# Effect of Phosphorus, Calcium and Boron on the Growth and Yield of Groundnut (*Arachis hypogea* L.)

Rezaul Kabir, Sabina Yeasmin, A K M Mominul Islam**
and Md Abdur Rahman Sarkar

*Department of Agronomy, Bangladesh Agricultural University, Mymensingh, Bangladesh*

**Corresponding author email address: bulbulbau@gmail.com*

***Abstract***

*The optimization of the mineral nutrition is the key to optimize the production of groundnut, as it has very high nutrient requirement and the recently released high yielding varieties take away still more nutrients from the soil. On contrary severe mineral nutrient deficiencies due to inadequate and imbalance use of nutrients is one of the major factors responsible for low yield in groundnut. Thus, to observe the effect of Phosphorus (P), Calcium (Ca) and Boron (B) on the growth and yield of groundnut cv. BARI Cheenabadam 7, fertilizer doses of P ($P_0$=0, $P_1$= 25 and $P_2$=50 kg $ha^{-1}$), Ca ($Ca_0$=0, $Ca_1$=110 and $Ca_2$= 165 kg Ca $ha^{-1}$) and B (0, 2 and 2.5 kg $ha^{-1}$) were used. Among the growth parameters plant height, number of branches $plant^{-1}$, dry weight $plant^{-1}$, LAI and CGR were highest at 100 DAS in $P_2 \times Ca_1 \times B_2$ treatment combination. Among the yield attributing characters number of total pods $plant^{-1}$ was highest for $P_1 \times Ca_2 \times B_2$, 100 pod weight $plant^{-1}$ for $P_1 \times Ca_2 \times B_1$, shelling percentage, pod yield, biological yield, straw yield and harvest index for $P_2 \times Ca_1 \times B_2$. The lowest values of all these parameters were found at control treatment. The combined dose of $P_2$, $Ca_1$ and $B_2$ produced the highest values for almost all the above parameters. Thus, it can be concluded that the fertilizer level for P, Ca and B should be 50 kg $ha^{-1}$, 110 kg $ha^{-1}$ and 2.5 kg $ha^{-1}$, respectively for obtaining the highest yield of groundnut under this particular soil.*

***Keywords:*** *Mineral nutrient, high yielding variety, growth parameters, yield components*

## 1. Introduction

Groundnut (*Arachis hypogea* L.) is one of the principal economic crops of the world that ranks 13th among the food crops [1]. In Bangladesh, groundnut is the 2nd important oil seed crop next to mustard (*Brassica* spp.) on the basis of annual production, and stands third next to sesame (*Sesamum indicum* L.) on the basis of acreage among the major oil crops. The oil content of groundnut is higher than those of soybean (*Glycine max*) and mustard. To make the country self sufficient in edible oil, it is extremely necessary to increase the total production of oil seed crops including groundnut either by increasing their yield per hectare or by increasing their acreage of cultivation or by a combination of them. The productivity of groundnut depends on proper selection of variety, fertilizer management and other management practices [2]. Proper fertilizer doses of nitrogen, phosphorus, calcium and boron have vital effect on the yield of groundnut [3].

Nitrogen (N) is required by plants in comparatively larger amounts than other elements. As a crop of Leguminosae family, groundnut can fix as much as 40-80 kg N $ha^{-1}$ $yr^{-1}$ [4]. About 86-92% of the N taken up by the groundnut comes from Biological Nitrogen Fixation (BNF) which is equivalent to 125-178 kg N $ha^{-1}$ [5]. Although legumes can fix their own N, they often need phosphorus and calcium and other nutrients for good seed formation [6].

Phosphorus (P) is the second major essential nutrient element for crop growth and good quality yield. The most obvious effect of P is on the plant root system. The requirement of P in nodulating legumes is higher compared to non-nodulating crops as it plays a significant role in nodule formation and fixation of atmospheric nitrogen [7]. Due to the important role played by P in the physiological processes of plants, application of P to soil deficient in this nutrient leads to increase groundnut yield.

Calcium (Ca) is required by groundnut plants from the time when pegs begin to appear, fruit formation, until the pods are mature [8]. Ca deficiency leads to high percentage of aborted seeds (empty pods), improperly filled pods [9], and causes of the aborted or shrivelled fruit, including darkened plumules and production of pods without seed [10]. On some low Ca-content soils, gypsum can also increase seed-oil content [11]. In contrast, there are also indications that high level of soil Ca are associated with reduced incidence of various pod and root rots.

Boron (B) plays an important role in the physiological process of plants, such as, cell elongation, cell maturation, meristematic tissue development and protein synthesis [12]. This is why the application of micronutrients (B) in the soils is increasing gradually. The need for B application in groundnut is, therefore, to increase the growth, development and at the same time to increase the yield of crops. The application of B also promotes the absorption of N by groundnut and increases the plant height, plant dry weight and the total number of pods [13].

Thus, the optimum fertilizers combination is the main concern for maximum yield of groundnut. Though groundnut is cultivated in many parts of Bangladesh, very little research work has so far been conducted on the appropriate fertilizer management for groundnut cultivation. With the above background, the main objective of this study was to determine the effect of P, Ca and B on the growth and yield of groundnut.

