Environment and Ecology 41 (2) : 883—890, April—June 2023
ISSN 0970-0420

Foliar Application of Nano Urea and Boron on Growth, Yield Attributes and Yield in Wheat (*Triticum aestivum* L.)

Sudhir Kumar Yadav, M. A. Khan, Sunil Kumar Prajapati, Pradeep Kumar, Shivam Verma, Kuldeep Patel, Shikhar Verma

Received 19 December 2022, Accepted 23 February 2023, Published on 17 May 2023

ABSTRACT

A field experiment was conducted in the wired net house under pots, to study the combined effect of foliar application of Nano Urea and Boron on growth, yield attributes and yield in wheat (*Triticum aestivum* L.) were conducted during *rabi*-season in the year 2021-22 in Department of Crop Physiology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh (UP). The experiment comprising three levels of nitrogen (Nano urea) i.e., Nano urea @ 2000 ppm, Nano urea @ 2500 ppm and Nano urea @ 3000 ppm and three levels of boron i.e., Boron @ 0.20 kg ha^{-1}, Boron @ 0.25 kg ha^{-1} and Boron @ 0.3 kg ha^{-1} in Factorial Completely Randomized Design (FCRD) with three replications. The results indicated that the foliar application of nitrogen (Nano urea) @ 3000 ppm show better growth, yield attributes and yield viz., Plant height (82.23 cm), Dry weight $plant^{-1}$ (22.41 g), No. of leaves $plant^{-1}$ (27.17), Leaf area $plant^{-1}$ (433.69 cm^{-2}), at 75 DAS, Chlorophyll intensity (45.13) at pre flowering and Chlorophyll intensity (40.32) at post flowering, Days of heading (78.96), Days of maturity (123.40), No. of tillers $plant^{-1}$ (6.15) at maturity and seed yield $plant^{-1}$ (14.34 g). However, the boron level @ 0.30 kg ha^{-1} gave better growth, yield attributes and yield viz., Plant height (82.03 cm), Dry weight $plant^{-1}$ (22.36 g), No. of leaves $plant^{-1}$ (27.08), Leaf area $plant^{-1}$ (432.16) at 75 DAS, Chlorophyll intensity (44.94) at pre flowering and Chlorophyll intensity (45.13) at post flowering, Days of heading (78.90), Days of maturity (122.96), No. of tillers $plant^{-1}$ (5.84) at maturity and Seed yield $plant^{-1}$ (14.28 g). The results obviously suggest and may be concluded that foliar application of nitrogen and boron on wheat variety K-1006 significantly changed in morphological characteristics, yield attributes and yield due to improvement in vegetative and reproductive growth for higher productivity. On the basis of observed results were advised to farmers raise wheat with foliar application of nitrogen (Nano urea) @ 3000 ppm and boron @ 0.30 kg ha^{-1} for increases the production of wheat

Sudhir Kumar Yadav[1]*, M.A. Khan[2]
[2]Assistant Professor
Department of Crop Physiology, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, UP 208002, India

Sunil Kumar Prajapati[3], Shivam Verma[5]
Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, UP 208002, India

Pradeep Kumar[4]
[4]PhD Research Scholar
Department of Soil Conservation and Water Management, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, UP 208002, India.

Kuldeep Patel[6], Shikhar Verma[7]
[7]PhD Research Scholar
[6]Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore 03, India
[7]Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, UP 208002, India

Email : ysudhir185@gmail.com
*Corresponding author

crop. Where the interaction effect was non-significant.

Keywords Wheat, Nano urea, Boron, Yield, Yield attributes.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a self-pollinated cleistogamous type of annual plant, belonging to the family poaceae (grasses). It is an allohexaploid in nature with 21 pairs of chromosome (2n=42) and size of genome was approx 16 GB. These chromosomes are subdivided into 3 closely related (homoeologous) groups of chromosomes, A, B and D genomes. Each of these homoeologous groups normally contains 7 pairs of chromosomes (AABBDD). Generally, two species of wheat are commonly grown worldwide. The first one is *Triticum aestivum* or bread wheat, forms the classes hard red winter, hard red spring, soft red winter, hard white and soft white. The second, *Triticum turgidum* spp. durum, includes the durum and red durum wheat classes (macaroni or pasta wheat).

