International Journal of Chemical Studies

**P-ISSN: 2349–8528**
**E-ISSN: 2321–4902**
IJCS 2019; 7(6): 2521-2524

Received: 09-09-2019
Accepted: 13-10-2019

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# Effect of boron, gypsum on yield and yield attributes of Indian mustard (*Brassica juncea* L.) in amended alkali soil

**Sanjeev Sharma, RK Pathak, and Hanuman Prasad Pandey**

**Abstract**
A field experiment for two consecutive seasons (2016-2017, 2017-2018) was conducted to study the effect of three levels of Boron (0.5, 1.0, 1.5 $kgha^{-1}$) and three levels of gypsum (100, 150, 200 kg $ha^{-1}$) on yield of mustard, nutrient uptake and changes in soil characteristics under amended alkali soil condition. Results showed that yield and yield attributes of mustard were significantly improved with application of gypsum and B, either applied separately or conjointly. Conjoint use of Boron (@ 1$kgha^{-1}$), gypsum (@150 $kgha^{-1}$), however, gave best performance in terms of yield, yield attributes as also the nutrient uptake and oil content of mustard. Similar observations were recorded on changes in soil characteristics particularly in respect to drop in exchangeable Na levels.

**Keywords:** boron, gypsum, yield attributes, amended alkali

## Introduction
Mustard (*Brassica juncea* L.) is major rabi oil seed is India. This crop accounts for nearly one third of the oil produced in India. Rajasthan, U.P., Haryana, M.P. and Gujarat cover more than 80% of acreage under mustard. B plays an important role in physiology of mustard crop as it responds very well to B fertilization (Karthikeyan and Shukla 2008) [4]. Positive response to B application has also been reported by Mangel and Kirkby 1987 [8], Saha *et al*. 2003, Jaiswal *et al*. 2015 [3]. Farmers are generally unaware with the importance of B and as such do not fertilize mustard crop with B. Mustard, being family of cruciferae need sulphur for their growth and development. Sulphur plays a multiple role for better productivity as well as quality of oil seed (Briswas *et al*. 1995). Sulphur is the major constituent of amino acid like cystic etc. and helps in the formation of chlorophyll. Agricultural grade gypsum contains about 75% gypsum with 14-18% S. gypsum is available in India and is a cheaper source of S which may be used for oil seed crop. Therefore, present study was undertaken to evaluate response of B and gypsum, applied separately and conjointly, on yield, yield attributes and oil content of mustard under amended alkali soil condition. Study on corresponding improvement in soil characteristics as also on nutrient uptake by the crop due to various treatments was also undertaken.

## Material and Method
A field experiment was conducted at Krishi Vigyan Kendra, Thariyaon, Fatehpur Farm during 2016-17 and 2017-2018. Soil of the site was initially sodic in nature with pH 9.5, ECe ($dsm^{-1}$) 6.2 and ESP 58.5 which was amended with standardized technique of amelioration developed by C.S.S.R.I. Kernal using gypsum as amendment. After 5 years of standard practice the soil was brought to near normal showing following chemical parameters.

**Table 1:** Type of value

| Soil Characteristics | Value |
|---|---|
| Textural class | Sandy Loam |
| Bulk density ($Mgm^{-3}$) | 1.10 |
| Particle density ($Mgm^{-3}$) | 2.40 |
| Soil (pHs) | 8.0 |
| EC ($dsm^{-1}$) | 1.2 |
| E.S.P. | 14.2 |
| Organic carbon ($gkg^{-1}$) | 3.2 |
| Available N ($Kgha^{-1}$) | 158 |
| Available $P_2O_5$ ($Kgha^{-1}$) | 18.5 |
| Available $K_2O$ ($Kgha^{-1}$) | 255 |