## 2. Materials and Methods

The research work was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. Geographically the field is located at 24º75´ N Latitude and 90º50´E longitude at elevation of 18 m above the sea level [14]. The topography of the field was medium high and the soil was silty loam (Table 1) and well drained. The maximum and minimum temperatures during the growing season (December to May) of the crop were 32.45 ºC and 11.70 ºC, respectively. The climate of the location is characterized by heavy precipitation during April to October [15].

**Table 1. Physical and Chemical Characteristics of Soil of the Experimental Field**

| | | | |
|---|---|---|---|
| Textural Class | Silt Loam | Available P (ppm) | 6.90 |
| Sand(%) | 18.25 | Available S (ppm) | 11.41 |
| Silt (%) | 78.0 | Available K (ppm) | 0.09 |
| Clay (%) | 3.75 | Available B (ppm) | 0.65 |
| pH | 6.8 | Available Zn (ppm) | 1.17 |
| Organic Carbon | 0.83 | CEC (m. e. %) | 11 |

One improved variety of groundnut, BARI Cheenabadam7 was used for the present study which was collected from the Bangladesh Agricultural Research Institute. The seeds were sown in rows at a depth of 2-3 cm from the soil surface. The distances between row to row and seed to seed were 30 cm and 15 cm, respectively. The experiment was conducted in a randomized complete block design with 3 replications. The field was divided into 3 blocks each containing 27 plots of size 2.5m×2m. Three levels of phosphorus *viz*. $P_0$=0 (control), $P_1$=25 and $P_2$=50 kg $ha^{-1}$ (as triple superphosphate), three levels of calcium *viz*. $Ca_0$=0 (control), $Ca_1$=110 and $Ca_2$=165 kg $ha^{-1}$ (as gypsum), and three levels of boron *viz*. $B_0$=0 (control), $B_1$=2, and $B_2$=2.5 kg $ha^{-1}$ (as borax) were used. Treatment combinations were randomly allocated in each block. Urea and muriate of potash were also used to supply nitrogen (20 kg N $ha^{-1}$) and potassium (30 kg $K_2O$ $ha^{-1}$), respectively.

The 1st crop sampling was done at 20 days after emergence and it was continued till physiological maturity at 90 days after sowing (DAS) with an interval of 30 days and finally the crop was harvested at 150 DAS. The samplings were done by 2 ways; one is destructive and another is non-destructive. In destructive sampling three plants were uprooted carefully from each plot and were carried to the laboratory in properly labelled bags. Then the harvested plants were washed in running tap water to remove soil and soaked with blotting paper to remove the adhering water on it. Then the plants were separated into leaves, stems and roots. Total leaf area of individual sample was measured by an electronic leaf area meter (Licor-13000, USA). The components were oven dried at 70°C for 48 hours to record constant dry weights. Total dry weight was determined by recording the dry weight of each portion of the plant. In non-destructive sampling, 3 plants were selected randomly and plant height and primary branches per plant of these plants were recorded. The studied parameters were, growth parameters: plant height, number of branches $plant^{-1}$, leaf area index, crop growth rate (CGR), total dry weight of $plant^{-1}$; yield and yield contributing characters: number of total pods $plant^{-1}$, 100 pod weight (g), shelling (%), pod yield (t $ha^{-1}$), straw yield (t $ha^{-1}$), biological yield (t $ha^{-1}$) and harvest index (HI).

The dry matter accumulation of the crop per unit land area in unit of time is referred to crop growth rate (CGR), expressed as g $m^{-2}$ $d^{-1}$. The mean CGR values for the crop during the sampling intervals were computed using the following formula [16]-

$$CGR = \frac{W_2 - W_1}{SA(t_2 - t_1)}$$

Here, SA= Ground area occupied by the plant at each sampling. $W_1$ and $W_2$ are the total dry matter production in grams at the time $t_1$ and $t_2$, respectively.

$$HI = \left(\frac{Ecomomic\ yield}{Biological\ yield}\right) \times 100$$

Collected data were subjected to analysis by MSTAT and the differences among treatment means were compared by Duncan's Multiple Range Test (DMRT).

## 3. Results

### 3.1. Growth parameters

Plant height was significantly affected by the P, Ca and B levels at the all three sampling days (40, 70 and 100 DAS) (Table 2). It was revealed that plant height increased progressively with increase of level of three fertilizers *i.e*., the highest plant height was obtained at the highest level of fertilizers ($P_2$, $Ca_2$ and $B_2$) and the lowest one was found at control (0 kg $ha^{-1}$). The interaction effect of P, Ca and B on plant height was not significant (Table 3). Plant height was highest (9.0 cm at 40 DAS, 16.0 cm at 70 DAS and 64.5 cm at 100 DAS) for $P_2 \times Ca_1 \times B_2$, *i.e*., P (50 kg $ha^{-1}$), Ca (110 kg $ha^{-1}$) and B (2.5 kg $ha^{-1}$). Although all the three fertilizers are important for groundnut, P and B increased the height of the plant but the highest level (165 kg ha$^{-1}$) of the Ca was not encouraging for the height of plant.

