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Effect of Different Levels of Gypsum and Boron on Growth and Yield of Potato *(Solanum tuberosum* L.)

VEERESHKUMAR SHIRUR, S. CHANNAKESHAVA AND S. T. BHAIRAPPANAVAR
College of Agriculture, Hassan - 573 225
e-Mail : channa_2005@rediffmail.com

ABSTRACT

A field experiment was conducted during *kharif* 2018 in farmers field to study the effect of different levels of gypsum and boron on soil properties, growth and yield of potato with twelve treatments and replicated thrice using RBD. Different levels of Gypsum and Boron were applied *viz.,* 75 kg ha^{-1} and 150 kg ha^{-1} gypsum and 0.25 and 0.50 per cent foliar spray of boron along with RDF + FYM common to all treatments except absolute control. The study revealed that application of gypsum and boron at different levels improved the growth, yield and yield parameters over absolute control. Significantly higher plant height (40.93 cm) and number of branches (2.97) at harvest were observed in treatment T_{10} (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron) (2.97). Whereas, absolute control recorded significantly lowest plant height (33.10 cm) and number of branches per plant (1.87) in absolute control. Significantly higher dry matter of tubers at harvest was observed in treatment T_{10} (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron) (4356.30 kg ha^{-1}) which was significantly superior over all other treatments. Significantly lowest dry matter of tubers (1666.13 kg ha^{-1}) recorded in control. As regard to yield parameters, 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}) were recorded with the application of 150 kg Gypsum ha^{-1} + Foliar spray of 0.5 per cent Boron along with RDF +FYM. Significantly lower tuber yield was found in absolute control (12.08 t ha^{-1}). 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 : Growth & yield of patato, Levels of gypsum & boron, Dry matter

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 egg plant. 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 and the leaves near the growing tip appear stunted. Lack of boron reduces both tuber quality and quantity of tubers. Boron stabilizes calcium in the cell wall and acts synergistic with calcium to improve plant resistance to disease, pest and environmental stresses. In this respect, it can help to minimize apical necrosis of sprouts. In potato calcium is the key nutrient in cell wall strength and cellular adherence. Calcium deficiency in potatoes is most severe in acidic (*i.e.,* pH<5) sandy soils. 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 is undertaken to study 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' N Latitude and 750 33' E Longitude at an altitude of 827 m above Mean Sea Level. The initial soil properties of experimental site were analysed using standard methods (Table 1) as described by Jackson (1973). The experiment was layed out in Randomised block design with twelve treatments and replicated thrice. The gross plot size of experimental plot was 5 m x 5 m and net plot size was 3 m x 4.2 m. The twelve treatments were imposed as per the treatments detailed as below.

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^{-1}
2. FYM @ 25 t ha^{-1} 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 through Gypsum.
5. T_5 to T_{12} : Boron was applied through Solubor

Table 1

Initial physical and chemical properties of soil at the experimental site

Parameter	Value
Physical parameters	
Sand %	73.20
Silt %	12.25
Clay %	13.60
Soil texture	Sandy
Chemical properties	
pH (1:2.5)	7.25
EC (dSm^{-1}) (1:2.5)	0.37
CEC[c mol (p+) kg^{-1}]	6.68
Organic carbon (g kg^{-1})	5.30
Available N (kg ha^{-1})	299.25
Available P_2O_5 (kg ha^{-1})	47.68
Available K_2O (kg ha^{-1})	173.54
Exchangeable Ca (c mol (p+) kg^{-1})	3.45
Exchangeable Mg (c mol(p+) kg^{-1})	1.86
Available sulphur (kg ha^{-1})	11.83
DTPA Fe (mg kg^{-1})	8.83
DTPA Mn (mg kg^{-1})	11.49
DTPA Zn (mg kg^{-1})	0.74
DTPA Cu (mg kg^{-1})	0.61
Hot water soluble boron (mg kg^{-1})	0.45

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 temperature

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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 Mancozeb (2.0 g in one litre of water) for 20 minutes and dried in shade overnight before planting to prevent the decay of seed tubers.

The growth and yield parameters were recorded at harvest in selected plants in each treatment and replication. The plant samples at harvest were collected and analysed for major (N, P & K) and micronutrients (Zn,Cu, Mn and B) uptake studies. Experimental data obtained were subjected to statistical analysis adopting Fisher's method of analysis of variance as out lined by Gomez and Gomez (1984). The level of significance used in F' test was given at five per cent. Critical difference (CD) values are given in the table at five per cent level of significance.

RESULTS AND DISCUSSION

Results from the study revealed that significantly higher plant height (Table 2) was noticed in treatment T_{10} (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron) (40.93 cm) and was at par with T_6 (T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}) (40.13 cm) and T_9 (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25 % Boron) (39.67cm). Whereas, the lowest plant height was noticed in case of absolute control T_1 (33.10cm).

Significantly higher plant height under these treatments were due to the variation among the different treatments and also may be due to different dose of gypsum which is in accordance with the findings of Bhagyalakshmi *et al.* (2010).

