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# Boron Management in Green gram (*Vigna radiata* L. Wilczek) under Custard Apple (*Annona squamosa* L.) based Agri-horti System in Semi-arid Region

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**Abstract:** An experiment was conducted at the Agricultural Research Farm, RGSC, BHU, Barkachha, Mirzapur (UP) on sandy clay loam soil during kharif 2016-17 to evaluate the effect of three levels of Boron (0.75, 1.50 and 2.25 kg $ha^{-1}$) and foliar spray of two levels of Solubor (0.2 and 0.3%) on green gram (*Vigna radiata* L. Wilczek) under custard apple (*Annona squamosa* L.) based Agri-horti system. The growth and yield parameters were significantly affected by different levels of Boron and Solubor. Data revealed that application of Boron @ 2.25 kg $ha^{-1}$ gave maximum values of growth parameters, yield attributes, grain and stover yield, harvest index as well as content and removal of N and S by green gram over rest of the levels. Similarly, the application of solubor @ 0.3% $ha^{-1}$ exhibited higher in all growth parameters, yield attributes, yield, N and S content and its removal over rest of the levels. Moreover, the maximum net return (Rs. 60505 $ha^{-1}$) was also observed under the application of boron (2.25 kg $ha^{-1}$) along with solubor (0.3% $ha^{-1}$).

**Key words**: Agri-horti system, green gram, custard apple, boron, yield.

The agroforestry system creates a more integrated, diverse, productive, profitable, healthy and sustainable land-use system (Sharma *et al*. 2017b) in addition to the reclamation of degraded, wastelands (Sharma *et al*., 2017a), soil water conservation (Singh *et al*., 2020) and climate change adaptation and mitigation (Verma *et al*., 2021). Agri-horticultural system is a modified traditional cropping system of India that utilizes the maximum capability of land as well as growing season and simultaneously enhances the productivity of land. Pulse crop along with Guava, Bael, Aonla, Custard apple and Karonda etc. are more commonly grown in Vindhyan region under the agri-horticultural system (Minz *et al*., 2021). India is the largest producer and consumer of pulses in the world accounting for 25% of total world production and 27% of world's consumption. Green gram [*Vigna radiata* (L.) Wilczek] commonly known as "mung bean" is one of the important short duration pulse crops grown in India. It ranks third among all the pulses grown in India after chickpea and pigeonpea (Tamang *et al*., 2015). The seeds of green gram are highly nutritious with protein, carbohydrates, minerals and vitamins. Proteins are rich in lysine, leucine and threonine but poor in methionine, tryptophan, tyrosine. Every 100 g of edible portion of green gram seed contains 75 mg calcium, 4.5 mg phosphorus, 24.5 g protein and 348 kilo calories energy (Meena *et al*., 2013). Boron is one of the most widely applied micronutrients. Solubor tetra borate ($Na_2B_4O_7.5H_2O$) is the most common B source containing 20% B. Solubor is a highly concentrated, soluble B source that can be used as foliar in form of liquid or dust. It is also used in liquid and suspension fertilizers. Solubor is preferred to borax because it dissolves more readily (Alloway, 2009). Solubor is a specially developed product for speedy and economic correction of boron deficiency in fruit trees, vegetables and other crops (Havlin *et al*., 2014). Further, boron is an essential plant nutrient and primary function of boron is in plant cell wall structural integrity. Boron also provide cross links between cell wall polysaccharides for providing structure to the cell wall-important for cell expansion, regulation of hydrogen ion ($H^+$) transport retention of cellular $Ca^{+2}$, and control of lignin production following cell expansion. Considering the above facts in view the present investigation is carried out to find the effect of Boron management in green gram (*Vigna radiata* L. Wilczek) under custard apple (*Annona squamosa* L.) based agri-horti system.