**Table 2. Effect of Phosphorus, Calcium and Boron on the Growth Parameters of Groundnut**

| Level of fertilizer (kg ha$^{-1}$) | Plant height (cm) | | | Number of branches plant$^{-1}$ | | | Dry weight of plant$^{-1}$ | | | CGR (g m$^{-2}$ d$^{-1}$) | | Leaf area index (LAI) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 40 DAS | 70 DAS | 100 DAS | 40 DAS | 70 DAS | 100 DAS | 40 DAS | 70 DAS | 100 DAS | 40-70 DAS | 70-100 DAS | 40 DAS | 70 DAS | 100 DAS |
| **Phosphorus** | | | | | | | | | | | | | | |
| $P_0$ | 7.25c | 14.04c | 47.18c | 2.92c | 6.00c | 6.22c | 0.52c | 3.16c | 27.76c | 1.95c | 18.22c | 0.14c | 1.50c | 1.50c |
| $P_1$ | 7.90b | 14.56b | 53.16b | 3.26b | 6.81b | 7.00b | 0.54b | 3.41b | 30.30b | 2.11b | 19.92b | 0.15b | 1.61b | 1.61b |
| $P_2$ | 8.35a | 15.40a | 59.68a | 3.41a | 7.41a | 7.52a | 0.61a | 3.67a | 32.09a | 2.26a | 21.06a | 0.17a | 1.76a | 1.76a |
| ANOVA | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| **Calcium** | | | | | | | | | | | | | | |
| $Ca_0$ | 7.25c | 14.04c | 47.18c | 3.00b | 6.18b | 6.44b | 0.53b | 3.19b | 28.44b | 1.97b | 18.70b | 0.14b | 1.51b | 3.14b |
| $Ca_1$ | 7.90b | 14.56b | 53.16b | 3.29a | 6.96a | 7.07b | 0.56a | 3.46a | 30.60a | 2.15a | 20.10a | 0.15ab | 1.67a | 3.25ab |
| $Ca_2$ | 8.35a | 15.40a | 59.68a | 3.30a | 7.07a | 7.22a | 0.57a | 3.57a | 31.10a | 2.21a | 20.39a | 0.16a | 1.69a | 3.28a |
| ANOVA | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | * |
| **Boron** | | | | | | | | | | | | | | |
| $B_0$ | 7.55b | 14.36b | 51.02b | 3.07b | 6.59b | 6.82 | 0.54b | 3.24b | 29.22b | 2.0b | 19.25b | 0.15 | 1.58 | 3.16 |
| $B_1$ | 7.99a | 14.86a | 53.97a | 3.18b | 6.70ab | 6.89 | 0.56ab | 3.47a | 30.19ab | 2.15a | 19.79ab | 0.15 | 1.65 | 3.24 |
| $B_2$ | 7.95a | 14.78a | 55.03a | 3.33a | 6.93a | 7.04 | 0.57a | 3.52a | 30.73a | 2.17a | 20.16a | 0.15 | 1.65 | 3.27 |
| ANOVA | ** | ** | ** | ** | * | NS | ** | ** | * | ** | * | NS | NS | NS |

In a column, figures with same letter or without letter do not differ significantly, whereas figures with dissimilar letter differ significantly.

*Significant at 5% level of significance, ** Significant at 1% level of significance, NS= Not significant

Here, $P_0$=0 (control), $P_1$=25 and $P_2$=50 kg ha$^{-1}$; $Ca_0$=0 (control), $Ca_1$=110 and $Ca_2$=165 kg ha$^{-1}$; $B_0$=0 (control), $B_1$=2, and $B_2$=2.5 kg ha$^{-1}$

The effect of P, Ca and B on number of branches plant$^{-1}$ was highly significant at all the three sampling dates except for B at 100 DAS (Table 2). The highest number of branches plant$^{-1}$ was obtained at the highest level of fertilizers. The interaction effect of P, Ca and B on number of branches plant$^{-1}$ was significant (Table 3). The highest number of branches plant$^{-1}$ was obtained from the treatments combination of $P_1 \times Ca_1 \times B_2$, $P_1 \times Ca_2 \times B_1$, $P_2 \times Ca_1 \times B_0$, $P_2 \times Ca_1 \times B_2$, $P_2 \times Ca_2 \times B_1$ and $P_2 \times Ca_2 \times B_2$ at 40 DAS (3.67), and from $P_2 \times Ca_1 \times B_1$, $P_2 \times Ca_1 \times B_2$, and $P_2 \times Ca_2 \times B_2$ at 70 DAS and 100 DAS (8.00).

Total dry weight plant$^{-1}$ and CGR were significantly enhanced by all the three fertilizers application at all sampling days (Table 2) but interaction effect of P, Ca and B was not significant for the both parameters (Table 3). The highest dry matter (33.0 g) and CGR (22.22 g m$^{-2}$d$^{-1}$) was recorded with $P_2 \times Ca_1 \times B_2$ at 100 DAS and the lowest one (25.90 g of total dry weight and 16.89 g m$^{-2}$d$^{-1}$ of CGR) was found at control ($P_0 \times Ca_0 \times B_0$).

LAI was significantly affected by P and Ca individually but not affected by B at any of the three sampling dates. Also, the interaction effect of P, Ca and B on LAI was not significant (Table 3).

