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Evaluation of various levels of calcium and boron on yield and economics of groundnut (*Arachis hypogaea* L.) in Irugur soil series of Madurai district

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Abstract
A field experiment was conducted to study the interaction effect of calcium and boron on improving the productivity of groundnut (VRI 2) in Irugur soil series of Madurai district, Tamil Nadu during Rabi season 2020. The experiment was laid out in a factorial randomized block design with three replications having 20 treatment combinations *viz* four levels of calcium (0, 100, 150 and 200 kg Ca ha^{-1}) applied through gypsum as factor A and five levels of boron (0, 0.5, 1.0, 1.5 and 2.0 kg B ha^{-1}) applied through borax as factor B. The results revealed that application of Ca @ 150 kg ha^{-1} and boron @ 1.5 kg ha^{-1} proved to be the best treatment in improving the grain and haulm yield. Higher doses of calcium and boron did not increase the grain and haulm yields further. Thus calcium and boron exhibited a strong synergistic relationship at $Ca_{150}B_{1.5}$ kg ha^{-1} on yield of groundnut with grain yield (2132 kg ha^{-1}) and haulm yield (3112 kg ha^{-1}) in Irugur soil series of the district.

Keywords: Calcium, boron, interaction, groundnut, yield

Introduction
Groundnut (*Arachis hypogaea* L.) is the fourth most important source of edible oil and important source of vegetable protein in the oilseed crop of India and an important agricultural export commodity. It contains about 50 per cent oil, 25 to 30 per cent protein, 20 per cent carbohydrate and 5 per cent fiber and ash which make a substantial contribution to human nutrition (Patel and Zinzala. 2018) [5]. Groundnut covers 295 lakh hectares with productivity of 1647 kg per hectare (FAOSTAT, 2019) [1]. India is one among the top three groundnut producing countries occupies second next to China. Gujarat is the largest producer contributing 33 per cent of the total production of groundnut followed by Rajasthan (21%), Tamil Nadu (14%). Andhra Pradesh and Telangana contributes 7 and 5 per cent respectively in groundnut production during the year 2018-19 (Rajashree *et al.*, 2021) [7].

Calcium is an essential plant nutrient which plays a pivotal role in plant growth and development such as cell division, cell polarity, circadian rhythms, stomatal closure, senescence, and responses to multiple stresses. Calcium deficiency induce the abortion of groundnut embryos or prevent the expansion of kernel (empty pods), improperly filled pods and causes aborted or shriveled fruit, including darkened plumules and production of pods without seed and this may eventually lead to the reduction of peanut yields. Supplied with sufficient calcium would increase the groundnut pod yield. It has been suggested that calcium plays an important role in the development of groundnut pods (Yang *et al.*, 2020) [11].

Micronutrients play an important role in increasing yield of oilseed legumes. Among the micro nutrients boron is very important in plant metabolism by catalyzing certain enzyme, cell division, carbohydrate transport, and calcium and potassium uptake and protein synthesis; ultimately it enhances pod yield. Among the micronutrients boron ranks third place in its concentration in seed, as well as its total amount after zinc and the range between deficient and toxic concentration is smaller than any other nutrient element (Movalia *et al.*, 2020) [3].

Sustainable groundnut production depends on proper selection of variety, fertilizer and other management practices as optimal application of fertilizer have positive effect on the performance of groundnut (Nyuma *et al.*, 2019) [4].

Most of the farmers are growing groundnut by applying less amount of nutrients such as N, P and K with or without the addition of secondary and micro nutrients. Previous research work carried out by various researchers have also proved a positive response for the application of

Ca and B. Separately in groundnut but the information on the combined application of calcium and boron is lacking on groundnut.

It was therefore necessary to develop a strong workable and compatible package of calcium and boron management for groundnut based on scientific facts and local conditions. Thus the present study was undertaken to investigate the effect of calcium and boron on yield and economics of groundnut in Madurai district of Tamil Nadu.