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## Material and Methods

The field experiment was carried out during kharif season of 2016-17 at the Rajiv Gandhi South Campus Agricultural Research Farm, Barkachha (BHU), Mirzapur, located in the Vindhyan region of Mirzapur (25°10'' latitude, 82°37'' longitude and 427 meters above sea level) UP, India. Mirzapur falls to the sub-humid climate in a semi-arid belt. The normal period for the onset of monsoon in this region is June's third week and lasts until the end of September or sometimes extends to the first week of October. From December to mid-February, winter showers are often experienced. Overall, however, March to May is dry. On average, the major fraction (75%) of the total annual rainfall is received from June to September. The monthly mean maximum and minimum temperature during the period of experiment, ranges from 25.3°C to 36.7°C and 10.5°C to 27.3°C, respectively.

The soil of the experimental field was sandy clay loam in texture. The experimental soil was low in available nitrogen (147.7 kg $ha^{-1}$), organic carbon (0.36%), as well as available sulphur (12.2 kg $ha^{-1}$) and medium in phosphorus (14.2 kg $ha^{-1}$) and potassium (218.5 kg $ha^{-1}$). The experimental crop (green gram) was sown as an allay cropping in 9 years old custard apple which was planted in August, 2007 at the spacing of 5 x 5 meter. The experiment was conducted in randomized block design having Boron (0.75 kg $ha^{-1}$) + 0.2% Solubor for foliar spray, Boron (1.50 kg $ha^{-1}$) + 0.2% Solubor for foliar spray, Boron (2.25 kg $ha^{-1}$) + 0.2% solubor for foliar spray, Boron (0.75 kg $ha^{-1}$) + 0.3% Solubor for foliar spray, Boron (1.50 kg $ha^{-1}$) + 0.3% Solubor for foliar spray, Boron (2.25 kg $ha^{-1}$) + 0.3% Solubor for foliar spray, and Control (No Boron and Solubor) with variety (HUM-16) Malviya Jankalyani of green gram in three replications. The experiment consists of 7 treatment combinations. The gross and net plot size of experimental unit was 3 x 3 $m^2$ and 2.25 x 2.0 $m^2$, respectively. Row to row and plant to plant spacing was 30 cm and 10 cm, respectively. Observations of growth parameters were recorded at an interval of 20 days, i.e. $20^{th}$, $40^{th}$ days after sowing and at maturity. Similarly, yield attributing characters were also recorded at harvesting. After harvesting, seed and stover samples were processed and analysed for N content (Colorimetric method), S content (Turbidimetric method) and nutrient removal. Data obtained from various observations were analysed statistically by adopting the appropriate "Analysis of Variance" method (Gomez and Gomez, 1984). The treatment differences were tested by 'F' test of significance on the basis of null hypothesis. Critical differences were worked out at 5% level of probability where 'F' test was significant.

## Results and Discussion

The experimental results revealed that application of 0.3% Solubor and 2.25 kg boron $ha^{-1}$ recorded significantly higher growth parameters viz. plant height, root nodules $plant^{-1}$, trifoliate leaves $plant^{-1}$, branches $plant^{-1}$ and dry matter accumulation as compared to other treatments (Table 1). This may be due to important role of boron in tissue differentiation and carbohydrate metabolism. It is also a constituent of cell membrane and maintenance of conducting tissue with regulatory effect on other element. The similar result also observed by Kaisher *et al.* (2010) in green gram when they found that 30 kg S and 5 kg B $ha^{-1}$ was best in respect to plant height, number of branches $plant^{-1}$, number of pod $plant^{-1}$, number of seeds $pod^{-1}$, 1,000-seed weight, seed yield and protein content

Increase in nodule number and nodule development also observed with the application of 2.25 kg B $ha^{-1}$. Improvement in nodule development with the application of boron was due to its role in formation of nodule in leguminous plant concerned with precipitation of excess cation, buffer action and regulatory effect on other nutrient element. Such beneficial effect of boron with better edaphic environment available to the crop, might have improved all the growth parameters. Similar finding have also been reported by Shamsuddoha *et al.* (2011), Mathew *et al.* (2013), Parry *et al*. (2016). Similarly highest yield and yield attributing characters were also observed by the application of 0.3% Solubor and 2.5 kg B $ha^{-1}$ (Table 1 and 2). The beneficial effect of boron on yield attributes may be due to flower development, pollen grain formation, pollen viability, pollen tube growth for proper pollination and seed development. Similar results were reported by Mathew *et al.* (2013) in Sesamum. The findings also supported by the result of Kumar *et al*.