**Table 3. Interaction Effect of Phosphorus, Calcium and Boron on the Growth Parameters of Groundnut**

| Interaction (P×Ca×B) | Plant height (cm) | | | Number of branches plant$^{-1}$ | | | Dry weight of plant$^{-1}$ | | | CGR (g m$^{-2}$ d$^{-1}$) | | Leaf area index (LAI) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 40 DAS | 70 DAS | 100 DAS | 40DAS | 70 DAS | 100 DAS | 40 DAS | 70 DAS | 100 DAS | 40-70 DAS | 70-100 DAS | 40 DAS | 70 DAS | 100 DAS |
| $P_0 \times Ca_0 \times B_0$ | 7.10 | 13.50 | 44.50 | 2.67c | 5.33g | 5.33f | 0.50 | 2.95 | 25.90 | 1.81 | 16.89 | 0.13 | 1.34 | 2.93 |
| $P_0 \times Ca_0 \times B_1$ | 7.10 | 13.70 | 45.20 | 3.00bc | 5.33g | 6.33de | 0.50 | 3.10 | 25.90 | 1.93 | 17.00 | 0.13 | 1.41 | 2.98 |
| $P_0 \times Ca_0 \times B_2$ | 7.15 | 13.75 | 46.53 | 2.67c | 6.00efg | 6.33de | 0.51 | 3.05 | 26.10 | 1.88 | 17.07 | 0.13 | 1.42 | 2.93 |
| $P_0 \times Ca_1 \times B_0$ | 7.20 | 13.90 | 46.50 | 3.00bc | 5.67fg | 6.00ef | 0.52 | 3.00 | 26.20 | 1.84 | 17.19 | 0.13 | 1.48 | 3.02 |
| $P_0 \times Ca_1 \times B_1$ | 7.33 | 14.00 | 47.60 | 3.30ab | 6.00efg | 6.00ef | 0.53 | 3.25 | 28.50 | 2.01 | 18.70 | 0.14 | 1.54 | 2.93 |
| $P_0 \times Ca_1 \times B_2$ | 7.40 | 14.30 | 48.40 | 3.00bc | 6.00efg | 6.00ef | 0.53 | 3.30 | 29.50 | 2.05 | 19.40 | 0.14 | 1.60 | 2.98 |
| $P_0 \times Ca_2 \times B_0$ | 7.20 | 14.20 | 47.00 | 2.67c | 6.33def | 6.33de | 0.52 | 3.15 | 28.80 | 1.95 | 19.00 | 0.14 | 1.53 | 2.97 |
| $P_0 \times Ca_2 \times B_1$ | 7.40 | 14.50 | 49.40 | 2.67c | 6.67cde | 7.00bcd | 0.54 | 3.25 | 29.20 | 2.00 | 19.22 | 0.14 | 1.62 | 3.05 |
| $P_0 \times Ca_2 \times B_2$ | 7.40 | 14.50 | 49.50 | 3.33ab | 6.67cde | 6.67cde | 0.54 | 3.35 | 29.70 | 2.08 | 19.52 | 0.14 | 1.59 | 3.04 |
| $P_1 \times Ca_0 \times B_0$ | 7.30 | 14.00 | 48.00 | 3.00bc | 6.00efg | 6.67cde | 0.50 | 3.00 | 28.20 | 1.85 | 18.67 | 0.13 | 1.44 | 3.06 |
| $P_1 \times Ca_0 \times B_1$ | 7.80 | 14.10 | 50.10 | 3.00bc | 6.33def | 6.33de | 0.52 | 3.15 | 27.00 | 1.95 | 17.67 | 0.14 | 1.49 | 3.16 |
| $P_1 \times Ca_0 \times B_2$ | 7.80 | 14.05 | 51.40 | 3.33ab | 6.33def | 6.33de | 0.52 | 3.25 | 28.70 | 2.02 | 18.85 | 0.14 | 1.51 | 3.13 |
| $P_1 \times Ca_1 \times B_0$ | 7.60 | 14.15 | 51.20 | 3.00bc | 6.67cde | 7.00bcd | 0.53 | 3.20 | 29.50 | 1.98 | 19.48 | 0.14 | 1.64 | 3.12 |
| $P_1 \times Ca_1 \times B_1$ | 8.50 | 15.30 | 53.30 | 3.00bc | 7.67ab | 7.67ab | 0.56 | 3.60 | 31.90 | 2.25 | 20.96 | 0.15 | 1.71 | 3.13 |
| $P_1 \times Ca_1 \times B_2$ | 7.50 | 14.10 | 54.00 | 3.67a | 7.33abc | 7.33abc | 0.55 | 3.55 | 32.00 | 2.22 | 21.07 | 0.15 | 1.70 | 3.10 |
| $P_1 \times Ca_2 \times B_0$ | 7.90 | 14.30 | 53.00 | 3.33ab | 7.00bcd | 7.00bcd | 0.54 | 3.45 | 30.80 | 2.15 | 20.26 | 0.15 | 1.66 | 3.08 |
| $P_1 \times Ca_2 \times B_1$ | 8.33 | 15.65 | 58.50 | 3.67a | 6.67cde | 7.00bcd | 0.57 | 3.70 | 31.90 | 2.32 | 20.89 | 0.15 | 1.74 | 3.18 |
| $P_1 \times Ca_2 \times B_2$ | 8.33 | 15.40 | 58.90 | 3.33ab | 7.33abc | 7.67ab | 0.59 | 3.75 | 32.70 | 2.24 | 21.44 | 0.16 | 1.60 | 3.27 |
| $P_2 \times Ca_0 \times B_0$ | 7.33 | 14.50 | 50.50 | 3.00bc | 7.67ab | 7.67ab | 0.55 | 3.00 | 30.10 | 1.81 | 20.07 | 0.15 | 1.53 | 2.98 |
| $P_2 \times Ca_0 \times B_1$ | 8.33 | 15.20 | 56.60 | 3.00bc | 6.00efg | 6.00ef | 0.58 | 3.55 | 32.00 | 2.20 | 21.07 | 0.16 | 1.71 | 3.53 |
| $P_2 \times Ca_0 \times B_2$ | 8.33 | 15.25 | 59.00 | 3.33ab | 6.67cde | 7.00bcd | 0.63 | 3.65 | 32.10 | 2.24 | 21.07 | 0.16 | 1.77 | 3.57 |
| $P_2 \times Ca_1 \times B_0$ | 8.00 | 15.20 | 58.50 | 3.67a | 7.33abc | 7.67ab | 0.59 | 3.60 | 31.30 | 2.23 | 20.52 | 0.16 | 1.76 | 3.57 |
| $P_2 \times Ca_1 \times B_1$ | 8.67 | 15.70 | 62.50 | 3.33ab | 8.00a | 8.00a | 0.62 | 3.75 | 32.60 | 2.32 | 21.37 | 0.17 | 1.80 | 3.63 |
| $P_2 \times Ca_1 \times B_2$ | 9.00 | 16.00 | 64.50 | 3.67a | 8.00a | 8.00a | 0.63 | 3.90 | 33.90 | 2.42 | 22.22 | 0.18 | 1.84 | 3.75 |
| $P_2 \times Ca_2 \times B_0$ | 8.33 | 15.50 | 60.00 | 3.33ab | 7.33abc | 7.67ab | 0.61 | 3.80 | 32.20 | 2.36 | 21.04 | 0.17 | 1.82 | 3.71 |
| $P_2 \times Ca_2 \times B_1$ | 8.50 | 15.60 | 62.50 | 3.67a | 7.67ab | 7.67ab | 0.62 | 3.85 | 32.70 | 2.39 | 21.37 | 0.18 | 1.82 | 3.56 |
| $P_2 \times Ca_2 \times B_2$ | 8.67 | 15.65 | 63.00 | 3.67a | 8.00a | 8.00a | 0.63 | 3.85 | 31.90 | 2.39 | 20.78 | 0.18 | 1.83 | 3.70 |
| ANOVA | NS | NS | NS | ** | ** | * | NS | NS | NS | NS | NS | NS | NS | NS |

