**Influence of different level of Boron on uptake of nutrients in wheat (*Triticum aestivum* L.) crop**

**Abstract:** A field experiment was conducted at the research plot of Udai Pratap Autonomous College (UPAC), Varanasi, Uttar Pradesh, adjoining the Department of Agricultural Chemistry and Soil Science, to study the effect of levels of boron on nutrient uptake in the wheat crop of *the rabi* season 2012-13. Boron was applied at six levels (0.0, 0.5, 1.0, 1.5, 2.0, and 2.5 kg ha-1), with NPK @ 120:80:60, and the experiment was laid out in Randomized block design (RBD) with three replications. The application of 2 kg boron ha-1 recorded significantly higher boron uptake (95.50 g ha-1) in grain, higher uptake of boron in straw (145.27 g ha-1), total boron uptake (240.77 g ha-1). The amount of increase in P uptake above control was larger at the optimum B level (2.0 kg B ha-1) treatment. The authors suggested the use of optimum level of boron for better nutrient uptake.

**Introduction:**

Wheat (*Triticum aestivum* L.) is the most important food security crop in the world with a production of 791.02 million tons (MT) on about 234 million hectares (Mha) (USDA, 2024). India contributes 14 % of global production of wheat. India ranks third position in wheat production. Uttar Pradesh contributes 30% of the total production of wheat in the country, Madhya Pradesh contributes 23%, and Punjab contributes 15%. Wheat serves as a staple food, contributing approximately 20% of the protein and calories consumed globally (FAOSTAT, 2015). It is consumed in various forms, including bread, cakes, biscuits, bakery products, and numerous confectionery items. The straw serves as animal feed and is also utilised in paper manufacturing (Iqtidar *et al*., 2006). Boron is a critical element for vascular plants (Warrington, 1923; Wimmer *et al*., 2020). Low availability of Boron (B) in soils hinders the development of floral organs and the elongation of pollen tubes, which leads to a loss of crop production (Shorrocks, 1997). Wheat has more sensitivity to boron. Boron shortage is more severe than in maize and rice. Boron negatively impacts numerous stages of wheat growth and development. Wheat variety has varying responses to their adaptation to low boron levels in soils.

**Materials and Methods:**

The experiment was conducted at research plot of Udai Pratap Autonomous College (U.P. College), Varanasi (Uttar Pradesh), adjoining the Department of Agricultural Chemistry and Soil Science during *rabi* season of 2012-13. The climate of this area is subtropical monsoon type. The experiment was laid out in Randomized Block Design (RBD) with three replications. The experiment comprised with six levels of boron *viz.* (T0: Control, T1: 0.5 kg/ ha, T2: 1.0 kg/ ha, T3: 1.5 kg/ ha, T4: 2.0 and T5: 2.5 kg/ ha). There were total 18 treatment combinations. The uniform application of 120:80:60: N:P2O5:K2­O kg/ ha except in T0 (absolute control) were applied. Seeds of wheat were sown with the spacing of 20 × 10 cm in the last week of November. All the recommended cultural was followed throughout the experimental period. Initial physico-chemical properties of experimental soil were presented in table 1. The data on nutrient uptakes were recorded and analysed as per Huu *et al.* (2022).

**Table 1:** Initial physico-chemical properties of experimental soil

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Values** | **Parameters** | **Values** |
| Bulk density (Mg/ m3) | 1.37 | Available nitrogen (kg/ ha) | 214.8 |
| Particle density (Mg/ m3) | 2.57 | Available phosphorus (kg/ ha) | 16 |
| Porosity (%) | 47 | Available potassium (kg/ ha) | 130 |
| pH | 7.6 | Available sulphur (kg/ ha) | 12.4 |
| EC (dS/ m) | 0.29 | Available boron (ppm) | 0.42 |
| Organic carbon (%) | 0.54 | Texture class | Sandy loam |

$$Nutrient uptake \left(kg ha^{-1}\right)= \frac{Nutrient content \left(\%\right)×yield \left(kg ha^{-1}\right)}{100}$$

