm Yard Manure @ 25 t ha^{-1}

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