In a column, figures with same letter or without letter do not differ significantly, whereas figures with dissimilar letter differ significantly.

*Significant at 5% level of significance, ** Significant at 1% level of significance, NS= Not significant

Here, $P_0$=0 (control), $P_1$=25 and $P_2$=50 kg ha$^{-1}$; $Ca_0$=0 (control), $Ca_1$=110 and $Ca_2$=165 kg ha$^{-1}$; $B_0$=0 (control), $B_1$=2, and $B_2$=2.5 kg ha$^{-1}$

### 3.2. Yield and yield components

The result of variance analysis showed that the effect of no. of total pods plant$^{-1}$ was highly significant to the different level of P and Ca, and the highest number of pods plant$^{-1}$ was obtained from $P_2$ (18.96) and $Ca_1$ (18.47). But the effect of B was not significant to the no. of total pods plant$^{-1}$ (Table 4). The interaction effect of P, Ca and B was also not significant to this parameter.

**Table 4. Effect of phosphorus, calcium and boron on the yield and yield components of groundnut**

| Level of fertilizer (kg ha$^{-1}$) | No. of total pods plant$^{-1}$ | 100 pod weight (g) | Shelling (%) | Pod yield (t ha$^{-1}$) | Biological yield (t ha$^{-1}$) | Straw yield (t ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|---|---|
| **Phosphorus** | | | | | | | |
| $P_0$ | 16.62b | 108.19b | 58.02b | 2.09c | 8.94c | 6.84c | 23.38b |
| $P_1$ | 17.18b | 109.97b | 63.12a | 2.47b | 10.24b | 7.78b | 23.85b |
| $P_2$ | 18.96a | 110.84a | 64.22a | 2.85a | 10.87a | 8.02a | 26.02a |
| ANOVA | ** | ** | ** | ** | ** | ** | ** |
| **Calcium** | | | | | | | |
| $Ca_0$ | 16.44b | 108.60 | 60.36b | 2.19c | 9.38c | 7.19b | 23.38b |
| $Ca_1$ | 18.47a | 109.93 | 62.23a | 2.55b | 10.19b | 7.64a | 23.85b |
| $Ca_2$ | 17.85a | 110.47 | 62.78a | 2.67a | 10.48a | 7.81a | 26.02a |
| ANOVA | ** | NS | ** | ** | ** | ** | ** |
| **Boron** | | | | | | | |
| $B_0$ | 17.47 | 109.12 | 59.88b | 2.27b | 9.54b | 7.28b | 23.61b |
| $B_1$ | 17.94 | 110.45 | 62.07a | 2.52a | 10.13a | 7.60a | 24.84a |
| $B_2$ | 17.37 | 109.44 | 63.43a | 2.61a | 10.38a | 7.77a | 24.80a |
| ANOVA | NS | NS | ** | ** | ** | ** | ** |