World wheat production is 779.30 million tones, in an area of 222.27 million hectares and productivity of 3.51 million tones per hectare (USDA 2021-22). To ensure global food security for rapidly growing population, wheat production needs to be doubled by 2050 (Hunter *et al.* 2017). India is the third largest wheat producer in the world. It contributes about 12% of wheat production in world. India produced 109.59 million tones and ranked next to the China in global wheat production during 2021-22 with acreage of 31.13 million hectares and average yield is 35.20 q ha^{-1}. In India, Uttar Pradesh, Maharashtra, Punjab, Haryana are major wheat producing states. In Uttar Pradesh, the area under wheat growing is 10.80 lakh ha and production was 38.00 lakh tones, with average productivity was 1740 kg ha^{-1} (Anonymous 2021-22). Wheat is a *rabi* season crop that is grown-up in tropics and sub tropics region and conjointly want cool temperature throughout its growth cycle.

Wheat kernel contains about 12% water including carbohydrates (65–80%) mainly as starch, protein 8–15%, containing adequate amounts of all essential amino acids (except lysine and tryptophan), fats (1.5-2%) minerals (1.5-2%), vitamins (such as B complex and vitamin E) and 2.2% crude fibers. Wheat straw is used for livestock feed and bedding industrial uses of wheat grain include starch for paste, alcohol oil and glut in straw may be used for now print paper board and other products.

Boron is one of the essential plant micronutrients taken up via the roots mostly in the form of boric acid. Its important role in plant metabolism which involves the stabilization of molecules with cis-diol groups. This element involves in the cell wall and nurtures membrane structure and functioning. It also participates in numerous ion, metabolite and hormone transport reactions. Plant species, as well as the genotypes within the species, dramatically differ in terms of boron requirements. The available soil boron which is deficient for one crop may exhibit toxic effects on another. Boron (B) deficiency is a widespread problem in relatively humid areas of the world (Gupta 2016). Despite such a problem, there are a few research publications on boron toxicity of crops. Boron is a unique micro-nutrient in that the threshold between deficiency and toxicity is narrow (Chatzistathis *et al.* 2021). It was found that 5-8 mg B kg^{-1} soil is unsuitable for some crops to grow. The deficiency problem can be solved by fertilization, whereas soil boron toxicity can be ameliorated using various procedures, however, these approaches are costly and time-consuming and they often show temporary effects. Boron poses a challenge as its management is difficult due to its high permeability and presence as an uncharged molecule at physiological pH. Boron is highly soluble and can be easily leached under high rainfall conditions to cause, deficiency in plants. Under low rainfall conditions, the opposite is often true that it is not sufficiently leached and, therefore, may accumulate to a level in the leaves that become toxic to plant growth and metabolism (Reid 2007). Boron may also accumulate in top-soil due to irrigation of crops using groundwater containing high boron content. Underground water for irrigation contains toxic amounts of B in arid or semiarid states of India, such as Uttar Pradesh, Rajasthan, Haryana, Punjab, and Gujrat (Sharma *et al.* 2014) demonstrated that B tolerance as well as drought tolerance is needed in dry areas having high levels of subsoil B. Similar, B and salinity or alkalinity tolerance are also needed in many areas having these problems. Our understanding of B toxicity is rather fragmented and limited despite agronomic importance (Lauchli 2002). Given the large areas of 3.79 m ha of alkaline soils in the Indo gangetic plains (CSSRI-A journey to excellence) and the association of B toxicity with saline and alkaline soils could be a major constraint to wheat production in India (Sharma *et al.* 2014). The particular focus of this research is to highlight any genetic differences in B tolerance of Indian relative to other wheat varieties.

Boron is also involved in the transport of sugars, synthesis and lignification of cell wall, cell wall structure, metabolism of carbohydrate and RNA, respiration, functions of membranes, synthesis of DNA and regulation of metal activated enzymes (Bhat *et al.* 2020). The range between the concentration of B essential for plant growth and the concentration causing toxicity is narrow (Nejad and Etesami 2020). In the regions of the world where climate is arid and semi-arid, high B concentrations are usually found in saline soils (Rengasamy 2006). It is reported that B toxicity reduces photosynthetic efficiency, leaf expansion and fruit set which ultimately decreased crop productivity (Yang *et al.* 2021). Plants exposed to B toxicity have reduced the root growth than at optimal B application and also toxicity causes abnormalities in the process of cell division in the meristematic regions of root (Gunes *et al.* 2003). Boron toxicity causes the oxidative stress in which the production of O_2 - and H_2O_2 is increased, and the excess B induces a significant reduction in photosynthetic rate and increase in intercellular CO_2 concentration (Sotiropoulos *et al.* 2002). Although it has been known that excess B inhibits photosynthesis, yet the information regarding the mechanism is still scarce (Chen *et al.* 2012). The various factors including decrease in photosynthetic enzymatic activities, oxidative load and diminished electron transport seem to reduce CO_2 assimilation under excess B conditions (Han *et al*. 2009).