**Result and Discussion:**

The data about boron uptake by wheat grain is reported in table 2 and represented in figure 1. The incorporation of boron improved the average boron uptake from 19.30 g ha-1 in the control (T0) to 70.17 g ha-1 (T1), 77.30 g ha-1 (T2), 83.27 g ha-1 (T3), 95.50 g ha-1 (T4), and 94.10 g ha-1 under T5 treatment. The data in table 2 clearly indicates that the application of B significantly changed B uptake by straw across all treatment levels. A comparable tendency was observed with straw, analogous to that of grain. Nevertheless, the extent of boron uptake in straw exceeded that in grain. This may be attributed to an elevated concentration of B in the straw and increased straw yield. The total boron uptake (grain + straw) altered by soil-applied boron is reported in table 2 and represented in Figure 1. Analysis of the data revealed that higher amounts of applied boron significantly improved its uptake, rising from 54.13 q ha-1 in the control treatment to 344.80 q ha-1 with the application of 2.0 kg B ha-1 (T4). Analysis of the total dry matter yield (Table 3) and total boron uptake indicated that dry matter production peaked at 2.0 kg B ha-1, with a little decline noticed at the higher level of 2.5 kg B ha-1. This suggests that application of Boron over optimum level had negative influence on crop productivity (Mehboob *et al.,* 2021; Zhao *et al.*, 2021). Analysis of the data on boron uptake by grain, straw, and total boron uptake revealed that a smaller proportion of total boron was utilised in grain production, while a greater amount was kept in straw. This implies limited mobility of B in plant. The rise in total B uptake was proportional to an increase in B level. The percent recovery of applied B ranged from 24.88 at T1 (0.5 kg B ha-1) to 7.22 percent at 2.5 kg ha-1. This indicated that maximum recovery occurred at 0.5 kg B ha-1, and it reduced with increasing levels of B treatment.

**Influence of boron application on phosphorus and sulphur uptake**

Boron, phosphorus, and sulphur are anionic nutritional elements, and the application of one may influence the uptake of other elements (Vera-Maldonado *et al.,* 2024). The variable response of wheat to B might influence P and S nutrition; hence the effect of B treatment on the uptake of these nutrients by the wheat crop was taken under study.

**Table 2:** Boron uptake by the wheat crop as affected by different treatments

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatment** | **B uptake by grain****(g ha-1)** | **B uptake by straw****(g ha-1)** | **Total B uptake****(g ha-1)** | **Percent increase over control at B level (kg ha-1)** | **Percent recovery at B level (kg ha-1)** |
| **T0** | 19.30 | 34.83 | 54.13 | - | - |
| **T1** | 70.17 | 108.37 | 178.53 | 229.82 | 24.88 |
| **T2** | 77.30 | 118.03 | 195.33 | 261.22 | 14.12 |
| **T3** | 83.27 | 127.53 | 210.80 | 289.94 | 10.44 |
| **T4** | 95.50 | 145.27 | 240.77 | 344.80 | 9.33 |
| **T5** | 94.10 | 104.67 | 234.77 | 333.72 | 7.22 |
| **S.Em** | 2.17 | 2.53 | 4.05 | - | - |
| **C.D.** | 6.91 | 8.09 | 12.93 | - | - |

**Note:** T0= Control (no input), T1= B @ 0.5 kg ha­-1, T2= B@ 1.0 kg ha­-1, T3= B @ 1.5 kg ha­-1, T4= B @ 2.0 kg ha­-1, T5= B @ 2.5 kg ha­-1

**Figure 1:** Boron uptake by the wheat crop as affected by different treatments

**Phosphorus uptake (grain + straw)**

As regards P uptake by wheat crops, it was revealed that B application greatly influenced it (Table 3). The total P absorption by the wheat crop changed from 3.84 kg ha-1 in the control (T0) to 14.18 and 14.33 kg ha-1 with T4 and T5, respectively. The amount of increase in P uptake above control was larger at the optimum B level (2.0 kg B ha-1) treatment. It was inferred that B application in B-deficient soil boosts the efficiency of wheat crops to exploit native phosphorous for their usage by crops. Increased root growth at even early stages owing to B treatment appears to be the key explanation for this. Irfan *et al.* (2019) also observed a favourable effect of B treatment on P uptake by the wheat crop.