TABLE 2

Effect of different levels of Gypsum and Boron on plant height (cm) and number of branches $plant^{-1}$ at different growth stages of potato

Treatments	Plant height (cm)			Number of branches $plant^{-1}$		
	30 DAP	60 DAP	At Harvest	30 DAP	60 DAP	At Harvest
T_1 : Absolute control	17.86	31.41	33.10	1.79	1.87	1.87
T_2 : RDF + FYM (POP)	18.13	34.12	36.33	1.95	2.07	2.07
T_3 : T_2 + 75 kg Gypsum ha^{-1}	20.22	36.43	37.33	2.23	2.43	2.43
T_4 : T_2 + 150 kg Gypsum ha^{-1}	20.33	35.61	37.63	2.29	2.47	2.47
T_5 : T_2 + 75 kg Gypsum ha^{-1} + soil application of Boron @ 2.5 kg ha^{-1}	20.86	36.78	38.93	2.47	2.70	2.70
T_6 : T_2 + 150 kg Gypsum ha^{-1} + soil application of Boron @ 5 kg ha^{-1}	22.40	38.15	40.13	2.64	2.87	2.87
T_7 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.25 % Boron	20.66	36.56	38.13	2.44	2.67	2.67
T_8 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron	21.67	37.17	39.17	2.51	2.73	2.73
T_9 : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25 % Boron	21.93	37.85	39.67	2.61	2.80	2.80
T_{10} : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron	22.86	38.92	40.93	2.74	2.97	2.97
T_{11} : T_2 + 0.25 % Foliar spray of Boron	19.33	34.36	36.73	2.07	2.27	2.27
T_{12} : T_2 + 0.5 % Foliar spray of Boron	19.66	35.12	37.23	2.12	2.33	2.33
S.Em.±	0.65	1.11	1.12	0.08	0.09	0.09
CD @ 5%	1.90	3.26	3.28	0.24	0.28	0.28

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

Significantly higher number of branches per plant at harvest (Table 2) were observed in treatment T_{10} (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron) (2.97) followed by T_6 (T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}) (2.87) and T_9 (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25 % Boron) (2.80) which were significantly superior over all other treatments. Where, absolute control recorded significantly lowest number of branches per plant (1.87). The maximum number of branches were recorded in T_{10} (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron) at harvest (2.97 branches plant^{-1}) which are in close proximity with the findings of Channakeshava *et al.* (2016) who reported maximum number of branches *i.e.,* (4-5) in *cv.* Kufri Sutlej of potato.

Dry Matter of Haulms (kg ha^{-1})

Dry matter production of haulms differ significantly (Table 3) due to application of different levels of gypsum and boron. However, Significantly higher dry matter of haulms at harvest was observed in treatment T_{10} (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron) (2192.33 kg ha^{-1}) followed by T_6 (T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}) (2056.01 kg ha^{-1}) and T_9 (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25 % Boron) (1867.18 kg ha^{-1}) which were significantly superior over all other treatments. Where, absolute control recorded significantly lowest dry matter of haulm (619.95 kg ha^{-1}).

Dry Matter of Tubers (kg ha^{-1})

The data on the dry matter of tubers at harvest that were significantly influenced by different levels of

TABLE 3

Effect of different levels of Gypsum and Boron on dry matter production (kg ha^{-1}) of potato at harvest

Treatments	Dry matter of haulms (kg ha^{-1})	Dry matter of tubers (kg ha^{-1})	Total dry matter (kg ha^{-1})
T_1 : Absolute control	619.95	1666.13	2286.08
T_2 : RDF + FYM (POP)	1261.27	2767.12	4028.39
T_3 : T_2 + 75 kg Gypsum ha^{-1}	1530.89	3329.82	4860.71
T_4 : T_2 + 150 kg Gypsum ha^{-1}	1817.92	3440.46	5258.38
T_5 : T_2 + 75 kg Gypsum ha^{-1} + Soil application of Boron @ 2.5 kg ha^{-1}	1634.23	3854.62	5488.85
T_6 : T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}	2056.01	4204.24	6260.25
T_7 : T_2 + 75 kg Gypsum ha^{-1}+ Foliar spray of 0.25 % Boron	1671.29	3950.64	5621.93
T_8 : T_2 + 75 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron	1834.56	3989.69	5824.24
T_9 : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25 % Boron	1867.18	4162.67	6029.84
T_{10} : T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron	2192.33	4356.30	6548.63
T_{11} : T_2 + 0.25 % Foliar spray of Boron	1416.20	3051.30	4467.50
T_{12} : T_2 + 0.5 % Foliar spray of Boron	1465.30	3072.17	4537.47
S.Em.±	95.67	113.95	209.32
CD @ 5%	280.59	334.19	614.78

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

gypsum and boron on potato are presented in Table 3. Significantly higher dry matter of tubers at harvest was observed in treatment T_{10} (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron) (4356.30 kg ha^{-1}) followed by T_6 (T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}) (4204.24 kg ha^{-1}) and T_9 (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25 % Boron) (4162.67 kg ha^{-1}) which were significantly superior over all other treatments. Whereas, absolute control recorded significantly lowest dry matter of tubers (1666.13 kg ha^{-1}). Higher total dry matter of tubers at harvest was observed in treatment T_{10} (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.5 % Boron) (6548.63 kg ha^{-1}) followed by T_6 (T_2 + 150 kg Gypsum ha^{-1} + Soil application of Boron @ 5 kg ha^{-1}) (6260.25 kg ha^{-1}) and T_9 (T_2 + 150 kg Gypsum ha^{-1} + Foliar spray of 0.25 % Boron) (6029.84 kg ha^{-1}) which were significantly superior over all other treatments. Whereas, absolute control recorded significantly lowest total dry matter (2286.08 kg ha^{-1}).