Nitrogen is most important nutrient, which determine the growth and development of plant and also increase the protein content and yield of wheat crop (Haileselassie *et al.* 2014). It is considered essential for synthesis of protein and other biochemical product of the plant such as protoplasm which is the basis of life. Therefore, nitrogen is directly concerned with physiological process occurring within the plant. Although nitrogen is the most important element which play the vital role in wheat nutrition as it is required throughout the growing period of the crop. Nitrogenous fertilizers play vital role in production and quality of wheat (Aulakh and Malhi 2005). The nitrogen fertilizer which is applied directly to the soil is utilized only 20–50% by crops and rest of nitrogen is lost through denitrification and leaching, therefore, some struggles are required to reduce these losses. Foliar spray of nitrogen is a successful method which increases the accessibility of nitrogen to crop. Foliar applications of nitrogen have increased grain yield, especially when applied at tillering stage. Foliar spray of nitrogen is also very beneficial to get more growth and higher yield. The objectives of the experiments were to assess the effect of foliar application of nano urea and boron and it's combination on growth, yield and yield attributes of wheat.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in the wire net house under pots, during *rabi* season 2021-22 in the Department of Crop Physiology, CS Azad University of Agriculture and Technology, Kanpur (UP).

Climatic conditions

Climate is a summation of weather conditions over a region during a comparatively long period. It is related to longer area like zone, state, country and continent and for long-duration like months, season, and year. Geo-graphically, Kanpur is situated in the central part of Uttar Pradesh and the sub-tropical semi-arid tract of North India. It lies between 26°29' 35" North latitude and 80°18' 25" East longitudes and is located on an elevation of about 125.9 meters above mean sea level in Gangetic plain. It is situated in the central plain zone of Uttar Pradesh which is located on the right bank of the holy river the Ganga and falls under the upper Indo-Gangetic plain zone of India. The average annual rainfall is about 885.6 mm out of which normally about 88.70% is received during July to September.

Experimental details

The experiment comprising three levels of nitrogen (Nano urea) i.e. Nano urea @ 2000 ppm, Nano urea @ 2500 ppm and nano urea @ 3000 ppm and three levels of boron i.e., boron @ 0.20 kg ha^{-1}, boron @ 0.25 kg ha^{-1} and boron @ 0.3 kg ha^{-1} in Factorial Completely Randomized Design (FCRD) with three replications in 30 pots.

Variety

K-1006 (Shekhar) : It was released from Chandra Shekhar Azad University of Agriculture and Technology (UP) Kanpur in 2014. The optimum time of sowing this variety ranges from the 1st week of November to the 2nd week of December and its yield potential is 50–60 q ha^{-1}.

Characteristics of pot soil

The pot soil was sandy loam texture taken from the top 30 cm of the adjacent from the soil and it was completely free from roots and shoots and well pulverized. The chemical characteristics of pot soil viz., Organic carbon (0.48%), Total nitrogen (0.055%), Total phosphorus (0.083%), Total potash (0.024%) and was PH (7.3). The 8 kg of air-dried soil was in each pot in small lots and compacted after each filling. The pots were irrigated two days before sowing.

Fertilization

The phosphorus and potassium @ 60 kg/ha, 40 kg/ha, respectively were given by DAP and MOP as basal at the time of sowing, boron by borax while nitrogen through nano urea were sprayed on standing crop at three spits as per treatment. The use of a hand sprayer, the solution was carefully sprayed on the plants, and 1 liter of the solution was sprayed on the leaves. Through foliar spray at 30, 50 and 70 DAS after sowing and data took 35 DAS, 55 DAS, 75 DAS and maturity stage.