**Sulphur uptake (grain + straw)**

As regards P uptake by wheat crops, it was revealed that B application greatly influenced it (Table 3). The total P absorption by the wheat crop changed from 3.84 kg ha-1 in the control (T0) to 14.18 and 14.33 kg ha-1 with T4 and T5, respectively. The amount of increase in P uptake above control was larger at the optimum B level (2.0 kg B ha-1) treatment. It was inferred that B application in B-deficient soil boosts the efficiency of wheat crops to exploit native phosphorous for their usage by crops. Increased root growth at even early stages owing to B treatment appears to be the key explanation for this. Dash *et al.* (2015) also observed a favourable effect of B treatment on P uptake by the wheat crop.

**Boron content in post-harvest soil**

The data on Boron which is available to plant have been represented in table 3. A glimpse over the data made it evident that application of boron at 0.5, 1.0, 1.5, 2.0 and 2.5 kg ha-1 significantly improve the mean available boron in soil from 0.39 (T0: control) to 0.66, 0.70, 0.78, 0.83 and 0.84 mg kg-1, respectively. The result also showed that the available B status of soil was enhanced due to B application to sufficient level (more than critical level of 0.48 mg kg-1) even after the harvest of wheat crop which confirm the general concept that a sufficient residual amount is left in soil after B application. Appreciable increases in B status of soil after their applications have also been reported by Laik *et al*. (2021).

**Table 3:** Phosphorus and sulphur uptake and B content in post-harvest soil as affected by different treatments

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment** | **Phosphorus uptake by crop (kg ha-1)** | **Sulphur uptake by crop (kg ha-1 )** | **B Content in soil (mg kg-1)** |
| **T0** | 3.84 | 6.16 | 0.39 |
| **T1** | 10.15 | 11.03 | 0.66 |
| **T2** | 11.12 | 10.87 | 0.70 |
| **T3** | 11.97 | 10.68 | 0.78 |
| **T4** | 14.18 | 10.48 | 0.83 |
| **T5** | 14.33 | 9.71 | 0.84 |
| **S.Em** | 0.25 | 0.18 | 0.01 |
| **C.D.** | 0.80 | 0.57 | 0.02 |

**Note:** T0= Control (no input), T1= B @ 0.5 kg ha­-1, T2= B@ 1.0 kg ha­-1, T3= B @ 1.5 kg ha­-1, T4= B @ 2.0 kg ha­-1, T5= B @ 2.5 kg ha­-1

**Figure 2:** Phosphorus and sulphur uptake as affected by different treatments

**Conclusion:**

On the basis of above findings it can be concluded that, application of optimum dose of boron significantly and positively affected uptake of boron in wheat crop and B status of soil. Boron application @ 2.0 kg ha-1 was found to be the optimum dose for wheat crop. Its application beyond 2.0 kg ha-1 may adversely affect the yield of wheat. Highest phosphorus uptake (14.33 kg ha-1) was found to be recorded with application of higher dose of boron (2.5 kg ha-1).

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**References:**

Dash, A. K., Singh, H. K., Mahakud, T., Pradhan, K. C., & Jena, D. (2015).Interaction effect of nitrogen, phosphorus, potassium with sulphur, boron and zinc on yield and nutrient uptake by rice under rice– rice cropping system in inceptisol of coastal Odisha. *Int. Res. J. Agric. Sci. Soil Sci*. 5 (1), 14–21.

FAOSTAT (Food and Agricultural Organization of the United Nations Statistics), 2015. Food Balance Sheets. FAOSTAT, Rome.