The experiment was laid out in randomized block design with 3 levels of Boron (0.5, 1.0, 1.5 $Kgha^{-1}$) and 3 levels of gypsum (100, 150, 200 ($Kgha^{-1}$) with their combination. Mustard (R.H. 749) was taken as test crop. Recommended dose of nitrogen (N), Phosphorus ($P_2O_5$), Potash (K2O) and Zinc (Zn) was applied @ 80:40:40:5$Kgha^{-1}$ to the crop in the form of urea, di-ammonium phosphate, muriate of potash and zinc Sulphate with composition of 46%N, 18% N and 46% $P_2O_5$, 60% $K_2O$, 21% Zn respectively. Half dose of N and full doses of phosphorus, potash and Zn were applied as basal and remaining half dose of N was applied as top dressing at 30 days after showing. Plots were treated with boron (Borax 10.5/B) and gypsum with their required doses according to treatments prior five days of sowing of mustard crop. Boron and gypsum with possible combination comprised of sixteen treatments including control. Experimental plots, as per treatment, received agricultural grade gypsum showing 75% purity ($CaSO_4.2H_2O$) and thus supplied S @14 kg per 100 kg agricultural grade gypsum. The important biometric observations and yield attributes were recorded. Plant samples were collected of maturity stage and were analysed for various chemical indices. Soil samples were collected at 0-15 cm depth after harvest of crop every season and analysed for chemical characteristics. N was determined by micro Kjeldahl method (Piper 1966). Available P was determined using 0.5 M $NaHCO_3$ and available K was determined using 1 N $NH_4OAC$ extractant with the help of flame photometer. Plant samples were digested in di-acid mixture of $HNO_3$ and $HClO_4$ (4:1) and in the extract phosphorus and potassium were determined by vanadomolybdate phosphoric yellow colour method and flame photometer respectively. Dry ashing method (Chapman and Prat 1961) was adopted for the preparation of seed and stover samples to estimate B. The soil samples were analysed for available P by extracting with hot 0.02 M $CaCl_2$ (Aitken *et al*. 1987). Boron content in soil extract and plant digest was determined by Spectrophotometer using azomethine-H (John *et al*. 1975). Exchangeable Na% was determined by finding out C.EC and exch. Na values by the method suggested in USDA Handbook 60. Oil content in seed was determined by following the solvent extraction process using soxhlet apparatus (AOAC 1970) with petroleum ether as the solvent.

## Result and Discussion

### Effect boron and gypsum application on growth and yield attributes

Observations presented in Table 2 clearly showed distinct response on plant height when boron and gypsum were applied separately. Increasing doses of B did not show improvement in height of mustard plant while increasing doses by gypsum responded to increased height of the plant, maximum with gypsum @ 150 $Kgha^{-1}$. The combined effect of boron and gypsum application, however, showed positive response to progressively increased height of mustard crop. Maximum plant height of 175.2 cm was recorded in T3+T6 treatment receiving boron and gypsum conjointly @1$Kgha^{-1}$ and @150$Kgha^{-1}$ respectively. Contrary to above observations, the number of seeds $siliquae^{-1}$, number of siliqua $plant^{-1}$ and length of siliqua (cm) significantly increased with increasing doses of boron as against control, being maximum of 16.9, 240, 5.1 cm respectively under $T_3$ treatment receiving B @ 1 $Kgha^{-1}$. Almost similar trend in terms of these attributes were observed with gypsum application when applied @ 150 Kg $ha^{-1}$. Conjunctive effect of boron and gypsum application, however, showed that number of seeds $siliquae^{-1}$, number of siliqua $plant^{-1}$, length of siliqua (cm) improved significantly not only over control but also against boron and gypsum treatment applied separately, being maximum of 18.2, 248, 5.8 cm respectively under $T_3$+$T_6$ treatments.

Treatment effects as presented in Table 2 clearly showed marked improvement in stover and seed yield with progressive increase in dose of B and gypsum applied separately being maximum under B and gypsum applied @ 1$kgha^{-1}$ and 150 $Kgha^{-1}$ respectively. Maximum stover yield of 0.56 t $ha^{-1}$ was recorded under T3 and T6 treatments receiving boron and gypsum @ 1 $Kgha^{-1}$ and 150 $Kgha^{-1}$ respectively. Similarly significantly increased seed yield of 2 t $ha^{-1}$ and 2.1$tha^{-1}$ was recorded under T3 and T6 treatments respectively. The maximum stover (0.62 t $ha^{-1}$) and seed yield (2.5 t $ha^{-1}$) accounting an increase of 10 and 31 percent respectively was however recorded under T3+T6 treatment over control showing beneficial effect of combined application of boron and gypsum. Significant effect of B on yield and yield attributes of crop particularly mustard has been reported by Hossain *et al*. (2012) [2], Mathew and George (2013). The increase in yield and yield attributes of mustard may be due to role of B in cell division, carbohydrate metabolism and its regulatory effect on other element.

