EFFECT OF APPLICATION OF NITROGEN AND BORON TO CAULIFLOWER (*Brassica oleracea var. botrytis* L.) IN THE SOIL OF RAMPUR, CHITWAN

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ABSTRACT

A field experiment was conducted at Agriculture and Forestry University, Chitwan, Nepal from Nov 2017 to March 2018 to study the effects of Nitrogen and Boron on the nutrient uptake by the plant, soil properties, and biological yield of cauliflower (variety Indham-9803). Randomized complete block design with four replications and nine treatment combinations, including three doses of boron (1.7, 1.1, and 0.5 Kg/ha) and three doses of Nitrogen (260, 200, and 140 Kg/ha) were used in the trial. In the case of Nitrogen application, biological yield, soil organic matter, soil nitrogen, and leaf boron were recorded maximum from nitrogen dose N1, and those parameters were recorded minimum from nitrogen dose N3. Meanwhile, leaf boron and soil boron were recorded maximum from the individual doses of nitrogen N3 and N2 respectively and those parameters were recorded minimum from nitrogen dose N3. Increasing nitrogen dose to N1 significantly decreased the soil pH, while bulk density showed no significant changes with the application of nitrogen. In the case of boron application, biological yield, soil nitrogen, leaf nitrogen, soil boron, and leaf boron were recorded maximum from boron dose B1 and those parameters were recorded minimum from B3. Soil pH, Bulk density, and soil organic matter showed no significant changes with the application of boron. In the case of combined effect, maximum leaf nitrogen and soil boron was recorded from treatment T3:- N2B1. Therefore, relevant management of nitrogen fertilizers in the soil in combination with boron is crucial.

Keywords: *organic matter, randomized complete block design, soil nitrogen*

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the popular vegetable crop among cole crops belonging to the family Cruciferae. Cauliflower is a cool-season annual crop with the temperature requirement of 17°C to 18°C. Cauliflower is a widely cultivated vegetable in Nepal as well as all over the world. The annual production of cauliflower in Nepal is worth NRs 6.5 billion (Prasai, 2011). With the productivity of 10.4 tons per hectare and 352535 tons of production, cauliflower is being grown in Nepal in an area of around 33880 hectares (ABPSD, 2014). In Chitwan district of Nepal, the annual production of cauliflower is 5172 tons in an area of 431 hectares, with productivity 12 metric tons per hectare (MoALD, 2017).

Nitrogen is associated with vigorous vegetative growth. It is a constituent of protein, nucleic acid, chlorophyll, etc. It is helpful in large size compact curd development. The method of soil application of nitrogen is an important factor in increasing the yield of cauliflower. Basically in south Asia where land availability for crop production is low, nitrogen fertilizers are being progressively applied to crops to boost their yield and soil quality. Soil quality can be deteriorated by the extravagant application of nitrogen through fertilizers as they escalate the acidification process in soil, ammonia, and nitrogen oxide emissions, and nitrogen leaching (Herrero et al., 2010). Crop production can be optimized and the potential for nitrogen losses can be minimized by adjusting N fertilization rates using soil residual and potentially mineralizable nitrogen values (Schepers & Mosier, 1991).

Boron is indispensable for the normal growth and development of plants as it plays a crucial role in curd quality, curd yield, flowering and fertilization, and seed yield of cauliflower.

Boron is involved in the buffer action, precipitation of excess cation, nitrogen absorption, and nurturing of conducting tissues. The threshold between deficiency and toxicity is very narrow which makes boron unique among the other micronutrients (Shuang et al., 2009). Basically in Nepal boron has been applied at the rate of 5-10 Kg ha^{-1} in several vegetable crops to control the browning problem as well as to increase the yield (Kumar et al., 2014). Boron is found to be deficient in sandy loam soils due to more leaching; henceforth, the problem of boron deficiency is ubiquitous in the Chitwan district. In the context of Nepalese agriculture, farmers are haphazardly using various nitrogenous fertilizers for increasing productivity without following any scientific combinations which have resulted in serious degradation of soil and environmental quality via soil acidification and nitrogen leaching. Though the government of Nepal has made site-specific urea and borax recommendations for certain crops, farmers tend to apply their estimated fertilizer dose which has led to serious soil and yield-related issues.

