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Research Article

Soil and Foliar Nutrition of Calcium, Magnesium and Boron influences Yield and Quality of Cabbage (*Brassica oleracea* L. *var*. *capitata*)

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ABSTRACT

An experiment was carried out to study the effect of soil and foliar application of calcium, magnesium and boron on growth, yield and quality of cabbage .The result revealed that application of calcium and boron as foliar spray and magnesium as soil application recorded the maximum plant height (37.12 cm), number of leaves per plant (32.66), plant spread (59.21 cm), leaf area (699.12 cm^2) , minimum number of days to head formation (50.66 DAT) and head maturity (85.33 DAT) in cabbage .The highest available Mg (215.66 mg kg^{-1}) and available S (11.69 mg kg^{-1}) in soil , N content in leaves (2.28 %) and cabbage head (2.21 %), Ca content (2.42 %) in leaves and in cabbage head (0.99 %) were obtained in the same treatment. With regard to nutrient uptake also the same treatment recorded the highest uptake of N (1.912 g plant $^{-1}$) ,Ca (1.112 g plant $^{-1}$), Fe (0.299 g plant $^{-1}$) and Mn (0.434 g plant $^{-1}$). The highest fresh weight of plant (1.833 kg), head yield (1.216 kg) and the quality parameters like protein content (1.93 %)and vitamin C content(64.55 mg $^{-1}$ 100 g) were obtained due to the soil application of Mg and foliar spray of B and Ca . The highest B: C ratio (1.82) was registered by the same treatment and was found to be significantly superior. This treatment effect has registered the highest nutrient use efficiency for Ca (42.55 g pot $^{-1}$) and B (85.66 g pot $^{-1}$) .The highest available boron in soil of 1.32 mg kg^{-1} and available nitrogen of 397.22 kg ha $^{-1}$ were observed in treatment receiving soil application of Mg and B and foliar spray of Ca. The content and uptake of P , K , Mg and B in cabbage were found to be the highest in treatment receiving soil application of Ca and foliar spray of Mg and B. The highest sulphur content in leaves (0.43%) and head (0.34 %) and also uptake of 0.283 g plant $^{-1}$ were obtained in treatment receiving soil application of Ca and B and foliar spray of Mg. The foliar application of Ca, Mg and B increased the chlorophyll content in leaf (5.39 mg g $^{-1}$) at heading stage and nutrient use efficiency for Mg (27.81 g pot $^{-1}$).

Keywords: *Cabbage, Calcium, Magnesium, Boron, Yield, Quality*

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INTRODUCTION

Cabbage is a common dietary staple vegetable throughout the world and can be consumed as salad, boiled vegetable, dehydrated vegetable and it is a rich source of carbohydrate, protein, fibre, vitamins A, B and C . Cabbage is one of the susceptible crops to mineral nutrient deficiencies which is the major contributing factor for yield and quality reduction in cabbage. Ca, Mg, B and Mo are the secondary and micronutrients that are commonly found to be deficient in cabbage. . In cabbage, tip burn disorder occurs due to inadequate supply of calcium, which affects leaf margins causing collapse and death of plant tissue cells. Magnesium deficiency can occur most often on soils with low pH and its deficiency symptom appears on older leaves as interveinal chlorosis, also the interveinal zones get curled up. Boron deficiency leads to cracked and corky stems, browning of curds, and finally results in hollow stem disorder.

Calcium deficiency can occur in highly weathered soils due to continuous cropping, intensive soil erosion, leaching of exchangeable bases, reduction of soil organic matter and adsorption by aluminium and iron hydroxides (Steiner & Lana, 2013). Ashraf et al. (2017) found that the foliar application of calcium chloride at the rate of 0.2 % has improved the plant height, number of leaves per plant, number of flowers per plant, fruit weight and the fruit yield per plant in tomato. Herrera and López (2012) reported that calcium has got a significant effect in reducing the cracking disorder of gooseberry fruit. Huang et al. (2016) reported that application of magnesium sulphate fertilizer increased the Chinese cabbage yield. Singh (2003) found that the combined application of boron in soil at the rate of 5 kg ha^{-1} and boron as foliar spray at the rate of 0.25 per cent at 45 and 60 DAP has resulted in highest number of leaves per plant, leaf area, curd weight, curd width, curd length and curd yield in cauliflower. The maximum fruit size, ascorbic acid content and TSS in tomato were recorded in treatment receiving 0.3 per cent borax as foliar spray and the percentage of fruit cracking disorder was found to be lower (Neuhaus et al., 2014).