This might be due to application of calcium and sulphur which had played an important role in improving the nutrient uptake,that provides better conditions for improving growth characters. Micronutrient showed somewhat lower effect in increasing the dry matter of haulms and tubers. The similar findings was also reported by Ali *et al*. (2013) found that the increasing dose of sulphur up to 50 kg / ha increases the plant height, haulms and growth parameters.

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

Significantly higher tuber weight per plant at harvest (Table 4) 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 $plant^{-1}$).

TABLE 4

Effect of different levels of Gypsum and Boron on yield components and 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}

Number of Tubers per Plant

Significantly higher number of tubers per plant (Table 4) 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 (Table 4) 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 and 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.

Singh *et al.* (2014) found increased tuber yield due to increasing calcium to medium levels. The results imply that applying additional gypsum (15 t ha^{-1}) might significantly increased the tuber yield, but further increase in the gypsum rate (40 t ha^{-1}) might not have a positive effect on the tuber yield.

Application of B significantly increased tuber number as well as tuber yield per hectare. Combined application of NPK and B produced higher tuber yield with reduced cracking of tubers which might be ascribed to either direct or cumulative effect of supplied macro and micro-nutrients on metabolic processes of potato (Singh *et al.*, 2014). Greater tuber yield might further be attributed to increased availability of these nutrients for the actively growing plants (Singh *et al.*, 2014), increasing RNA and DNA contents in reproductive tissues increased the translocation of photosynthates from source to sink or tubers during entire tuber growth stage.

Protein Content

The data on protein content as influenced by different levels of gypsum and boron on potato after harvest are presented in Fig.1. The data reveals that T_{10} (T_2+ 150 kg Gypsum ha^{-1} + foliar spray of Boron @ 0.5 %) recorded significantly higher protein of 10.28 per cent, 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 per cent. Lower protein content of 6.38 per cent was recorded in T_1 that is absolute control.

Starch Content

The data on starch content (Fig. 1) as influenced by different levels of gypsum and boron on potato after harvest 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 per cent, which 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 per cent. Lower starch content of 58.65 per cent was recorded in T_1 that is absolute control.

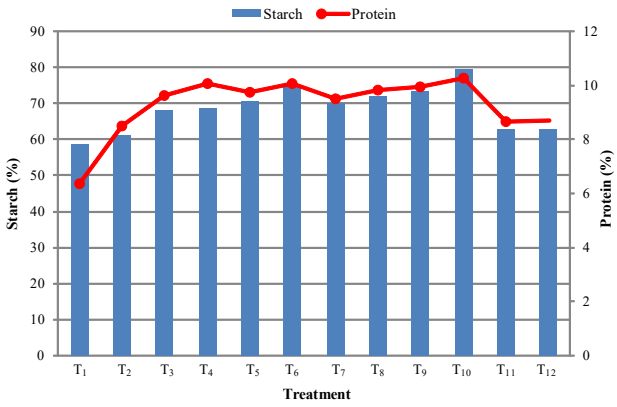

Fig. 1 : Effect of different levels of Gypsum and Boron on starch and protein content (%) of potato tuber

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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.

Economics of Crop

The highest B:C ratio was found in T_{10} (4.51) followed by T_9 (4.38) compared to all other treatments. The higher B: C ratio obtained with these treatments was mainly due to higher yield obtained (Fig. 2).

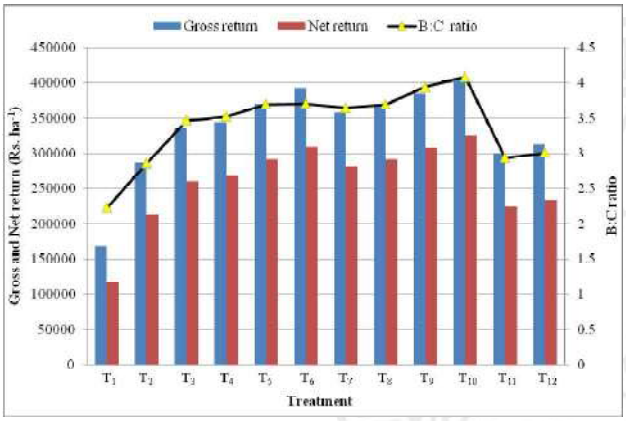

Fig. 2 : Economics of potato as influenced by application of different levels of gypsum and boron

Application of gypsum @ 150 kg per hectare and 0.5 per cent foliar spray of boron along with RDF increased the yield parameters and yield of tubers significantly over other treatments. The similar trend was also followed with respect to protien and starch content of potato.

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