*Table 1. Effect of Boron and Solubor on growth and yield attributes of green gram under custard apple based agri-horti system*

| Treatment | Plant height (cm) | Trifoliate leaves (no. plant$^{-1}$) | Root nodules (no. plant$^{-1}$) | Primary branch/ plant | Dry matter accumulation plant$^{-1}$ (g) | Pods/ plant (No.) | Pods length (cm) | Grains pod$^{-1}$ (No.) | Test weight (g) |
|---|---|---|---|---|---|---|---|---|---|
| Levels of Solubor (20% B) | | | | | | | | | |
| 0.2% | 49.68 | 6.66 | 5.06 | 6.02 | 5.06 | 15.22 | 7.47 | 6.61 | 38.27 |
| 0.3% | 51.23 | 10.97 | 5.22 | 6.27 | 5.22 | 15.64 | 7.72 | 6.79 | 38.73 |
| SEm | 0.26 | 0.95 | 0.14 | 0.13 | 0.14 | 0.19 | 0.14 | 0.08 | 0.31 |
| CD (P = 0.05) | 0.56 | 2.08 | NS | NS | NS | NS | NS | 0.17 | NS |
| Levels of Boron (kg ha$^{-1}$) through Borax (10.5% B) | | | | | | | | | |
| 0.75 | 48.22 | 6.47 | 4.92 | 5.92 | 4.92 | 14.72 | 7.25 | 6.40 | 36.82 |
| 1.50 | 50.10 | 6.68 | 5.11 | 5.93 | 5.11 | 15.30 | 7.55 | 6.63 | 38.58 |
| 2.25 | 53.05 | 10.29 | 5.40 | 6.58 | 5.40 | 16.28 | 7.98 | 7.07 | 39.00 |
| SEm | 0.31 | 1.17 | 0.17 | 0.15 | 0.17 | 0.23 | 0.13 | 0.10 | 0.38 |
| CD (P = 0.05) | 0.68 | 2.54 | 0.37 | 0.33 | 0.37 | 0.50 | 0.29 | 0.21 | 0.83 |
| Control (No solubor and No Boron) | 45.47 | 6.13 | 4.63 | 5.83 | 4.63 | 11.67 | 6.83 | 6.03 | 34.03 |
| Rest of the treatment | 50.46 | 8.81 | 5.14 | 6.14 | 5.14 | 15.43 | 7.59 | 6.70 | 38.50 |
| SEm | 0.09 | 0.41 | 0.05 | 0.04 | 0.05 | 0.07 | 0.04 | 0.03 | 0.11 |
| CD (P=0.05) | 0.31 | 1.37 | 0.17 | 0.15 | 0.17 | 0.23 | 0.13 | 0.10 | 0.38 |

(2006) in cowpea, Singh *et al*. (2015) in mung bean and Parry *et al*. (2016), Singh *et al*. (2008) in blackgram. With increasing levels of Solubor from 0.2% to 0.3% ha$^{-1}$, removal of nitrogen and sulphur by seed and stover were significantly increased. Similar results were reported by Islam *et al*. (2006), Halwai *et al*. (2016).

The data on relative economics of various treatments revealed that the maximum net return (Rs. 73775 ha$^{-1}$) was recorded with application of 0.3% Solubor and 2.25 kg B ha$^{-1}$ to green gram under custard apple based agri-horti system, while the control (no Solubor and no boron) showed (Rs. 69206 ha$^{-1}$) value of net

*Table 2. Effect of Boron and Solubor on yield and yield attributes of green gram under custard apple based agri-horti system*