Sowing and harvesting

Foundation seed of wheat varieties K 1006 is sown on 16 November 2021. Sowing was done by manually at proper moisture with a uniform seed rate of 100 kg ha^{-1}and cover the seeds properly by manually. The crop was harvested when the ear head turned golden yellow in color and leaves and stem became dry. The plants were cut close to the ground and kept for drying. Bundled, and tagged separately. Bundles were brought to the floor and weighted after complete drying in the sunlight. Threshing was done pot-wise through manually, yield and yield attributes data were recorded carefully.

Observations recorded

Morphological characters

Plant height (cm) : Plant height was measured with the help of meter scale and recorded at 35, 55, and 75 DAS and maturity stage in three tagged plants in each pot. The height was measured from the base of the plant to the tip of the main stem of randomly tagged plants and mean values were calculated.

Leaf area plant^{-1} (cm^2) : Leaf area of three selected plants were measured with the help of automatic ear area meter and average leaf area was calculated and recorded at 35, 55 and 75 DAS was noted.

Dry weight of plant (g) : Three plants were selected randomly from each plot uprooted and chopped in all pieces and put them in the oven at 80°C till the constant weight after the dried samples were kept overnight in desiccators and then their dry weight of stem, leaf and total weighed.

Chlorophyll content (SPAD)

It was recorded by a hand-held device chlorophyll model: SPAD-502 PLUS (MANTOLA) and taken at pre- flowering and post-flowering stages.

Yield and yield component

Number of tiller plant^{-1} : Number of tiller on different stage of each of the randomly three selected each treatment per replication were counted separately and expressed on per plant basis as mean number of tiller on different plant.

Table 1. Effect of foliar application of nano urea and boron on growth indices of wheat.

Treatments	Plant height (cm) at maturity	Dry weight plant^{-1} at maturity	No. of leaves plant^{-1} at 75 DAS	Leaf area plant^{-1} (cm^2) at plant 75 DAS
Nitrogen (nano urea)				
2000 ppm urea	75.12	20.49	24.83	396.20
2500 ppm urea	78.58	21.42	25.95	414.26
3000 ppm urea	82.23	22.41	27.17	433.69
SEm(±)	1.25	0.36	0.62	7.07
CD (p=0.05)	2.64	0.76	1.32	14.85
Boron				
0.2 kg ha^{-1} boron	75.23	20.52	17.24	397.20
0.25 kg ha^{-1} boron	78.67	21.44	18.00	397.20
0.3 kg ha^{-1} boron	82.03	22.36	18.75	397.20
SEm (±)	1.25	0.36	0.62	7.07
CD (p=0.05)	2.64	0.76	1.32	14.85
Interaction (urea × boron)				
SEm (±)	2.17	0.63	1.08	12.24
CD (p=0.05)	NS	NS	NS	NS

Seed yield plant^{-1} (g) : Five samples plants were randomly selected from each plot and threshed weighed these. Separately and mean of these were count and recorded in gram to represent the seed yield plant.

Statistical analysis

The allocation of different treatments in the pot was allotted as per design. The data recorded on different growth characters, yield attributes, and grain yield during the investigation was subjected to statistical analysis of variance techniques in a Factorial Complete Randomized Design (Gomez and Gomez 1976).

RESULTS AND DISCUSSION

Growth indices

The perusal of the data reveals that the growths of plant (Table 1) were observed significantly better with the application of nitrogen (Nano urea) @ 3000 ppm and boron @ 0.3 kg ha^{-1}. The growth characteristics viz., Plant height (82.23 cm), Dry weight plant^{-1} (22.41 g), Number of leaves plant^{-1} (27.17, 27.08), Leaf area plant^{-1} (433.69, 432.16) at 75 DAS were found to be maximum by foliar application of nitrogen 3000 ppm. Among boron level the maximum plant growth was also recorded by application of @ 3 kg ha^{-1} boron viz, Plant height (82.03 cm), Dry weight plant^{-1} (22.36 g) at maturity, No. of tillers plant^{-1} (65.84) at maturity, No. of leaves plant^{-1} (27.08), Leaf area plant^{-1} (432.16) at 75 DAS. The interaction effect of nitrogen and boron was statistically non-significant and maximum growth was recorded with treatment combination of nitrogen (Nano urea) @ 3000 ppm + boron @ 0.3 kg/ha. Similar finding were also observed by Kamal (2009), Rahale (2010), Tulasi *et al.* (2011), Rawashdeh and Sala (2013), Raliya *et al.* (2013), Rawashdeh and Sala (2014), Leghari *et al.* (2016) and Mekdad and Shaaban (2020).