Their application in the soil is expected to not only improve crop productivity but also influence soil properties and the status of other nutrients as they leave considerable residues in the soil. Yet on this prospect, there have been limited researches on the soils of Chitwan. Keeping these facts in view, the present research, therefore, was conducted to determine the effects of different doses of boron and nitrogen on the nutrient status, nutrient uptake, and the biological yield of cauliflower.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the horticulture farm of Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal from November 2017 to March 2018. Geographically, the experimental site is located at 27°37' N latitude and 84°25' E longitude, at an altitude of about 256 m above mean sea level. The experimental area is dominated by sandy loam (SL) type of soil. The topography of the study area was mainly low land with decent irrigation facilities and well-drained soil.

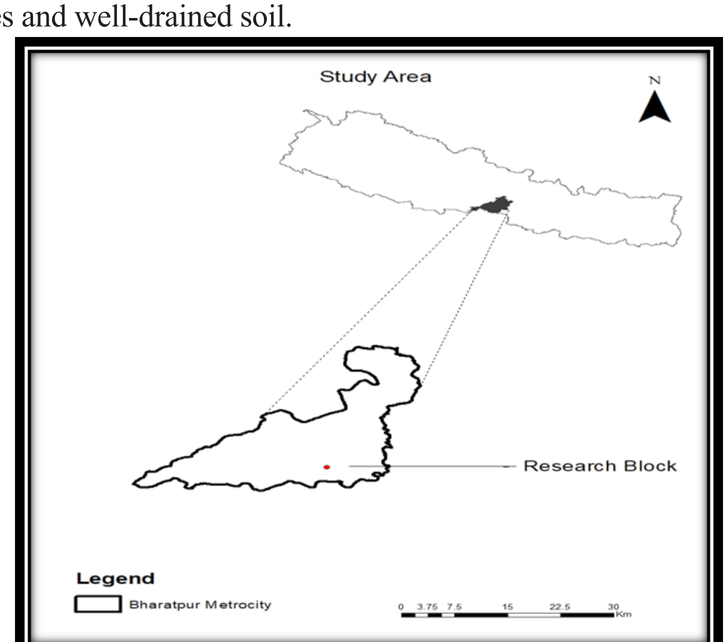

Figure 1. Study area located at Agriculture and Forestry University, Rampur Chitwan

Soil and weather condition

Composite soil samples were taken from each replication from the plough layer (0-15 cm) before transplanting the cauliflower seedlings. There were four composite samples for chemical analysis. The soil samples were air-dried and sieved through 2 mm for analysis. Nitrogen, phosphorus, potassium, and boron were analyzed by the Kjeldahl distillation unit (Bremmer & Mulvaney, 1982), Olsen's bicarbonate (Olsen et al., 1954), Ammonium acetate (Pratt, 1965), and Azomethine-H (Gaines & Mitchell, 1979) methods respectively. Soil texture by hydrometer (Gee & Bauder, 1986), organic matter content by Walkley & Black (1934), and soil pH by digital pH meter were analyzed. After the harvest of cauliflower, composite leaf and soil samples were digested with concentrated sulphuric acid and digestion mixture in micro Kjeldahl's assembly for estimating total leaf and soil nitrogen. Similarly, composite plant samples from each plot were analyzed for total boron using Azomethine-H (Gaines & Mitchell, 1979).

These analyses were carried out at Agriculture Technology Center, Lalitpur, Nepal. The chemical and physical properties of initial soil samples are presented in Table 1**.**

Table 1. Properties of the soil of experimental field before transplanting of cauliflower seedlings at Rampur, Chitwan

Blocks	OM (%)	N (%)	P_2O_5 (Kg/ha)	K_2O (Kg/ha)	Soil pH	EC (mmho/cm) at 25°C	Soil Texture	Soil boron (ppm)
1	2.48	0.12	33.06	160.80	6.40	0.10	SL	0.10
2	2.80	0.14	20.60	134.00	5.75	0.10	SL	0.11
3	2.67	0.13	30.90	147.40	5.58	0.10	SL	0.12
4	3.16	0.16	30.90	160.80	5.58	0.15	SL	0.11
Average	2.78	0.14	28.87	150.75	5.83	0.11	SL(Sandy Loam)	0.11

The experimental field was under a conventional rice wheat maize cropping system one year before the experiment. Meanwhile, it remained fallow for a year before cultivating cauliflower.