Materials and Methods

A field experiment was conducted in farmers' fields at Doddappanaickanur village, Usilampatti block, Madurai district, Tamil Nadu with test crop of groundnut (VRI 2) during the year 2020 to evaluate the effect of calcium and boron and to optimize the Ca and B to get maximum productivity in groundnut crop. The soil of the experimental site belong to Irugur series and according to USDA soil taxonomy it is classified as *Typic Ustropept*. The details of soil initial properties are given in Table 1. The experiment was laid out in factorial randomized block design with three replications and twenty treatment combinations *viz* four levels of calcium (0, 100, 150 and 200 kg Ca ha^{-1}) as factor A and five levels of boron (0, 0.5, 1.0, 1.5 and 2.0 kg B ha^{-1}) as factor B. Nitrogen, phosphorus and potassium were applied @ 87, 94 and 42 kg ha^{-1} respectively on STCR basis. Calcium and boron were applied as per the treatment as gypsum and boron respectively. The experimental plot size was 5 x 4 m. The crop was sown in middle of December. The Groundnut variety used was VRI 2 sown at the rate 120 kg ha^{-1} with a spacing of 30 cm × 10 cm. Hand weeding was done at 45 days after sowing.

Five plants from each plot were selected at random, tagged and yield parameters were recorded. The pods collected from the net plot area of different treatments were dried, threshed and after drying grain yield was recorded at 12 per cent moisture from each plot and expressed as kg ha^{-1}. The dry weight of haulm yield from each plot was also recorded. The net return was worked out for all the treat mental combinations. The cost of inputs, labour charges and prevailing market rates of farm produce were taken into consideration for working out the economics. Cost benefit analysis were worked out for all the treatments.

The data collected were statistically analyzed as suggested by Gomez and Gomez (1984) [2].

Results and Discussion

Effect of calcium and boron on grain and haulm yield of groundnut

The effect of different levels of Ca and B on grain and haulm yield of groundnut is presented in Table 2. It is apparent from the data that the application of Ca significantly and markedly increased the grain and haulm yield up to Ca 150 kg ha^{-1} and thereafter a declining trend was observed. The highest grain and haulm yield of 1932 and 2937 kg ha^{-1} respectively were recorded in the treatment receiving Ca 150 kg ha^{-1}. Generally Ca play an important role in the reproductive organs development of groundnut. This is probably because in the absence of proper supply of calcium to both xylem and phloem, the penetrating gynophores have modified themselves into absorbing organs of Ca from the immediate fruiting zone. Thus developing pods might have absorbed Ca directly from the soil and the adequate supply of Ca reduced the "Pops" or blackened plumule inside the seed known as "Black heart" and yielded the sound pods. This is in close agreement with the findings of Singh (2007) [10].

Similar to boron application also significantly increased the grain and haulm yield upto 1.5 kg B ha^{-1} and thereafter a declining trend was observed. The highest grain and haulm yield of 1773 and 2749 kg ha^{-1} respectively were recorded while applying B 1.5 kg ha^{-1}. The application of B enhanced the uptake of other nutrients such as N, P and K in the crops due its synergistic effect, which might have been the reason for the increased pod and haulm yield (Revathi *et al*., 1996) [8]. Besides the application of boron enhanced the uptake of other micronutrients, as B has a synergistic effect over other micronutrients and the availability of Fe, Mn, Zn, Cu and B also get increased which could have intern increased the pod and haulm yields of the groundnut crop as B is involved in catalyzing the carbohydrate metabolism. The increased yield might also be attributed to significant increase in growth and yield attributes due to the application of boron, which is evidenced by increased uptake of these nutrients at various stages of crop growth. These results are in inconformity with the findings of Poonguzhali and Pandian (2018) [6].

The combined application of calcium and boron also had a favourable influence on groundnut yield. The highest pod and haulm yield of 2132 and 3112 kg ha^{-1} was registered while applying Ca and B @ 150 and 1.5 kg ha^{-1} respectively.