Table 2. Effect of foliar application of nano urea and boron on chlorophyll intensity, day of heading and day of maturity of wheat.

Treatments	Chlorophyll intensity at pre flowering	Chlorophyll intensity at post flowering	Day of heading	Day of maturity
Nitrogen (nano urea)				
2000 ppm urea	41.37	36.94	79.36	121.50
2500 ppm urea	43.27	38.66	78.81	122.50
3000 ppm urea	45.13	40.32	78.96	123.40
SEm (±)	0.50	0.33	0.14	0.31
CD (p=0.05)	1.07	0.71	0.30	0.66
Boron				
0.2 kg ha^{-1} boron	41.11	36.73	79.20	121.86
0.25 kg ha^{-1} boron	43.31	36.73	78.64	122.56
0.3 kg ha^{-1} boron	44.94	40.15	78.90	122.96
SEm (±)	0.50	0.33	0.14	0.31
CD (p=0.05)	1.07	0.71	0.30	0.66
Interaction (urea × boron)				
SEm (±)	0.88	0.58	0.24	0.54
CD (p=0.05)	NS	NS	NS	NS

Table 3. Effect of foliar application of nano urea and boron on number of tiller plant^{-1} and seed yield plant^{-1} (g) of wheat.

Treatments	No. of tiller plant^{-1} at maturity	Seed yield plant^{-1} (g)
Nitrogen (nano urea)		
2000 ppm urea	4.93	13.13
2500 ppm urea	5.24	13.75
3000 ppm urea	6.15	14.34
SEm (±)	0.20	0.18
CD (p=0.05)	0.42	0.38
Boron		
0.2 kg ha^{-1} boron	4.97	13.06
0.25 kg ha^{-1} boron	5.50	14.24
0.3 kg ha^{-1} boron	5.84	14.28
SEm (±)	0.20	0.18
CD (p=0.05)	0.42	0.38
Interaction (urea × boron)		
SEm (±)	0.35	0.31
CD (p=0.05)	NS	NS

Chlorophyll intensity

The data showed that the chlorophyll intensity (Table 2) at different growth stage were observed significantly better with the application of nitrogen (Nano urea) @ 3000 ppm and boron @ 0.3 kg ha^{-1}. The chlorophyll intensity at pre-flowering (45.13) and post-flowering (40.32) were found to be maximum by foliar application of nitrogen 3000 ppm. Similarly the maximum chlorophyll intensity of plant recorded at pre flowering (44.94) and at post flowering (40.15) with foliar spray of boron @ 0.30 kg ha^{-1}. Interaction effect was found to be non-significant but numerically higher value was observed with treatment nitrogen (Nano urea) @ 3000 ppm + boron @ 0.30 kg ha^{-1} at pre flowering (47.18) and post flowering (42.15). Similar finding were also observed by Tulasi *et al.* (2011) and by Nadim *et al.* (2012).

Days of heading

The data showed to the day of heading (Table 2) of wheat was significantly influenced by level foliar applied of Nano urea and boron. The foliar application of Nitrogen (Nano urea) @ 3000 ppm recorded highest day of heading (78.96) to followed by foliar application nitrogen (Nano urea) @ 2500 ppm (78.81). The days of heading increased significantly with increasing spraying of boron level @ 0.25 kg ha^{-1} (78.64 day) and @ 0.30 kg ha^{-1} (78.90 day). Combined effect was found to be non-significant but numerically higher value was observed with treatment nitrogen (Nano urea) @ 3000 ppm + boron @ 0.30 kg ha^{-1}at (77.20 day). Similar finding were also observed by (Zhang *et al.* 2012).

Day of maturity

The data showed to the day of maturity (Table 2) of wheat was significantly influenced by level foliar applied of nano urea and boron. The maximum day of maturity with foliar application of nitrogen (Nano urea) @ 3000 ppm (123.40). The day of maturity increased significantly with increasing spraying dose of boron level @ 0.25 kg ha^{-1} (122.56 days) and @ 0.30 kg ha^{-1} at day maturity (122.96 days). Combined effect was found to be non-significant but numerically higher value was observed with treatment (nitrogen @ 3000 ppm + boron @ 0.30 kg ha^{-1} at 123.90). Similar finding were also observed by Wang *et al.* (11).