Beneficial effect of gypsum on yield and yield attributes of mustard may be ascribed to beneficial role of sulphur and Ca present in gypsum which in combination with B not only improved biotic activity but also helped improve physico-chemical properties of soil which ultimately improved availability of macro-micronutrients to the crop. Beneficial effect of S on mustard crop has also been reported by Raj *et al*. (1998).

### Effect of treatments on nutrient uptake and oil content.

The uptake of N, P, K, S and boron as influenced by treatments is presented in Table 3. The uptake of NPK and S by seed and stover increased significantly with increasing levels of boron and gypsum application. A critical examination revealed that increasing order of uptake of NPK and S in seed and stover of mustard crop was observed only up to boron and gypsum dose of 1 $Kgha^{-1}$ and 150 $Kgha^{-1}$ respectively. Further increase in their doses did not show any enhanced impact on uptake of nutrients under reference. A maximum uptake of 61.0g $ha^{-1}$ and 18.2 $gha^{-1}$ of N, 10.5 $gha^{-1}$ and 6.9 $gha^{-1}$ of P, 13.5 $gha^{-1}$ and 50.6 $gha^{-1}$ of K and 19.2$gha^{-1}$ and 10$gha^{-1}$ of S was recorded in seed and stover of mustard respectively under $T_2$ (Boron @ 1 $Kgha^{-1}$). Similar trend in uptake of these nutrients was observed with application of gypsum, maximum being under T6 (gypsum @150 $Kgha^{-1}$) treatment. Further examination of data revealed that combination of boron and gypsum enhanced uptake these nutrients significantly in seed and stover of mustard, highest being under the treatment of $T_3+T_6$ recording maximum of 65 gha$^{-1}$ and 20.0 gha$^{-1}$ of N, 130.0gha$^{-1}$ and 8.5gha$^{-1}$ of P, 15.4 gha$^{-1}$ and 55.2 gha$^{-1}$ K and 25.5 gha$^{-1}$, 11.4 gha$^{-1}$ of Sin seed and stover respectively. Similarly Boron uptake by mustard seed and stover increased significantly over control by treatment of boron and gypsum application. Maximum B uptake by stover and seed of 337gha$^{-1}$ and 120.6 gha$^{-1}$ respectively was recorded under T3+T6 treatment which showed about 4 times increase in B uptake as against control. The increase in uptake of these nutrients by crop under influence of boron and gypsum appears partly due to boron and sulphur which attributed to profuse vegetative and root growth, thereby activating biotic activity leading to enhanced absorption of nutrients. The role of sulphur and Ca present in gypsum proved helpful in enhancing availability of nutrients in amended alkali soil condition with initial pHs 8.0. Singh *et al*. (2007) [11], Patel *et al*. (2007) [8] and Kumar and Yadav (2007) [5] also observed positive effect of S on uptake of nutrient in mustard.

The oil content increased significantly with application of Boron and gypsum when applied separately. A Maximum of 35% and 34.9% oil content was recorded under $T_3$ (B @1kgha$^{-1}$) and $T_6$ (gypsum @150 kgha$^{-1}$) respectively. Combined application of boron and gypsum, however, responded to highest oil content to the level of 36.8% under $T_3+T_6$ treatment. The increase in oil content may be due to B and Son biosynthesis of oil and fatty acid. These observations are in agreement of Malewar *et al*. 2001; Mallick and Raj 2015 [7]; Mandal and Das (2014).

