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# Interaction effect of Calcium and Boron on Growth, Yield Attributes and Yield of Groundnut in Vylogam Soil Series of Madurai District

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**ABSTRACT: A field experiment was carried out to investigate the interaction impact of calcium and boron on increasing groundnut yield in the Vylogam soil series in Madurai district during the rabi season 2019. The experiment was designed in a factorial randomized block design with three replications having 20 treatmental combinations including four levels of calcium (0, 100, 150, 200 kg per Ca ha$^{-1}$ applied through gypsum) as factor A and five levels of boron (0, 0.5, 1.0, 1.5, 2.0 kg B ha$^{-1}$ applied through borax) as factor B. Calcium and boron levels were revealed to have a significant influence on groundnut growth and yield properties. The treatment receiving Ca @ 150 kg ha$^{-1}$ and B 1.5 kg ha$^{-1}$ was proved to be the most effective in improving growth and yield characteristics. The interaction of calcium and boron exhibited a strong synergistic relationship at $Ca_{150}$ $B_{1.5}$ kg ha$^{-1}$ on growth and yield of groundnut (VRI 2) with pod yield (2317 kg ha$^{-1}$) and haulm yield (3463 kg ha$^{-1}$).**

**Keywords:** Groundnut, Calcium, Boron, Growth, Yield attributes.

## INTRODUCTION

Millions of farmers around the Globe cultivate Groundnut as a valuable cash, because of its remunerative and nutritious value. Despite applying the necessary fertiliser dose (NPK – nitrogen, phosphorus, potassium), the yield does not meet the potential level (Sahu et al., 1999). Lack of secondary and micronutrients is one of the key restrictions in decreasing groundnut production.

Oil seed crops have the highest secondary nutrient requirements. Calcium is a component of the cell wall and is required for the stability of plant cell membranes. One of the secondary nutrients that causes groundnut pegs and pods to abort and decreases output is a lack of calcium. Groundnut has the unusual ability to absorb Ca through the development of pegs and pods. Because Ca is very immobile in the plant and is not translocated in sufficient amounts to fruiting organs, Ca must be available in adequate amounts in the pod formation zone, indicating the nutrient's importance in groundnut production (Meena *et al.,* 2007).

Micronutrients are responsible for the key physiological processes in particular with photosynthesis and respiration (Marschner, 2012). On the other hand, micronutrient deficiencies can create severe limits in physiological and metabolic processes, even though plants only require a trace amount of micronutrient for adequate crop development and production. (Nasiri *et al.,* 2010). Boron is an important element that plants require for growth and development. Boron not only increases photosynthetic and enzymatic activity in plants, but also improves pollen grain germination, pollen tube growth and pollen grain viability (Prusty *et al.,* 2020).

Sustainable groundnut production is dependent on good variety selection, fertilizer management and other management practices, as optimal fertiliser rates have a favourable effect on groundnut performance (Nyuma *et al.,* 2019).

Calcium and boron are highly required for groundnut production. Gypsum is applied as calcium source to meet out the calcium requirement but boron is not applied for this crop. Due to non application of boron, the boron deficiency is one of the important constraints in groundnut cultivation in Madurai district. Besides, calcium and boron are antagonistic to each other. But the data base on available calcium and boron status of groundnut growing soils are lacking. In addition optimum requirement of calcium and boron is also not available to maximize the groundnut productivity is not available. Hence this investigation was made to assess the available calcium and boron status and to optimize the calcium and boron to harvest maximum yield from groundnut.

The study's goal was to determine the interaction impact of calcium and boron application on groundnut growth, yield, and yield characteristics, as well as to determine the optimal level of calcium and boron for boosting groundnut productivity.