In a column, figures with same letter or without letter do not differ significantly, whereas figures with dissimilar letter differ significantly.

** Significant at 1% level of significance, NS= Not significant.

Here, $P_0$=0 (control), $P_1$=25 and $P_2$=50 kg ha$^{-1}$; $Ca_0$=0 (control), $Ca_1$=110 and $Ca_2$=165 kg ha$^{-1}$; $B_0$=0 (control), $B_1$=2, and $B_2$=2.5 kg ha$^{-1}$

A significant effect on 100 pod weight was observed only from different levels of P fertilizer. Ca and B did not show any significant effect on 100 pod weight (Table 4). Different levels of P, Ca and B fertilizer application also significantly influenced the shelling percentage. Highest shelling percentage (68.0) was obtained from the treatment combination of $P_2 \times Ca_1 \times B_2$, which implies that this treatment combination gave the healthier seeds compared to others. Pod yield, biological yield, straw yield and HI increased significantly with increasing level of P, Ca and B individually. But the interaction effect of P, Ca and B on all the yield and yield components were not significant (Table 5). Biological yield (11.75 t $ha^{-1}$), straw yield (8.6 t $ha^{-1}$) and HI (26.80 %) were highest for $P_2 \times Ca_1 \times B_2$.

**Table 5. Interaction Effect of Phosphorus, Calcium and Boron on the Yield Components and Yield of Groundnut**

| Interaction (P×Ca×B) | No. of total pods $plant^{-1}$ | 100 pod weight (g) | Shelling (%) | Pod yield (t $ha^{-1}$) | Biological yield (t $ha^{-1}$) | Straw yield (t $ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|---|---|
| $P_0 \times Ca_0 \times B_0$ | 16.67 | 108.04 | 56.00 | 1.80 | 8.20 | 6.40 | 21.9 |
| $P_0 \times Ca_0 \times B_1$ | 17.34 | 105.56 | 57.20 | 1.90 | 8.40 | 6.50 | 22.61 |
| $P_0 \times Ca_0 \times B_2$ | 17.33 | 105.56 | 57.90 | 1.90 | 8.70 | 6.80 | 21.83 |
| $P_0 \times Ca_1 \times B_0$ | 16.33 | 111.11 | 56.80 | 2.00 | 8.80 | 6.80 | 22.72 |
| $P_0 \times Ca_1 \times B_1$ | 16.67 | 112.24 | 57.90 | 2.20 | 9.20 | 7.00 | 23.91 |
| $P_0 \times Ca_1 \times B_2$ | 16.00 | 108.90 | 58.70 | 2.25 | 9.25 | 7.00 | 24.32 |
| $P_0 \times Ca_2 \times B_0$ | 17.67 | 108.58 | 57.00 | 2.10 | 8.90 | 6.80 | 23.60 |
| $P_0 \times Ca_2 \times B_1$ | 18.00 | 107.78 | 59.10 | 2.30 | 9.50 | 7.20 | 24.21 |
| $P_0 \times Ca_2 \times B_2$ | 17.00 | 105.90 | 61.60 | 2.40 | 9.50 | 7.10 | 25.26 |
| $P_1 \times Ca_0 \times B_0$ | 16.33 | 111.11 | 60.15 | 2.00 | 9.40 | 7.40 | 21.28 |
| $P_1 \times Ca_0 \times B_1$ | 18.33 | 108.90 | 62.80 | 2.25 | 9.75 | 7.50 | 23.08 |
| $P_1 \times Ca_0 \times B_2$ | 18.33 | 108.90 | 63.70 | 2.25 | 9.85 | 7.60 | 22.84 |
| $P_1 \times Ca_1 \times B_0$ | 16.67 | 105.43 | 62.00 | 2.30 | 9.80 | 7.50 | 23.47 |
| $P_1 \times Ca_1 \times B_1$ | 17.66 | 111.39 | 63.40 | 2.60 | 10.40 | 7.80 | 25.00 |
| $P_1 \times Ca_1 \times B_2$ | 18.66 | 110.40 | 64.25 | 2.65 | 10.65 | 8.00 | 23.47 |
| $P_1 \times Ca_2 \times B_0$ | 20.67 | 110.30 | 62.50 | 2.50 | 10.10 | 7.60 | 24.75 |
| $P_1 \times Ca_2 \times B_1$ | 20.00 | 114.58 | 63.10 | 2.75 | 10.95 | 8.20 | 25.11 |
| $P_1 \times Ca_2 \times B_2$ | 20.67 | 108.77 | 66.20 | 2.90 | 11.30 | 8.40 | 25.67 |
| $P_2 \times Ca_0 \times B_0$ | 19.66 | 111.11 | 60.00 | 2.00 | 9.20 | 7.20 | 21.74 |
| $P_2 \times Ca_0 \times B_1$ | 18.66 | 109.48 | 62.50 | 2.70 | 10.20 | 7.50 | 26.47 |
| $P_2 \times Ca_0 \times B_2$ | 18.00 | 108.78 | 63.00 | 2.90 | 10.70 | 7.80 | 26.21 |
| $P_2 \times Ca_1 \times B_0$ | 16.67 | 107.70 | 62.50 | 2.80 | 10.60 | 7.80 | 26.41 |
| $P_2 \times Ca_1 \times B_1$ | 17.34 | 109.70 | 66.50 | 3.00 | 11.30 | 8.30 | 26.55 |
| $P_2 \times Ca_1 \times B_2$ | 17.33 | 112.51 | 68.00 | 3.15 | 11.75 | 8.60 | 26.80 |
| $P_2 \times Ca_2 \times B_0$ | 16.33 | 108.70 | 62.00 | 2.90 | 10.90 | 8.00 | 26.60 |
| $P_2 \times Ca_2 \times B_1$ | 16.67 | 114.40 | 66.00 | 3.05 | 11.45 | 8.40 | 26.64 |
| $P_2 \times Ca_2 \times B_2$ | 16.00 | 115.20 | 67.50 | 3.15 | 11.75 | 8.60 | 26.80 |
| ANOVA | NS | NS | NS | NS | NS | NS | NS |