## Treatment effect on soil properties

Varying levels of Boron and gypsum applied separately and in combination tended to have marked effect on properties of soil after harvest of mustard crop as would be evidenced from the data presented in table 4. Soil pH, Ec (dsm$^{-1}$) tended to decrease slightly as a result of treatment, reducing maximum under treatment $T_3+T_6$. Boron and gypsum, when applied separately, also showed marked influence on reducing soil pH and Ec dsm$^{-1}$ after harvest of mustard crop. Organic C (g kgha$^{-1}$) also improved as a result of treatments after harvest of mustard crop, maximum being 3.5 g kgha$^{-1}$ under treatment $T_3+T_6$ as against control (3.2 g kgha$^{-1}$). Availability of nutrients (N, P, K) was significantly influenced as a result of B and gypsum application whether applied separately or in combination. Data presented in Table 4 showed that successive increase in doses of boron and gypsum increased available N level s to 200 kgha$^{-1}$ from 180 kgha$^{-1}$. Similarly P levels increased to 22.3 kgha$^{-1}$ and 22.0 kgha$^{-1}$ as against 20.2 kgha$^{-1}$ (control) under $T_3$ and $T_6$ treatments respectively. Similarly K content increased to 290 kgha$^{-1}$ with application of Boron and gypsum as against control (280.8 Kgha$^{-1}$) after harvest of mustard crop. Maximum available N,P,K to the order of 212, 22.9 and 310 Kgha$^{-1}$ respectively was however recorded with conjoint use of B and gypsum under $T_3+T_6$ treatments receiving B and gypsum @ 1 Kgha$^{-1}$ and 150 Kgha$^{-1}$ respectively. Significant decrease in ExNa% was observed as against control under treatment receiving gypsum as compared to Boron application. Maximum and significant drop in Ex Na from 15.2 to 10.5% was, however, recorded under treatment $T_3+T_6$ after harvest of mustard crop.

Two years study on performance of mustard crop and soil characteristics to various treatment under amended alkali soil condition clearly indicate application of B and gypsum @ 1kgha$^{-1}$ and 150 kgha$^{-1}$ respectively either applied separately or conjointly significantly helped improve not only mustard yield but enhanced uptake of N,P,K and B by the crop. Similar observations were recorded in improvement of oil content of mustard. Relative efficacy of various treatment, however, revealed that conjoint use of Boron and gypsum @ 1kgha$^{-1}$, 150 kg ha$^{-1}$ ($T_3+T_6$) proved most effective in improving aforesaid parameters. Similar observations were recorded in terms of improvement in soil characteristics.

**Table 2:** Effect of graded dose of Boron and gypsum on seed and Stover yield of mustard and yield attributes.

| Treatments | Plant height (cm) | No. of seed Siliquae$^{-1}$ | No. of Siliquae Plant$^{-1}$ | Length of Siliquae (cm) | Stover yield (Tha$^{-1}$) | Seed yield (tha$^{-1}$) |
|---|---|---|---|---|---|---|
| $T_1$ Control | 170.0 | 15.2 | 210 | 4.7 | 0.52 | 1.77 |
| $T_2$ Boron @0.5 Kgha$^{-1}$ | 170.5 | 16.2 | 222 | 5.0 | 0.55 | 1.89 |
| $T_3$ Boron @1.0 Kgha$^{-1}$ | 170.8 | 16.9 | 240 | 5.1 | 0.56 | 2.0 |
| $T_4$ Boron @1.5 Kgha$^{-1}$ | 170.9 | 16.8 | 240 | 5.1 | 0.55 | 2.0 |
| $T_5$ Gypsum @100Kgha$^{-1}$ | 170.8 | 16.1 | 221 | 5.1 | 0.54 | 1.88 |
| $T_6$ Gypsum @150Kgha$^{-1}$ | 173.0 | 16.8 | 239 | 5.1 | 0.56 | 2.10 |
| $T_7$ Gypsum @200Kgha$^{-1}$ | 173.1 | 16.9 | 240 | 5.1 | 0.55 | 2.08 |
| $T_8$ $T_2+T_5$ | 171.6 | 17.0 | 241 | 5.3 | 0.57 | 2.00 |
| $T_9$ $T_2+T_6$ | 173.0 | 17.2 | 242 | 5.4 | 0.58 | 2.15 |
| $T_{10}$ $T_2+T_7$ | 173.0 | 17.2 | 243 | 5.5 | 0.58 | 2.12 |
| $T_{11}$ $T_3+T_5$ | 173.2 | 17.3 | 243 | 5.5 | 0.58 | 2.16 |
| $T_{12}$ $T_3+T_6$ | 175.2 | 18.2 | 248 | 5.8 | 0.62 | 2.50 |
| $T_{13}$ $T_3+T_7$ | 173.2 | 17.6 | 243 | 5.5 | 0.58 | 2.20 |
| $T_{14}$ $T_4+T_5$ | 173.4 | 17.5 | 243 | 5.4 | 0.58 | 2.21 |
| $T_{15}$ $T_4+T_6$ | 173.2 | 17.6 | 243 | 5.5 | 0.57 | 2.20 |
| $T_{16}$ $T_4+T_7$ | 173.5 | 17.5 | 243 | 5.6 | 0.58 | 2.22 |
| SEm± | | 0.50 | 5.0 | 0.10 | | 0.15 |
| CD (P=0.05) | | 1.90 | 13.0 | 0.26 | | 0.37 |