## MATERIALS AND MATHODS

During the year 2019, a field experiment was conducted in a farmers' field at Poonchuthi village, Melur block, Madurai district Tamil Nadu with a test crop of groundnut (VRI 2) to evaluate the interaction effect of calcium and boron and to determine the optimum level of Ca and B for maximum groundnut productivity in Madurai district. The experimental location is located at 9° 54′N latitude, 78°17′E longitude, and 121 metres above mean sea level. The soils of the experimental site belonged to Vylogam series. The details of soil initial parameters are given in Table 1.

**Table 1: Initial properties of the experimental soil.**

| | | |
|---|---|---|
| **A.** | **Texture** | |
| **B.** | **Physical properties** | |
| | Bulk density (Mg $m^{-3}$) | 1.35 |
| | Particle density(Mg $m^{-3}$) | 2.34 |
| | Total porosity (%) | 42.31 |
| **C.** | **Chemical properties** | |
| | Soil reaction (pH) | 7.69 |
| | Electrical conductivity ($dSm^{-1}$) | 0.31 |
| | Organic carbon (g $kg^{-1}$) | 4.3 |
| | Available nitrogen (kg $ha^{-1}$) | 210 |
| | Available phosphorus (kg $ha^{-1}$) | 14.5 |
| | Available potassium (kg $ha^{-1}$) | 550 |
| | Available sulphur (mg $kg^{-1}$) | 7.9 |
| | Exchangeable Ca (c mol ($p^{+}$) $kg^{-1}$) | 1.42 |
| | Available boron (mg $kg^{-1}$) | 0.28 |
| **D.** | **Taxonomical class** | *Typic Rhodustalf* |

The experiment was carried out in a factorial randomized block design (FRBD) with three replications having twenty treatment combinations viz. four levels of calcium (0, 100, 150 and 200 kg $ha^{-1}$) as factor A and five levels of boron (0, 0.5, 1.0, 1.5 and 2.0 kg $ha^{-1}$) as factor B. Nitrogen, phosphorus, and potassium were applied @ 37, 188 and 41.6 respectively on STCR basis. Nitrogen was applied through urea, phosphorus through single super phosphate and potassium through muriate of potash Calcium as gypsum and boron as borax were applied as basal. The experimental plot size was 5 m × 4 m. The crop was sown in December. The groundnut variety used was VRI 2 sown at the rate 120 kg $ha^{-1}$ with a spacing of 30 cm × 15 cm.

Five plants were selected randomly from each plot and tagged for recording the growth and yield parameters. Plant height was measured in cm from the ground to the tip of the terminal bud, and the number of nodules was counted from the selected tagged plants, and the mean number of nodules per plant was determined and given in numbers. The yield was recorded at physiological maturity stage and after the harvest of the crop.

According to Gomez and Gomez, the data obtained was statistically examined (1984). Wherever the treatment differences were determined to be significant, the crucial differences were calculated at a 5per cent probability level.

## RESULT AND DISCUSSION

*A. Effect of Ca and B on plant height of groundnut crop*

The data depicted on Table 2 showed that the plant height was significantly increased at all the growth stages due to different calcium levels. Among the various calcium doses application of Ca @ 150 kg $ha^{-1}$ resulted in exhibiting maximum plant heights of 37.0, 51.7, and 52.8 cm at vegetative, flowering, and at harvest stages respectively. Calcium increased the nutrient supply to the plants and played a vital role in photosynthesis, carbohydrates metabolism, protein synthesis, synthesis of growth stimulating substances, cell division, and cell elongation with would have resulted in increased height (Mansingh *et al.*, 2018).

Similar to calcium application of different levels of boron also had a positive effect on plant height with significantly higher values of 35.7, 50.5 and 51.7 cm recorded with the application of 1.5 kg B $ha^{-1}$ during vegetative, flowering, and at harvest stages respectively. Boron is essential for improving carbohydrate metabolism, sugar transport, cell wall structure, protein metabolism, root growth, and promoting other plant physiological activities. Boron is required for N fixation, which could have ensured better N supply to the crop and increased the plant height (Kumar *et al.*, 2016).