| Treatment | Grain yield (kg ha$^{-1}$) | Stover yield (kg ha$^{-1}$) | Harvest index (%) | Nitrogen removal (kg ha$^{-1}$) | Sulphur removal (kg ha$^{-1}$) |
|---|---|---|---|---|---|
| Levels of Solubor (20% B) | | | | | |
| 0.2% | 764 | 2489 | 23.5 | 61.26 | 5.63 |
| 0.3% | 789 | 2466 | 24.2 | 69.42 | 5.76 |
| SEm ± | 8.11 | 26.31 | 0.08 | 1.56 | 0.04 |
| CD (P=0.05) | 17.68 | NS | NS | 3.39 | 0.08 |
| Levels of Boron (kg ha$^{-1}$) through Borax (10.5% B) | | | | | |
| 0.75 | 738 | 2426 | 23.7 | 61.44 | 5.39 |
| 1.50 | 753 | 2440 | 23.2 | 63.82 | 5.53 |
| 2.25 | 838.77 | 2567.04 | 24.6 | 70.76 | 6.17 |
| SEm ± | 9.94 | 32.22 | 0.10 | 1.91 | 0.05 |
| CD (P=0.05) | 21.65 | 70.21 | 0.21 | 4.15 | 0.10 |
| Control (No solubor and No Boron) | 710.27 | 2409.87 | 22.3 | 50.33 | 4.45 |
| Rest of the treatment | 776.78 | 2477.62 | 23.9 | 65.34 | 5.70 |
| SEm ± | 2.91 | 11.16 | 0.03 | 2.06 | 0.02 |
| CD (P=0.05) | 9.94 | 34.37 | 0.10 | 6.34 | 0.05 |

*Table 3. Effect of Boron and Solubor on bio economics of green gram and custard apple based agri-horti system*

| Treatment | Cost of cultivation (Rs. ha$^{-1}$) | Gross income (Rs. ha$^{-1}$) | | | | Net return (Rs ha$^{-1}$) | Benefit : cost ratio |
|---|---|---|---|---|---|---|---|
| | | Grain | Stover | Custard apple (1306 kg fruits ha$^{-1}$) | Total | | |
| Boron ( 0.75 kg ha$^{-1}$ ) + 0.2% Solubor for foliar spray | 27784 | 38774.67 | 6095.48 | 52246 | 97116.15 | 69332 | 2.50 |
| Boron ( 1.50 kg ha$^{-1}$ ) + 0.2% Solubor for foliar spray | 28498 | 37819.43 | 6125.64 | 52246 | 96191.07 | 67693 | 2.38 |
| Boron ( 2.25 kg ha$^{-1}$ ) + 0.2% solubor for foliar spray | 29212 | 42621.97 | 6446.20 | 52246 | 101314.17 | 72103 | 2.47 |
| Boron ( 0.75 kg ha$^{-1}$ ) + 0.3% Solubor for foliar spray | 28042 | 39571.31 | 6034.47 | 52246 | 97851.78 | 69810 | 2.49 |
| Boron ( 1.50 kg ha$^{-1}$ ) + 0.3% Solubor for foliar spray | 28756 | 38956.84 | 6073.51 | 52246 | 97276.35 | 68520 | 2.38 |
| Boron ( 2.25 kg ha$^{-1}$ ) + 0.3% Solubor for foliar spray | 29470 | 44609.93 | 6389.02 | 52246 | 103244.96 | 73775 | 2.50 |
| No Boron and Solubor | 26754 | 36933.87 | 6024.67 | 52246 | 95204.54 | 68450.54 | 2.55 |

Production cost (Rs. ha$^{-1}$): seed 52, Stover 2.50, fruits of custard apple 40, Seasonal cost of production of custard apple Rs. 6227 ha$^{-1}$ for weeding, pest control and harvesting were included.

return but the benefit: cost ratio of control (no solubor and no boron) is higher (2.55) over other treatments (Table 3). This was due to the fact that application of 0.3% Solubor and 2.25 kg B ha$^{-1}$ exhibited increase in the seed and Stover yields and the cultivation cost was lower in control. These results were confirmed with the finding of Ram and Kumar (2009).

## Conclusion

From this study it is concluded that significant increase in growth characters, yield and yield attributes of green gram were recorded with the application of 0.3% Solubor and 2.25 kg B ha$^{-1}$. Similarly maximum nitrogen removal and net return is also resulted in the application of 0.3% Solubor and 2.25 kg B ha$^{-1}$. Hence the green gram intercropped in alley of custard apple with application of 0.3% Solubor and 2.25 kg B ha$^{-1}$ proved to be most remunerative for the soils of semi-arid region.

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