Iqtidar, H., Khan, M., & Khan, E. (2006).Bread wheat varieties as influenced by different nitrogen levels*. J. Zhejiang Univ. Sci. B*., 7 (1), 70–78.

Irfan, M., Abbas, M., Shah, J. A., Depar, N., & Sial, N. A. (2019). Interactive effect of phosphorus and boron on plant growth, nutrient accumulation and grain yield of wheat grown on calcareous soil. *Eurasian Journal of Soil Science*, 8(1), 17-26.

Jan, S., Nasrullah, R., Khan, M. I., & Ullah, I. (2018).Effects of zinc, boron and sulphur on the yield and nutrients uptake of wheat crop. *International Journal of Agricultural and Environmental Research*, *4*(2), 211-215.

Panse, V. G., & Sukhatme, P. V. (1985). Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi, India.

Sharma, N., Singh, R., & Kumar, K. (2012). Dry matter accumulation and nutrient uptake by Wheat (*Triticum aestivum* L.) under Poplar (*Populus deltoides*) based agroforestry system. *Agronomy*, 359673.

USDA. National Agricultural Statistics Service. (2024). 2022 census of agriculture, United States 836 summary and state data.

Manikant, P. (2002). Differential reaction of some wheat genotype to boron stress in calcareous soils. (M.Sc Thesis). Department of Soil Science *RAU, Pusa, Bihar*

Warington, K. (1923). The effect of boric acid and borax on the broad bean and certain other plants. *Annals of Botany*, 37(148), 629-672.

Wimmer, M.A., Abreu, I., Bell, R.W., Bienert, M.D., Brown, P.H., Dell, B., and Bienert, G.P. (2019). Boron: an essential element for vascular plants. *New Phytol*, 226(5), 1232-1237.

Shorrocks, V. M. (1997). The occurrence and correction of boron deficiency. *Plant and soil*, 193(1), 121-148.

Mehboob, N., Hussain, M., Minhas, W. A., Yasir, T. A., Naveed, M., Farooq, S., Alfarraj, S., & Zuan, A. T. K. (2021). Soil-Applied Boron Combined with Boron-Tolerant Bacteria (*Bacillus* sp. MN54) Improve Root Proliferation and Nodulation, Yield and Agronomic Grain Biofortification of Chickpea (*Cicer arietinum* L.). *Sustainability*, 13(17), 9811. https://doi.org/10.3390/su13179811

Zhao, Z., Wang, Y., Shi, J., Wang, S., White, P. J., Shi, L., & Xu, F. (2021). Effect of balanced application of boron and phosphorus fertilizers on soil bacterial community, seed yield and phosphorus use efficiency of Brassica napus. *Science of the total environment*, *751*, 141644.

Vera-Maldonado, P., Aquea, F., Reyes-Díaz, M., Cárcamo-Fincheira, P., Soto-Cerda, B., Nunes-Nesi, A., & Inostroza-Blancheteau, C. (2024). Role of boron and its interaction with other elements in plants. *Frontiers in Plant Science*, *15*, 1332459.

Laik, R., Singh, S. K., Pramanick, B., Kumari, V., Nath, D., Dessoky, E. S., Attia, A. O., Hassan, M. M., & Hossain, A. (2021). Improved Method of Boron Fertilization in Rice (*Oryza sativa* L.) Mustard (*Brassica juncea* L.) Cropping System in Upland Calcareous Soils. *Sustainability*, 13, 5037. https://doi.org/10.3390/ su13095037

Huu, T. N., Giau, T. T. N., Ngan, P. N., Van, T. T. B., & Khuong, N. Q. (2022). Potential of phosphorus solubilizing purple nonsulfur bacteria isolated from acid sulfate soil in improving soil property, nutrient uptake, and yield of pineapple (*Ananas comosus* L. Merrill) under acidic stress. *Applied and Environmental Soil Science*, *2022*(1), 8693479.