A closer scrutiny of data revealed that the interaction impact of calcium and boron on plant height was statistically significant. At the vegetative, flowering, and at harvest stages the combined application of $Ca_{150}$ $B_{1.5}$ kg $ha^{-1}$ registered the highest plant height of 39.2, 55.6, and 57.3 cm respectively. Which clearly indicates that both the nutrients are synergistic and they mutually help in their absorption and utilization by the groundnut. Chirwa *et al.* (2017) observed a positive interaction effect between Ca and B on improving the plant height.

*B. Effect of Ca and B on number of nodules plant$^{-1}$*

The findings illustrated in Table 3 revealed that the application of different levels of calcium and boron had a positive effect on nodule count at different phases of the crop growth. Maximum number of nodules 74.8, 94.3 and 85.6 at 45, 75 DAS and at harvest stages respectively were recorded while applying Ca @ 150 kg ha$^{-1}$. Bell *et al.* (1989) exerted that calcium is required for the establishment and stabilisation of Rhizobium bacterial population in the rhizosphere prior to root infection, which might explain the particular requirement of calcium for nodule growth.

As regard as boron application a significant differences were observed with increasing dose of boron upto 1.5 kg ha$^{-1}$. The mean number of nodules 66.1, 89.3 and 80.2 at different growth phases respectively, were counted while applying 1.5 kg B ha$^{-1}$. Increased nodulation could be attributed to boron's irrevocable role in maintaining nodule cell wall and membrane integrity (Bolanos *et al.,* 1994). Boron is essential for nodule-forming bacteria resulting in an increase in nodule count. This positive effect of boron was in line with the findings of Hirpara *et al.* (2017).

Further the interaction effect of calcium and boron had a profound effect on root nodules of groundnut. The maximum number of root nodules of 88.7, 102.5 and 93.8 was registered at vegetative, flowering and at harvest respectively by the combined application of $Ca_{150}$ $B_{1.5}$ kg ha$^{-1}$.

*C. Effect of Ca and B on yield attributes*

**Number of pods plant$^{-1}$.** The data pertaining to number of pods plant$^{-1}$ illustrated in Table 4 indicates that various levels of calcium showed a significant influence on number of pods plant$^{-1}$. The highest number of pods plant$^{-1}$ (40.9) was recorded with the application of calcium @ 150 kg ha$^{-1}$. Calcium application is important for proper groundnut kernel development. Gypsum application during flowering to provide adequate Ca availability in the fruiting zone, hence enhancing pod development. According to Chapman *et al.* (1993), reduced peg formation is caused by the lack of soluble calcium in the pegging zone.

Similarly incremental dose of boron also significantly contributed to the number of pods plant$^{-1}$ upto 1.5 kg B ha$^{-1}$. The maximum number of pod of 37.0 plant$^{-1}$ was registered while applying B @ 1.5 kg ha$^{-1}$ beyond which it got declined. The increase in number of pods due to application boron might possibly through differentiation of tissue from somatic to reproductive and meristematic activity. In addition, the formation of floral clusters may have increased the number of flowers, which would have facilitated in pod formation. These findings were in consistent with the reports of other researchers (Khanna and Gupta, 2005).

Further the interaction between Ca and B was found to be statistically significant and indicated that the maximum number of pods plant$^{-1}$ of 44.7 were recorded by the conjoint application of $Ca_{150}B_{1.5}$ kg ha$^{-1}$.

**Hundred grain weight.** Application of various levels of calcium significantly and markedly increased the 100 grain weight of groundnut (Table 4). The maximum hundred grain weight (45.0 g) was recorded in the treatment applied with Ca @ 150 kg ha$^{-1}$. Peanut is a calcium loving crop and more than 90 per cent of the Ca in peanut pods is absorbed from the soil during pod formation stage (Hepler and Wayne. 1985). Calcium is important for the development of peanut embryo and pod (Yang *et al.,* 2017). Besides calcium is important for normal structure of peanut cells as well as the synthesis of multiple endogenous plant hormones such as auxin, ethylene and gibberellin which a play significant role in the peanut pod formation (Zhang *et al.,* 2016). Auxin is essential for increased grain size and starch accumulation and calcium can affect the grain weight and pod yield (Khan *et al.,* 2010).