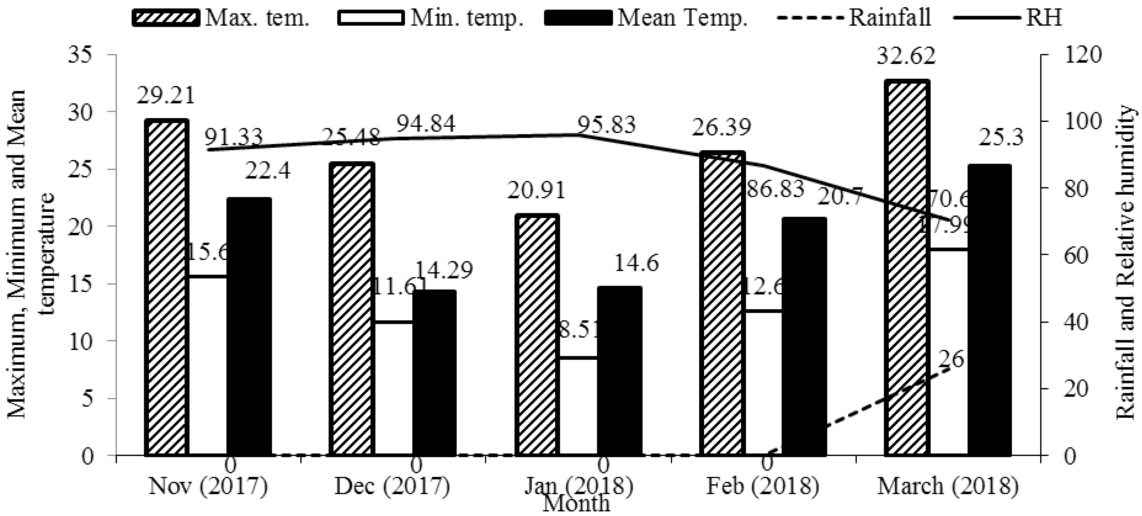

Figure 2. Monthly record of air temperature, rainfall, relative humidity, of the experimental site during the growing season

The experimental site is delineated by low rainfall, low temperature, and high relative humidity. Different weather parameters such as maximum, minimum temperature, mean temperature, total rainfall and relative humidity during the experimental period was collected from the National Maize Research Program (NMRP), Rampur, and is presented in Figure 2.

Experimental design and treatments

The experiment consisted of two factors, with Factor A consisting of three Nitrogen doses (N1: 260 Kg N ha^{-1}, N2: 200 Kg N ha^{-1}, N3: 140 Kg N ha^{-1}) and Factor B consisting of three boron doses (B1: 1.7 Kg B ha^{-1}, B2: 1.1 Kg B ha^{-1}, B3: 0.5 Kg B ha^{-1}). N2 and B2 are the recommended dose of nitrogen and boron fertilization for cauliflower for the Nepalese condition. The experiment was laid out in a Randomized Complete Block Design (RCBD) consisting of 9 treatment combinations with four replications. The treatment combinations were represented as T1=N1B2, T2=N3B3, T3=N2B1, T4=N3B1, T5=N2B2, T6=N1B1, T7=N3B2, T8=N2B3, and T9=N1B3. Boron was applied in the form of borax as borax contains 11.36 % boron.

Observation and statistical analysis

Necessary parameters for the calculation of biological yield were taken from the central five plants from each plot. The analysis of variance was done to sort out the significant differences among the treatments. DMRT (Duncan's Multiple Range Test) was used to compare the treatment means. The data analysis procedures were followed using R-studio (version: 3.4.2) and MS-Excel.