NS =Not significant

Here, $P_0$=0 (control), $P_1$=25 and $P_2$=50 kg $ha^{-1}$; $Ca_0$=0 (control), $Ca_1$=110 and $Ca_2$=165 kg $ha^{-1}$; $B_0$=0 (control), $B_1$=2, and $B_2$=2.5 kg $ha^{-1}$

## 4. Discussions

P, Ca and B application significantly increased plant height, number of branches $plant^{-1}$ (except at 100 DAS for B application), and total dry weight. Similar results have been reported by Sharma and Yadav [17] and Rahman [18]. The increases in plant growth and total dry weight due to P application may be attributable to the fact that P is known to help in the development of more extensive root system [17, 19] and nodulation, and thus enables plants to absorb more water and nutrients from depth of the soil. This in turn could enhance the plant's ability to produce more assimilates which were reflected in the high dry weight. Similar results have been reported by El- Habbasha *et al*., [20] and Gobarah *et al*., [19].

The increasing level of fertilizers also enhanced the CGR of the crop in the present study. It might be due to maximum branching and vegetative growth facilitated by proper nutrient supply and also could be positive effect of P, Ca and B. P requirement of crop is fairly high and seldom met from normal soil [21] and additional P application could increase the plant growth [22]. The result of this experiment is in agreement with these findings. Ca is important for vascular bundle development which could indirectly affect on plant growth. Opposite results also observed by Weiss [23] and Walker and Keisling [11]; who stated that high amount of Ca reduces production. In this study, applying 110 kg Ca $ha^{-1}$ and 165 kg Ca $ha^{-1}$ did not lead to significant difference in most of the parameters measured, indicating that 110 kg Ca $ha^{-1}$ was enough for the particular soil. Though B has no direct contribution, its application promoted the absorption of N by groundnut and thus helped in increasing plant growth and development [13].

The yield and most of the yield attributing characters were increased with increasing fertilizer level. The increase in yield due to P fertilizer may be attributed to the activation of metabolic processes, where its role in building phospholipids and nucleic acid is known. Moreover P is an important nutrient for all the crops in general and legumes in particular, it is a key constituent of ATP and plays significant role in energy transformation in plant and also roles in seed formation. Application of P, Ca and B fertilizers increased nutrients availability to the crop during the growing season which leads to greater utilization of assimilates into the pods and ultimately increased number of filled pods and shelling percentage.

From the above discussion and the interaction effect, it was revealed that most of the growth parameters, yield and yield contributing characters performed best with the treatment combination of $P_2 \times Ca_1 \times B_2$ *i.e.*, P (50 kg $ha^{-1}$), Ca (110 kg $ha^{-1}$) and B (2.5 kg $ha^{-1}$).

## 5. Conclusions

Results of this experiment suggests that application of 50 P kg $ha^{-1}$ and 110 kg Ca $ha^{-1}$ in combination with 2.5 kg B $ha^{-1}$ resulted in the best growth and yield of groundnut cv. BARI Cheenabadam 7. The study findings also have brought an expectation that further investigation on different levels of fertilizers along with different varieties, growing seasons and soil types can be a step forward to identify more realistic effect of different fertilizers on the growth and yield of groundnut. Finally these findings will help our farmer to apply balanced fertilizer application which will be synchronized with crop demand and also will reduce the cost of production.

## References

[1] R. J. Varnell and D. E. Mc Cloud, "Germplasm preservation and genotypes, evaluation in Arachis", International peanut program, Gainesville Florida, USA, **(1975)**.