A progressive increase in hundred grain weight was documented with an increasing levels of boron. Application of 1.5 kg B ha$^{-1}$ recorded the maximum hundred grain weight of 43.2 g. The increased hundred grain weight may be attributed to the timely application of B, would have played a significant role in cell metabolism, pod development and pod filling capacity (Li *et al.,* 1997).

Similar to the individual effect there was a significant difference in hundred grain weight of groundnut due to the combined application of calcium and boron. Among the different treatmental combinations the highest hundred grain weight of 46.7 g was recorded by the treatment applied with $Ca_{150}B_{1.5}$ kg ha$^{-1}$.

*D. Effect of Ca and B on pod and haulm yield*

On close examination of data furnished in Table 5 clearly showed a significant difference on yield by the influence of calcium and the highest pod (2116 kg ha$^{-1}$) and haulm (3288 kg ha$^{-1}$) yield were registered in the treatment applied with Ca @ 150 kg ha$^{-1}$. Crop yields have been linked to an increase in calcium (Caires *et al.,* 2008). Furthermore, the interaction effect of calcium on N and P may improve the chlorophyll content, stomatal conductance and quantum yield of photosystem II resulting in higher crop yield (Zangani *et al.,* 2021).

With respect to boron ferilization, the maximum pod (1958 kg ha$^{-1}$) and haulm (3100 kg ha$^{-1}$) yield was registered with the application of 1.5 kg B ha$^{-1}$. Boron significantly increased the chlorophyll content and photosynthetic leaf intensity, increased plant dry matter accumulation, early flowering and promoted the transport of photosynthates from vegetative organs to the reproductive organs, resulting in a significant increase in groundnut yield, according to Kumar *et al.* (2020b).

Also it is evident from the data that conjoint application of calcium and boron significantly increased the pod and haulm yield of groundnut. Among the different treatment combination imposed, combined application of 150 kg Ca ha$^{-1}$ + 1.5 kg B ha$^{-1}$ registered the maximum pod (2317 kg ha$^{-1}$) and haulm (3463 kg ha$^{-1}$) yield.

**Table 2: Effect of different levels of calcium and boron on plant height (cm) at different growth stages of groundnut (Mean of three replications).**

| Calcium levels (kg ha$^{-1}$) | Plant height (cm) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 45 DAS | | | | | | 75 DAS | | | | | | At harvest | | | | | |
| | Boron levels (kg ha$^{-1}$) | | | | | | Boron levels (kg ha$^{-1}$) | | | | | | Boron levels (kg ha$^{-1}$) | | | | | |
| | 0 | 0.5 | 1.0 | 1.5 | 2.0 | **Mean** | 0 | 0.5 | 1.0 | 1.5 | 2.0 | **Mean** | 0 | 0.5 | 1.0 | 1.5 | 2.0 | Mean |
| 0 | 32.1 | 32.8 | 33.5 | 33.5 | 33.9 | **33.2** | 44.5 | 47.2 | 47.4 | 47.9 | 48.3 | **47.0** | 48.2 | 48.9 | 49.6 | 49.6 | 50.0 | **49.2** |
| 100 | 34.0 | 34.7 | 34.9 | 35.2 | 36.2 | **35.0** | 48.3 | 49.1 | 49.1 | 49.6 | 49.6 | **49.1** | 50.0 | 50.8 | 50.8 | 51.3 | 51.3 | **50.8** |
| 150 | 34.1 | 36.9 | 37.2 | 39.2 | 37.4 | **37.0** | 48.4 | 50.6 | 51.3 | 55.6 | 52.8 | **51.7** | 50.1 | 52.3 | 53.0 | 57.3 | 53.5 | **52.8** |
| 200 | 34.0 | 34.3 | 34.5 | 34.9 | 34.2 | **34.4** | 48.4 | 48.6 | 48.7 | 49.0 | 48.5 | **48.6** | 50.1 | 50.3 | 50.4 | 50.6 | 50.2 | **50.3** |
| **Mean** | **33.6** | **34.7** | **35.0** | **35.7** | **35.4** | | **47.4** | **48.8** | **49.1** | **50.5** | **49.8** | | **49.6** | **50.6** | **50.9** | **51.7** | **51.2** | |
| | | **Ca** | **B** | **CaxB** | | | | **Ca** | **B** | **CaxB** | | | | **Ca** | **B** | **CaxB** | | |
| **SEd** | | 0.34 | 0.38 | 0.75 | | | | 0.45 | 0.50 | 1.00 | | | | 0.42 | 0.47 | 0.94 | | |
| **CD(P=0.05)** | | 0.68 | 0.76 | 1.53 | | | | 0.91 | 1.02 | 2.04 | | | | 0.85 | 0.95 | 1.91 | | |