RESULTS AND DISCUSSION

Biological yield

The biological yield responded significantly to the application of different nitrogen doses (Table 2). The maximum biological yield (73.84 t ha^{-1}) was observed from N1 (260

Kg N ha^{-1}), while the lowest biological yield (68.76 t ha^{-1}) was observed from N3 (140 Kg N ha^{-1}) which was statistically identical with N2 (200 Kg N ha^{-1}) i.e. 70.18 t ha^{-1}. The result is in accordance with Ghobadi et al. (2010).

Biological yield of cauliflower responded significantly to the boron application (Table 2). The maximum biological yield was recorded from the highest boron dose B1 (1.7 Kg B ha^{-1}) i.e. 72.60 t ha^{-1} while the minimum yield was recorded with the boron level B3 (0.5 Kg B ha^{-1}) i.e. 69.45 t ha^{-1} which was statistically identical with B2 (1.1 Kg B ha^{-1}) i.e. 70.63 t ha^{-1}. Farooq et al. (2018) on their experiment revealed that there was a significant and linear increase in the biological yield of cauliflower when the dose of boron was increased.

Table 2. Effect of different doses of nitrogen and boron on the biological yield of cauliflower at Rampur, Chitwan

Treatments	Biological yield (t ha^{-1})
Dose of Nitrogen	
N3	68.76^{b}
N2	70.18^{b}
N1	73.84^{a}
$LSD_{0.05}$	1.848**
Dose of Boron	
B3	69.45^{b}
B2	70.63^{b}
B1	72.60^{a}
$LSD_{0.05}$	1.848**
SEm±	0.633
CV (%)	3.1
Grand mean	70.93

Note: Means followed by the same letter(s) in column and row are not significantly different at 5% level
Source: Field data, 2017/18

Soil pH

The effect of nitrogen on soil pH was found significant on soil pH (Table 3). The highest soil pH (5.61) was found from N2 (200 Kg N ha^{-1}) which was statistically identical with N3 (140 Kg N ha^{-1}) i.e. pH 5.60, whereas the lowest pH of 5.43 was obtained from N1 (260 Kg N ha^{-1}). Singh (2018) stated that continuous application of high nitrogen may give rise to soil acidity. The individual effect of boron on was not found significant on soil pH. It may be because boron does not have a significant role in changing the acidity of the soil.

Bulk density

Bulk density was not significantly affected by the individual doses of nitrogen and the doses of boron as well (Table 3). It may be because the change in the bulk density is a long-term process that is affected by organic matter accumulation, amount of tillage's, cover crops, and crop rotations, amount of soil residues, and intensity of soil disturbances.

Organic matter (OM)

Soil organic matter was significantly affected by the application of nitrogen irrespective of its doses (Table 3). Highest OM (3.58 %) was measured from nitrogen dose N1 (260 Kg N ha^{-1}) which was statistically identical with N2 (200 Kg N ha^{-1}) i.e. 3.53 %, while the lowest OM (3.28 %) was recorded from N3 (140 Kg N ha^{-1}). Munroe (2016) stated that nitrogen (N) fertilizer application helps to build soil organic matter by increasing total crop production as the higher-yielding crop returns a greater amount of residue which eventually breaks down and contributes to soil OM.

Soil OM responded non-significantly to the application of different doses of boron (Table 3). This may be because microorganisms could not utilize the boron as the supplied boron may have been adsorbed on the soil colloids and eventually lost through leaching.

Soil nitrogen (%)

Total soil nitrogen was significantly affected by the application of nitrogen irrespective of its doses (Table 3). The highest total soil nitrogen (0.14%) was measured from N1 (260 Kg N ha^{-1}) dose which was statistically similar to N2 (200 Kg N ha^{-1}) i.e. 0.14 %, while the lowest (0.12 %) was recorded from N3 (140 Kg N ha^{-1}) dose. The result was in accordance with the result of Sainju (2014).

The effect of boron on total soil nitrogen was also found significant (Table 3). The highest total soil nitrogen (0.14%) was found from B1 (1.7 Kg B ha^{-1}) which was statistically similar to B2 (1.1 Kg B ha^{-1}) i.e. 0.14%, while the lowest soil nitrogen (0.11%) cm was recorded from B3 (0.5 Kg B ha-1). Sathya et al. (2013) revealed that soil application of boron brought about a considerable increase in the available nitrogen content of the soil. Hosseini et al. (2007) stated that the effect of boron on soil nitrogen concentration may be a synergistic relationship between these two nutrients.