Effect of calcium and boron on economics of groundnut

The economics of groundnut production was considerably influenced by the interaction of various levels of calcium and boron (Table 3). The cost of cultivation was maximum (Rs 44659) under the treatment $Ca_{200}B_{2.0}$ and minimum (Rs 39979) in the treatment Ca_0B_0. The maximum net profit was recorded under the treatment $Ca_{150}B_{1.5}$ (Rs 43809) and the lowest under Ca_0B_0 (Rs 39979). The magnitude of benefit-cost ratio varied from 1.59 to 2.39. The highest B-C ratio of 2.39 was registered in case of $Ca_{150}B_{1.5}$. Findings of this study provided a sound base to believe that combined application of calcium and boron increased the grain and haulm yield of groundnut crop over control and was proved to be the most economical treatment for increasing net profit. Similar findings were made by Sharma *et al.* (2019) [9].

Table 1: Initial properties of the experimental soil

A.	**Texture**	
B.	**Physical properties**	
	Bulk density (Mg m^{-3})	1.38
	Particle density(Mg m^{-3})	2.15
	Total porosity (%)	36
C.	**Chemical properties**	
	Soil reaction (pH)	7.79
	Electrical conductivity (dSm^{-1})	0.03

	Organic carbon (g kg^{-1})	1.2
	Available nitrogen (kg ha^{-1})	168
	Available phosphorus (kg ha^{-1})	25.0
	Available potassium (kg ha^{-1})	351
	Available sulphur (mg kg^{-1})	8.6
	Exchangeable Ca (c mol (p^{+}) kg^{-1})	1.28
	Available boron (mg kg^{-1})	0.31
D.	**Taxonomical class**	*Typic Ustropept*

Table 2: Effect of different levels of calcium and boron on yield of groundnut in Irugur soil series (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	1302	1384	1436	1482	1466	1414	2287	2325	2355	2377	2414	2352
100	1438	1798	1829	1847	1887	1760	2450	2813	2841	2862	2899	2773
150	1505	1953	2004	2132	2065	1932	2517	2965	3016	3112	3077	2937
200	1467	1733	1682	1632	1570	1617	2479	2745	2695	2644	2582	2629
Mean	1428	1717	1738	1773	1747		2433	2712	2727	2749	2743	
		Ca	B	CaxB				Ca	B	CaxB		
SEd		11.90	13.30	26.59				21.08	23.57	47.14		
CD(P=0.05)		24.2	27.0	54.1				42.8	47.9	95.8		

Table 3: Effect of different levels of calcium and boron on economics and benefit-cost ratio of groundnut in Irugur soil series

Calcium levels (kg ha^{-1})	Boron levels (kg ha^{-1})				
	0	**0.5**	**1.0**	**1.5**	**2.0**
Total cost of cultivation (Rs)					
0	39979	40299	40619	40939	41259
100	41679	41999	42319	42639	42959
150	42529	42849	43169	43489	43809
200	43379	43699	44019	44339	44659
Gross return (Rs)					
0	63640	67595	70106	72325	71575
100	70249	87711	89213	90087	92026
150	73499	95227	97700	103892	100659
200	71656	84557	82084	79658	76651
Net return (Rs)					
0	23661	27296	29487	31386	30316
100	28570	45712	46894	47448	49067
150	30970	52378	54531	60403	56850
200	28277	40858	38065	35319	31992
Benefit-Cost ratio					
0	1.59	1.68	1.73	1.77	1.73
100	1.69	2.09	2.11	2.11	2.14
150	1.73	2.22	2.26	2.39	2.3
200	1.65	1.93	1.86	1.8	1.72

Value of groundnut seed produced= Rs 48 kg^{-1}, Value of haulm= Rs 0.5 kg^{-1}

Conclusion

It has been observed that applying $Ca_{150}B_{1.5}$ kg ha^{-1} to groundnut had beneficial effect on the yield and economic returns of groundnut. It is concluded that calcium and boron are must require secondary and micronutrients for the better growth, yield and economic returns of groundnut crop.

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