**Table 3. Effect of different levels of calcium and boron on number of root nodules (no) at different growth stages of groundnut (Mean of three replications).**

| Calcium levels (kg ha$^{-1}$) | No. of root nodules | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 45 DAS | | | | | | 75 DAS | | | | | | At harvest | | | | | |
| | Boron levels (kg ha$^{-1}$) | | | | | | Boron levels (kg ha$^{-1}$) | | | | | | Boron levels (kg ha$^{-1}$) | | | | | |
| | 0 | 0.5 | 1.0 | 1.5 | 2.0 | **Mean** | 0 | 0.5 | 1.0 | 1.5 | 2.0 | **Mean** | 0 | 0.5 | 1.0 | 1.5 | 2.0 | **Mean** |
| 0 | 36.4 | 43.7 | 45.2 | 48.7 | 50.4 | **44.9** | 62.4 | 68.5 | 71.6 | 75.8 | 76.2 | **70.9** | 58.4 | 63.5 | 66.2 | 66.5 | 67.8 | **64.5** |
| 100 | 51.3 | 63.2 | 64.0 | 64.5 | 66.8 | **62.0** | 78.1 | 89.2 | 89.7 | 91.4 | 92.5 | **88.2** | 69.6 | 80.1 | 81.4 | 82.9 | 83.5 | **79.5** |
| 150 | 54.9 | 73.9 | 74.1 | 88.7 | 82.5 | **74.8** | 81.4 | 93.7 | 96.5 | 102.5 | 97.3 | **94.3** | 73.4 | 84.4 | 87.3 | 93.8 | 89.2 | **85.6** |
| 200 | 52.5 | 57.4 | 60.3 | 62.5 | 56.7 | **57.9** | 79.4 | 85.0 | 85.4 | 87.3 | 82.6 | **83.9** | 71.5 | 74.3 | 76.4 | 77.5 | 75.3 | **75.0** |
| **Mean** | **48.8** | **59.6** | **60.9** | **66.1** | **64.1** | | **75.3** | **84.1** | **85.8** | **89.3** | **87.2** | | **68.2** | **75.6** | **77.8** | **80.2** | **79.0** | |
| | | **Ca** | **B** | **CaxB** | | | | **Ca** | **B** | **CaxB** | | | | **Ca** | **B** | **CaxB** | | |
| **SEd** | | 0.47 | 0.52 | 1.05 | | | | 0.71 | 0.80 | 1.60 | | | | 0.74 | 0.83 | 1.66 | | |
| **CD(P=0.05)** | | 0.95 | 1.06 | 2.13 | | | | 1.45 | 1.62 | 3.25 | | | | 1.51 | 1.68 | 3.37 | | |