Leaf nitrogen (%)

Leaf nitrogen of cauliflower showed significant differences to the application of different nitrogen doses (Table 3). Maximum leaf nitrogen (4.33 %) was observed from N1 (260 Kg N ha^{-1}) which was statistically identical with N2 (200 Kg N ha^{-1}) i.e. 4.19%, while the lowest leaf nitrogen (3.87%) was observed from N3 (140 Kg N ha^{-1}). Prsa et al. (2007) found that nitrogen fertilization increased leaf nitrogen content in apple and the highest leaf nitrogen was found on the highest nitrogen level.

Different doses of boron significantly affected leaf nitrogen. Maximum leaf nitrogen (4.25%) was recorded from the boron dose B1 (1.7 Kg B ha^{-1}) which was statistically at par with B2 (1.1 Kg B ha^{-1}) i.e. 4.14%, while minimum leaf nitrogen (3.99%) was recorded from the boron dose B3 (0.5 Kg B ha^{-1}). Yadav and Manchanda (1979) noted that with an increase in the B content of the soil, tissue Ca and Mg concentrations in wheat and gram crops were significantly decreased, whereas nitrogen contents were significantly increased.

The combined effect of nitrogen and boron on leaf nitrogen was found significant and maximum leaf nitrogen (4.54 %) was found from the treatment T3:-N2B1 which was statistically similar with the treatments T9 :-N1B3, T1 :-N1B2, and T6 :-N1B1, meanwhile minimum leaf nitrogen (3.82%) was found from the treatment T2:-N3B3 (140 Kg N ha^{-1}

and 0.5 Kg B ha^{-1}) which was statistically identical with the treatment T8 :-N2B3 (Table 4). Mahmoud et al. (2006) declared that boron and nitrogen react synergistically and additively influence the nutrient content within faba bean plant tissues.

Soil boron (ppm)

Total soil boron showed significant differences due to the application of different nitrogen doses (Table 3). Maximum soil boron (0.29 ppm) was observed from N2 (200 Kg N ha^{-1}), while the lowest soil boron (0.22 ppm) was observed from N3 (140 Kg N ha^{-1}) which was statistically similar with N1 (260 Kg N ha^{-1}) i.e. 0.25 ppm. Fageria et al. (2010) found that an increase in the nitrogen level in soil assist in an increase in boron concentration in soil but excess nitrogen concentration in the soil can reduce residual soil boron.

Different doses of boron significantly affected the total soil boron (Table 3). Maximum soil boron (0.29 ppm) was recorded from the boron dose B1 (1.7 Kg B ha^{-1}) which was statistically similar to B2 (1.1 Kg B ha^{-1}) i.e. 0.26 ppm, while minimum soil boron (0.22 ppm) was recorded from B3 (0.5 Kg B ha^{-1}). Khadka and Rai (2005) after harvest of cauliflower found the highest residual soil boron from the highest level of boron application by hot water extraction method.

The combined effect of nitrogen and boron on total soil boron was found significant and maximum soil boron (0.31 ppm) was noted from the treatment T3:-N2B1 (200 Kg N ha^{-1} and 1.7 Kg B ha^{-1}) which was significantly similar with the treatments T4:-N3B1 and T5:-N2B2, meanwhile, minimum soil boron (0.17 ppm) was found from the treatment T2:-N3B3 (Table 5). It may be because nitrogen reacted synergistically with boron thus maximizing the residual soil boron while recommend nitrogen level was applied in combination with the highest dose of boron.

Leaf boron

Leaf boron of cauliflower showed significant differences due to the application of different nitrogen doses (Table 3). Maximum leaf boron (1.34 ppm) was observed from N3 (140 Kg N ha^{-1}), while the lowest leaf boron (1.15 ppm) was observed from N1 (260 Kg N ha^{-1}) which was statistically similar with N2 (200 Kg N ha^{-1}) i.e. 1.23 ppm. Petridis et al. (2013) found that by increasing doses of nitrogen in the soil, leaf B concentration reduced amongst all nitrogen doses increased. These results imply that an increase in nitrogen fertilizer may prevent boron toxicity in plants and maintain the leaf boron concentration.