[2] A. C. Lourduraj, "Nutrient management in groundnut (*Arachis hypogaea* L.) cultivation – A review", Agricultural Research Review, vol. 20, **(1999)**, pp. 14-20.

[3] K. Subrahmaniyan, P. Kalaiselvan and N. Arulmozhi, "Studies on the effect of nutrient spray and graded level of NPK fertilizers on the growth and yield of groundnut", International Journal of Tropical Agricultural, vol. 18, **(2000)**, pp. 287-290.

[4] M. S. Islam and S. Noor, "Performance of groundnut under different levels of phosphate fertilizers in grey floodplain soils of Jamalpur", Bangladesh Journal of Agricultural Research, vol. 7, **(1992)**, pp. 35-50.

[5] P. J. Dart, D. Mc Donald and R. W. Gibbons, "Groundnut production systems with some implication from recent research", Paper presented at Indonesia National Planning Seminar on Palawija, Yogyakarta, **(1983)** March.
[6] E. A. Asiedu, A. J. G. Vangastel and B. R. Gregg, "Extension agent's technical crop guidelines for assisting seed producers in Ghana", **(2000)**.
[7] N. C. Brady and R .R. Well, "The nature and properties of soils", 13th Ed. Pearson Education (Singapore) Pvt. Ltd. Indian branch, **(2002)**.
[8] M. E. Walker, "Calcium requirements for peanuts", Communication in Soil Science and Plant Analysis, vol. 6, **(1975)**, pp. 299-313.
[9] B. R. Ntare, A. T. Diallo, A. T. Ndjeunga and F. Waliyar, "Groundnut Seed Production Manual", Program International Crops Institute for the Semi-Arid Tropics, Patancheru, Andra Pradesh, 502324, India, **(2008)**.
[10] F. Singh and D. L. Oswalt, "Groundnut Production Practices", Skill Development series Number 3. ICRSAT Training and Fellowship, **(1995)**.
[11] M. E. Walker and T. C. Keisling, "Response of five peanut cultivars to gypsum fertilization on soils varying in calcium content", Peanut Science, vol. 5, **(1978)**, pp. 57-60.
[12] K. Mengel and E. A. Kirkby, "Principles of plant nutrition", 3rd Ed. International Potash Institute Bern Switzerland, **(1982)**, pp. 125.
[13] R. F. Jing, Q. G. Zhang, L. F. Han, F. S. Zhang and X. Q. Wei, "Effect of boric fertilizer on peanut absorption of boron and nitrogen", Soils, vol. 26, **(1994)**, pp. 83-86.
[14] M. S .K. Khan, "Effect of different levels of nitrogen on growth, yield and quality of wheat", Bangladesh Journal of Crop Science, vol. 8, **(1997)**, pp. 10-19.
[15] P. K. Biswas, "A study on the relative merits of mixed cropping under two levels of irrigations", Master of Science Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh **(1987)**, pp. 18.
[16] R. H. Brown, In: M. B. Teasar (Ed), "Growth of the green plant, Physiological Basis of Crop Growth and Development", ASA, CSSA, Madison, Wisconsin, USA, **(1984)**, pp.153-173.
[17] B. M. Sharma and J. S. P. Yadav, "Availability of phosphorus to grain as influenced by phosphatic fertilization and irrigation regimes", Indian Journal of Agricultural Science, vol. 46, **(1997)**, pp. 205-210.
[18] M. A. Rahman, "Effect of Calcium and Bradyrhizobium inoculation of the Growth, Yield and quality of groundnut (*Arachis hypogaea* L.*)*", Bangladesh Journal of Science and Industrial Research, vol. 41, **(2006)**, pp. 181-188.
[19] M. E. Gobarah, M. H. Mohammad and M. M. Tawfik, "Effect of phosphorus fertilizer and foliar spraying with zinc on growth, yield and quality of groundnut under reclaimed sandy soils", Journal of Applied Science Research, Pakistan, vol. 2, **(2006)**, pp. 491-496.
[20] S. F. El-Habbasha, A. A. Kandil, N. S. Abu-Hagaza, A. K. Abd-El-Haleem, M. A. Khalfallah and T. Gh. Behairy, "Effect of phosphorus levels and some biofertilizers on dry matter, yield and yield attributes of groundnut", Bulletin of Faculty of Agriculture, Cairo University, vol. 56, **(2005)**, pp. 237-252.
[22] A. R. M. Solaiman, A. F. M. S. Sattar, M.S. Islam and M. A. Khan, "Response of *Rhizobium* inoculated groundnut to nitrogen, phosphorus application under field conditions", Bangladesh Journal of Science, vol. 22, **(1991)**, pp. 51-58.
[21] J. G. Geus de, "Fertilizer guide for tropical and subtropical farming", Center D'Etude de L'Azote, Zurich, Switzerland, **(1967)**.
[23] E. A. Wesis. Oilseed crops. Longman Inc., NY, **(1983)**, pp. 660.

## Authors

**Rezaul Kabir** is a MS student, Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

**Sabina Yeasmin** is aAssistant Professor, Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

**A. K. M. Mominul Islam**, Assistant Professor, Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

**Dr. Md. Abdur Rahman Sarkar**, Professor, Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.