**Table 3:** Effect of graded doses of Boron and gypsum on N,P,K,S, Boron uptake and oil content in mustard (pooled data of two years) ($gha^{-1}$)

| Treatments | N | | P | | K | | S | | B | | Oil content (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seed | Stover | Seed | Stover | Seed | Stover | Seed | Stover | Seed | Stover | |
| $T_1$ Control | 47.2 | 15.1 | 9.5 | 6.0 | 10.0 | 41.0 | 15.2 | 8.0 | 80.0 | 30.0 | 33.8 |
| $T_2$ Boron @0.5 $Kgha^{-1}$ | 60.1 | 16.1 | 10.0 | 6.5 | 12.8 | 48.0 | 17.2 | 8.8 | 230.5 | 32.5 | 34.4 |
| $T_3$ Boron @1.0 $Kgha^{-1}$ | 61.0 | 18.2 | 10.5 | 6.9 | 13.5 | 50.6 | 19.2 | 10.0 | 280.0 | 88.0 | 34.9 |
| $T_4$ Boron @1.5 $Kgha^{-1}$ | 61.1 | 17.9 | 10.4 | 6.8 | 13.3 | 50.4 | 19.3 | 9.9 | 279.0 | 89.0 | 35.0 |
| $T_5$ Gypsum @100$Kgha^{-1}$ | 60.5 | 16.2 | 10.1 | 6.6 | 13.0 | 48.3 | 17.5 | 8.8 | 230.6 | 33.5 | 34.3 |
| $T_6$ Gypsum @150$Kgha^{-1}$ | 61.8 | 17.9 | 10.6 | 6.9 | 13.8 | 50.8 | 19.5 | 10.1 | 281.0 | 89.0 | 34.7 |
| $T_7$ Gypsum @200$Kgha^{-1}$ | 60.2 | 17.8 | 10.5 | 6.8 | 13.8 | 50.8 | 19.6 | 10.0 | 280.0 | 88.8 | 34.9 |
| $T_8$ $T_2$+$T_5$ | 62.8 | 18.8 | 11.0 | 7.1 | 14.0 | 51.7 | 21.5 | 10.8 | 305.0 | 100.2 | 35.2 |
| $T_9$ $T_2$+$T_6$ | 62.0 | 18.5 | 11.3 | 7.2 | 14.1 | 51.8 | 22.5 | 10.8 | 330.8 | 105.6 | 35.4 |
| $T_1$ $T_2$+$T_7$ | 62.2 | 18.6 | 11.5 | 7.3 | 14.2 | 51.8 | 22.6 | 10.9 | 332.0 | 107.8 | 35.3 |
| $T_{11}$ $T_3$+$T_5$ | 62.0 | 18.5 | 11.5 | 7.2 | 14.0 | 51.6 | 22.5 | 10.5 | 337.0 | 120.6 | 36.8 |
| $T_{12}$ $T_3$+$T_6$ | 65.0 | 20.0 | 13.0 | 8.5 | 15.4 | 55.2 | 25.5 | 11.4 | 333.0 | 108.6 | 35.4 |
| $T_{13}$ $T_3$+$T_7$ | 63.0 | 18.8 | 11.8 | 7.3 | 14.5 | 53.2 | 24.5 | 10.8 | 336.0 | 110.3 | 35.0 |
| $T_{14}$ $T_4$+$T_5$ | 63.3 | 18.6 | 11.9 | 7.4 | 14.3 | 53.5 | 24.6 | 10.7 | 335.0 | 112.3 | 35.4 |
| $T_{15}$ $T_4$+$T_6$ | 63.0 | 18.7 | 11.9 | 7.4 | 14.2 | 53.4 | 24.3 | 10.8 | 336.0 | 111.5 | 35.4 |
| $T_{16}$ $T_4$+$T_7$ | 62.99 | 18.7 | 11.9 | 7.4 | 14.2 | 53.2 | 24.4 | 10.8 | | | |
| SEm± | 1.0 | 0.40 | 0.25 | 0.20 | 0.30 | 1.10 | 0.45 | 0.25 | 0.13 | 7.61 | 0.58 |
| CD (P=0.05) | 3.10 | 0.13 | 0.70 | 0.60 | 0.85 | 3.10 | 1.20 | 0.68 | 38.70 | 23.20 | 1.70 |