**Table 4: Effect of different levels of calcium and boron on yield attributes of groundnut crop (Mean of three replications).**

| Calcium levels (kg ha$^{-1}$) | Yield attributes | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of pods plant$^{-1}$ | | | | | | 100 seed weight (g) | | | | | |
| | Boron levels (kg ha$^{-1}$) | | | | | | Boron levels (kg ha$^{-1}$) | | | | | |
| | 0 | 0.5 | 1.0 | 1.5 | 2.0 | **Mean** | 0 | 0.5 | 1.0 | 1.5 | 2.0 | **Mean** |
| 0 | 27.2 | 29.8 | 30.8 | 31.5 | 31.6 | **30.2** | 38.4 | 39.5 | 39.6 | 39.9 | 40.2 | **39.5** |
| 100 | 32.7 | 36.4 | 36.8 | 37.2 | 39.5 | **36.5** | 40.8 | 43.4 | 43.7 | 44 | 44.3 | **43.2** |
| 150 | 34.3 | 40.1 | 42.5 | 44.7 | 42.9 | **40.9** | 41.0 | 45.5 | 45.8 | 46.7 | 46.2 | **45.0** |
| 200 | 33.8 | 34.5 | 35.2 | 34.6 | 33.8 | **34.4** | 40.9 | 42.8 | 42.5 | 42.1 | 41.6 | **41.9** |
| **Mean** | **32.0** | **35.2** | **36.3** | **37.0** | **36.9** | | **40.3** | **42.8** | **42.9** | **43.2** | **43.1** | |
| | | **Ca** | **B** | **CaxB** | | | | **Ca** | **B** | **CaxB** | | |
| **SEd** | | 0.35 | 0.39 | 0.79 | | | | 0.35 | 0.39 | 0.78 | | |
| **CD(P=0.05)** | | 0.71 | 0.80 | 1.60 | | | | 0.71 | 0.80 | 1.60 | | |

**Table 5: Effect of different levels of calcium and boron on yield of groundnut crop (Mean of three replications).**

| Calcium levels (kg ha$^{-1}$) | Pod yield (kg ha$^{-1}$) | | | | | | Haulm yield (kg ha$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Boron levels (kg ha$^{-1}$) | | | | | | Boron levels (kg ha$^{-1}$) | | | | | |
| | 0 | 0.5 | 1.0 | 1.5 | 2.0 | **Mean** | 0 | 0.5 | 1.0 | 1.5 | 2.0 | **Mean** |
| 0 | 1487 | 1569 | 1621 | 1667 | 1651 | **1599** | 2638 | 2676 | 2706 | 2728 | 2765 | **2703** |
| 100 | 1623 | 1983 | 2014 | 2032 | 2072 | **1944** | 2801 | 3164 | 3192 | 3213 | 3250 | **3124** |
| 150 | 1690 | 2138 | 2189 | 2317 | 2250 | **2116** | 2868 | 3316 | 3367 | 3463 | 3428 | **3288** |
| 200 | 1652 | 1918 | 1867 | 1817 | 1755 | **1801** | 2830 | 3096 | 3046 | 2995 | 2933 | **2980** |
| **Mean** | **1613** | **1902** | **1922** | **1958** | **1932** | | **2784** | **3063** | **3078** | **3100** | **3094** | |
| | | **Ca** | **B** | **CaxB** | | | | **Ca** | **B** | **CaxB** | | |
| **SEd** | | 18.9 | 21.1 | 42.2 | | | | 25.1 | 28.1 | 56.1 | | |
| **CD(P=0.05)** | | 38.4 | 42.9 | 85.8 | | | | 51.1 | 57.0 | 114.2 | | |

## CONCLUSION

Result of the current study can be concluded that the application of 150 kg Ca $ha^{-1}$ + 1.5 kg B $ha^{-1}$ were found to be the optimum for better growth and yield of groundnut crop in the soils of Vylogam series of Madurai district of Tamil Nadu.

## FUTURE SCOPE

Conduction of on farm trails in various locations to validate the optimum requirement of calcium and boron for requirement.

Validation of calcium and boron requirement in other soil series where groundnut is grown.

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