Number of tiller plant^{-1}

The data showed to the number of tillers plant^{-1} (Table 3) of wheat was significantly influenced by level foliar applied of nano urea and boron. The highest number of tillers plant^{-1} (6.15) recorded with foliar application of nitrogen (Nano urea) @ 3000 ppm followed by foliar application of nitrogen (Nano urea) @ 2500 ppm (5.24). Among boron level, the highest number of tillers plant^{-1} (5.84) with application of boron @ 0.30 kg ha^{-1} followed by @ 0.25 kg ha^{-1} (5.50). Combined effect was found to be non-significant but numerically higher value was observed with treatment Nitrogen (Nano urea @ 3000 ppm + boron 0.30 kg ha^{-1} at 14.99 g). Similar finding were also observed by Kamal (2009) and Rawashdeh and Sala (2013).

Seed yield plant^{-1}

The data showed to the seed yield plant^{-1} (Table 3) of wheat was significantly influenced by level foliar applied of nano urea and boron. The highest seed yield plant^{-1} (14.34 g) recorded with foliar application of nitrogen (Nano urea) @ 3000 ppm followed by foliar application of nitrogen (Nano urea) @ 2500 ppm (13.75 g). Among boron level, the highest seed yield plant^{-1} (14.28 g) with application of boron @ 0.30 kg ha^{-1} followed by @ 0.25 kg ha^{-1} (14.24 g). Combined effect was found to be non-significant but numerically higher value was observed with treatment nitrogen (Nano urea @ 3000 ppm + boron 0.30 kg ha^{-1} at (14.99 g). Similar finding were also observed by Gunes *et al.* (2003), Bielski *et al*. (2020), Karthik *et al.* (2021).

CONCLUSION

On the basis of the experiment and discussion and it may be concluded that foliar application of Nano urea and boron on wheat significantly brought changes in growth, yield and yield attributes in vegetative and reproductive growth for higher yield. These substances insidiously workout can be employed successfully for yield maximization of wheat crop. Growth characteristics and yield viz., plant height, number of tillers plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1}, chlorophyll intensity, dry weight of plant and seed yield plant^{-1} were found to be maximum at foliar application of nitrogen (Nano urea) @ 3000 ppm and boron @ 0.3 kg/ha.

REFERENCES

Anonymous (2021-22) Annual progress report and area, production, Productivity of wheat. ICAR data book.

Aulakh MS, Malhi SS (2005) Interactions of nitrogen with other nutrients and water : Effect on crop yield and quality, nutrient use efficiency, carbon sequestration, and environmental pollution. *Adv Agron* 86 : 341—409.

Bhat BA, Islam ST, Ali A, Sheikh BA, Tariq L, Islam SU, Hassan Dar TU (2020) Role of micronutrients in secondary metabolism of plants. *In Pl Micronutrients*, pp 311—329.

Bielski S, Romaneckas K, Šarauskis E (2020) Impact of nitrogen and boron fertilization on winter triticale productivity parameters. *Agronomy* 10 (2) : 279.

Chatzistathis T, Fanourakis D, Aliniaeifard S, Kotsiras A, Delis C, Tsaniklidis G (2021) Leaf age-dependent effects of boron toxicity in two *Cucumis melo* varieties. *Agronomy* 11(4) : 759.

Chen X, Dobson JF, Raston CL (2012) *Vortex fluidic* exfoliation of graphite and boron nitride. *Chem Commun* 48 (31) : 3703—3705.

Gomez KA, Gomez AA (1976) Statistical procedure for agricultural research with emphasis on rice. 2nd edn. IRRI, Los Banos Philippine.

Gunes A, Alpaslan M, Inal A, Adak MS, Eraslan F, Cicek N (2003) Effects of boron fertilization on the yield and some yield components of bread and durum wheat. *Turkish J Agric For* 27 (6) : 329—335.

Gupta UC (2016) 8 Boron. *Pl Nutri*, pp 241.

Haileselassie B, Habte D, Haileselassie M, Gebremeskel G (2014) Effects of mineral nitrogen and phosphorus fertilizers on yield and nutrient utilization of bread wheat (*Tritcum aestivum* L.) on the sandy soils of Hawzen District, Northern Ethiopia. *Agricult For Fisheries* 3(3) : 189—198.