**Table 4:** Effect of graded dose of Boron and gypsum on pH, electrical conductivity, organic carbon, N,P,K in soil after harvest of mustard crop.

| Treatments | Pooled data for two cropping season (2016-17, 2017-2018) | | | | | | Ex Na% |
|---|---|---|---|---|---|---|---|
| | Phs | EC($dsm^{-1}$) | Organic C ($gkg^{-1}$) | Available nutrients ($Kgha^{-1}$) | | | |
| | | | | N | P | K | |
| $T_1$ Control | 8.0 | 1.2 | 3.2 | 180 | 20.2 | 280.8 | 15.2 |
| $T_2$ Boron @0.5 $Kgha^{-1}$ | 8.0 | 1.1 | 3.3 | 190 | 21.2 | 290.0 | 14.7 |
| $T_3$ Boron @1.0 $Kgha^{-1}$ | 7.9 | 1.1 | 3.2 | 200 | 22.3 | 291.0 | 14.6 |
| $T_4$ Boron @1.5 $Kgha^{-1}$ | 8.0 | 1.1 | 3.3 | 200 | 22.3 | 290.0 | 14.3 |
| $T_5$ Gypsum @100$Kgha^{-1}$ | 7.9 | 1.0 | 3.3 | 192 | 21.6 | 289.0 | 12.5 |
| $T_6$ Gypsum @150$Kgha^{-1}$ | 7.9 | 1.0 | 3.4 | 199 | 22.0 | 290.0 | 12.0 |
| $T_7$ Gypsum @200$Kgha^{-1}$ | 7.9 | 1.0 | 3.3 | 200 | 22.0 | 290.0 | 12.0 |
| $T_8$ $T_2$+$T_5$ | 7.8 | 1.0 | 3.3 | 205 | 22.4 | 300.0 | 11.5 |
| $T_9$ $T_2$+$T_6$ | 7.8 | 1.0 | 3.4 | 206 | 22.8 | 301.0 | 11.4 |
| $T_{10}$ $T_2$+$T_7$ | 7.8 | 1.0 | 3.4 | 208 | 22.8 | 302.5 | 11.4 |
| $T_{11}$ $T_3$+$T_5$ | 7.9 | 1.0 | 3.4 | 208 | 22.0 | 304.5 | 11.4 |
| $T_{12}$ $T_3$+$T_6$ | 7.7 | 0.9 | 3.5 | 212 | 22.9 | 310.0 | 10.5 |
| $T_{13}$ $T_3$+$T_7$ | 7.8 | 0.9 | 3.3 | 209 | 22.6 | 305.0 | 10.6 |
| $T_{14}$ $T_4$+$T_5$ | 7.9 | 0.9 | 3.4 | 209 | 22.7 | 306.0 | 10.8 |
| $T_{15}$ $T_4$+$T_6$ | 7.9 | 1.0 | 3.3 | 208 | 22.8 | 305.0 | 10.7 |
| $T_{16}$ $T_4$+$T_7$ | 7.8 | 0.9 | 3.3 | 209 | 22.7 | 305.0 | 10.7 |

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