Table 3. Effect of different doses of nitrogen and boron on soil properties and nutrient uptake after harvest of cauliflower at Rampur, Chitwan

Treatments	Soil pH	Bulk density (g cc^{-1})	Organic matter (%)	Soil Nitrogen (%)	Leaf Nitrogen (%)	Soil Boron (ppm)	Leaf Boron (ppm)
Dose of Nitrogen							
N3	5.60[a]	1.21	3.28[b]	0.12[b]	3.87[b]	0.22[b]	1.34[a]
N2	5.61[a]	1.24	3.53[a]	0.14[a]	4.19[a]	0.29[a]	1.23[b]
N1	5.43[b]	1.27	3.58[a]	0.14[a]	4.33[a]	0.25[b]	1.15[b]
$LSD_{0.05}$	0.135*	ns	0.179**	0.0146**	0.190**	0.035**	0.108**
Dose of Boron							
B3	5.49	1.22	3.39	0.11[b]	3.99[b]	0.22[b]	1.16[b]
B2	5.64	1.25	3.44	0.14[a]	4.14[ab]	0.26[a]	1.23[ab]
B1	5.50	1.26	3.55	0.14[a]	4.25[a]	0.29[a]	1.32[a]
$LSD_{0.05}$	Ns	ns	Ns	0.0146**	0.190*	0.035**	0.108*
SEm±	0.046	0.021	0.061	0.005	0.065	0.012	0.037
CV (%)	2.9	5.9	6.1	13.4	5.5	16.7	10.4
Grand mean	5.55	1.24	3.46	0.13	4.13	0.25	1.24

Note: Means followed by the same letter(s) in column and row are not significantly different at 5% level

Table 4. Combined effect of different doses of nitrogen and boron on leaf nitrogen of cauliflower at AFU, Rampur, Chitwan

Treatments	Leaf Nitrogen (%)		
	B3	B2	B1
N3	3.82[c]	3.89[bc]	3.90[bc]
N2	3.84[c]	4.21[ab]	4.54[a]
N1	4.33[a]	4.35[a]	4.31[a]
$LSD_{0.05}$	0.329*		
SEm±	0.113		
CV (%)	5.5		
Grand mean	4.13		

Note: Means followed by the same letter(s) in column and row are not significantly different at 5% level

Different doses of boron significantly affected the leaf boron concentration of cauliflower (Table 3). Maximum leaf boron (1.32 ppm) was recorded from the boron dose B1 (1.7 Kg B ha^{-1}) which was statistically at par with B2 (1.1 Kg B ha^{-1}) i.e. 1.23 ppm, while minimum leaf boron (1.16 ppm) was recorded from the boron dose B3 (0.5 Kg B ha^{-1}). Chaplin et al. (1980) in their experiment on the effect of nitrogen and boron fertilizer experiment on red raspberry found that nitrogen application constantly increased leaf nitrogen but reduced leaf boron, while boron application increased leaf boron.

Table 5. Combined effect of different doses of nitrogen and boron on soil boron after harvest cauliflower at Rampur, Chitwan

Treatments	Soil Boron (ppm)		
	B3	B2	B1
N3	0.17[e]	0.19[de]	0.30[ab]
N2	0.25[abcd]	0.30[ab]	0.31[a]
N1	0.22[cde]	0.28[abc]	0.24[bcd]
$LSD_{0.05}$	0.061*		
SEm±	0.021		
CV (%)	16.7		
Grand mean	0.25		

Note: Means followed by the same letter(s) in column and row are not significantly different at 5% level

CONCLUSION

The study showed that the biological yield was found maximum under the highest individual doses of nitrogen and boron at Rampur, Chitwan, Nepal but further research is required to quantify these effects at several agro-ecological zones of the district. Meanwhile, soil physicochemical properties and nutrient uptake varied among the individual doses of nitrogen and boron and sometimes to their combinations.

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