Han S, Tang N, Jiang HX, Yang LT, Li Y, Chen LS (2009) CO_2 assimilation, photosystem II photochemistry, carbohydrate metabolism and antioxidant system of citrus leaves in response to boron stress. *Pl Sci* 176 (1) : 143—153.

Hunter MC, Smith RG, Schipanski ME, Atwood LW, Mortensen DA (2017) Agriculture in 2050 : Recalibrating targets for sustainable intensification. *Biosci* 67(4) : 386—391.

Kamal A (2009) Effects of different methods of boron application on wheat. MSC thesis. Department of Soil Science, Bangladesh Agricultural University.

Karthik B, Umesha C, Sanodiya LK, Priyadarshini AS (2021) Impact of nitrogen levels and application of boron on yield and growth of greengram (*Vigna radiata* L.). *In Biol Forum–An Int J* 13 (3) : 08—11.

Lauchli A (2002) Functions of boron in higher plants : Recent advances and open questions. *Pl Biol* 4 : 190—192.

Leghari AH, Laghari GM, Ansari MA, Mirjat MA, Laghari UA, Leghari SJ, Abbasi ZA (2016) Effect of NPK and boron on growth and yield of wheat variety TJ-83 at Tandojam soil. *Ad Environ Biol* 10 (10) : 209—216.

Mekdad AAA, Shaaban A (2020) Integrative applications of nitrogen, zinc and boron to nutrients-deficient soil improves sugar beet productivity and technological sugar contents under semi-arid conditions. *J Pl Nutri* 43 (13) : 1935—1950.

Nadim MA, Awan LU, Baloch MS, Khan EA, Naveed K (2012) Response of wheat (*Triticum aestivum* L.) to different micronutrients and their application methods. *J Animal Pl Sci* 22 : 113—119.

Nejad SAG, Etesami H (2020) The importance of boron in plant nutrition. Metalloids in plants : Advances and future prospects, pp 433—449.

Rahale CS (2010) Nutrient lease pattern of nano-fertilizer formulations. PhD thesis. Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.

Raliya R, Tarafdar JCK, Gulecha, Choudhary K, Rameshwar Ram, Mal Prakash, Saran RP (2013) Review article ; scope of nanoscience and nanotechnology in agriculture. *J Appl Biol Biotechnol* 1 (03) : 041—044.

Rawashdeh HM, Sala F (2013) The effect of foliar ap plication of iron and boron on early growth parameters of wheat (*Triticum aestivum* L.). *Res J Agric Sci* 45 (1) : In press.

Rawashdeh HM, Sala F (2014) Influence of iron foliar fertilization on some growth and physiological parameters of wheat at two growth stages. Romania Scientific papers. *Series A Agron* 57 : 306—309.

Reid R (2007) Update on boron toxicity and tolerance in plants. *Adv Pl Animal Boron Nutri* 1 : 83—90.

Rengasamy P (2006) World salinization with emphasis on Australia. *J Experim Bot* 57 (5) : 1017—1023.

Sharma SK, Kumar A, Setter TL, Singh M, Lata C, Prasad KRK, Kulshrestha N (2014) Boron tolerance in wheat varieties. *Vegetos* 27(2) : 322—328.

Sotiropoulos TE, Therios NI, Dimassi NK, Bosbalidis A, Kofilids G (2002) Nutritional status, growth, CO_2 assimilation and leaf anatomical responses in two kiwi fruit species under boron toxicity. *J Pl Nutri* 25 : 1249—1261.

Tulasi G, Ramesh T, Rao PR, Sreedhar M (2011) Effect of boron application on total dry matter, grain filling and grain yield in rice (*Oryza sativa* L.). *J Res ANGRAU* 39 (4) : 86—88.

USDA (2021-22) Report US Department of Agriculture, Agricultural Res Service 2020 : 11—12.

Wang XY, Wang Y, Tian XH, Ma GH (2011) Effects of NM urea on nitrogen run of losses of surface water and nitrogen fertilizer efficiency in paddy field. *Trans Chin Soc Agric Engg* 1 : 106—111.

Yang LT, Pan JF, Hu NJ, Chen HH, Jiang HX, Lu YB, Chen LS (2021) Citrus physiological and molecular response to boron stresses. *Plants* 11(1) : 40.

Zhang ZM, Liu J, Han Z, Ma GH, Yuan LP (2012) The research of increasing the yield by nano-synergistic fertilizer on hybrid rice. *Humic Acid* 2 : 15—19.