Kerala soils are deficient in Ca and Mg among secondary nutrients, and boron, among micronutrients (Kerala State Planning Board, 2013). Calcium, magnesium and boron deficiency symptoms are common in cabbage grown in these soils as the plant available forms of these nutrients are highly water soluble. In recent years, vegetable cultivation has gained momentum in Kerala and tropical varieties of cabbage is widely cultivated in grow bags or pots. The biggest constraint associated with grow bag or container cultivation of cabbage is non uniform heading and smaller size of heads. The most important limiting factor identified is the widespread deficiency of secondary and micronutrients mostly calcium, magnesium and boron. Hence to overcome these deficiencies the present study on soil and foliar nutrition of calcium, magnesium and boron to cabbage was carried out .

MATERIALS AND METHODS

An experiment was carried out at College of Agriculture, Vellayani during the period from October to December 2017 to study the effect of soil and foliar application of calcium, magnesium and boron on growth, yield and quality of cabbage tropical variety NS 183 which is a hybrid with dark bluish green foliage and good wrapper leaves, in CRD with 9 treatments and 3 replications. The treatments consisted of two levels of calcium (C_1 - $CaCO_3$ as per lime requirement as basal, C_2 – $CaCl_2.2H2O$ @ 1% foliar spray on 15 th and 45 th DAP) , two levels of magnesium (M_1 – $MgSO_4.7H_2O$ @ 20 g $plant^{-1}$ in two equal splits on 15 th and 30 th DAP, M_2 – $MgSO_4.7H_2O$ @ 1 % foliar spray on 15 th and 45 th DAP) and two levels of boron (B_1 – $Na_2B_4O_7$. 10 H_2O @ 4 g $plant^{-1}$ in two equal splits on 15 th and 30 th DAP, B_2 – $Na_2B_4O_7$.10 H_2O @ 0.5 % foliar spray on 15 th and 45 th DAP) . The treatment combinations were T_1 - control , T_2- $C_1 + M_1 + B_1$, T_3 - $C_1 + M_1 + B_2$, T_4 - $C_1 + M_2 + B_1$, T_5 - $C_1 + M_2 + B_2$, T_6 - $C_2 + M_1 + B_1$, T_7 - $C_2 + M_1 + B_2$, T_8- $C_2 + M_2 + B_1$ and T_9 - $C_2 + M_2 + B_2$. FYM and NPK fertilizers were applied to all treatments as per POP recommendation of KAU, 2016.

The growth parameters like plant height, number of leaves per plant, plant spread, leaf area, days to head formation and head maturity and yield parameters like fresh weight of plant and cabbage head were recorded at vegetative, heading and harvest stage of the crop. Soil samples collected from the experiment during vegetative, heading and harvest stage of the crop were air dried, processed and analysed for available N, P, K, Ca, Mg, S, B, Fe, Cu, Mn and Zn using standard procedures. Cabbage head samples were collected at the time of harvest and index leaves were taken during vegetative, heading and harvest stages and analysed for calcium, magnesium and boron content. Plant samples at harvest stage were analysed for N, P, K, Ca, Mg, S, B, Fe, Cu, Mn and Zn using standard procedures and also uptake were calculated. The quality parameters like protein, crude fibre, vitamin C and oxalate content in cabbage head and chlorophyll content in leaves at heading stage. The benefit cost ratio and nutrient use efficiency were calculated. The result obtained from experiments was analysed statistically for the test of significance by standard procedures using WASP software.

Table 1: Physical and chemical properties of experimental soil

Sl No.	Soil parameters	Status	Rating
1	Bulk density	1.35	Normal
2	pH	5.71	Moderately acidic
3	Electrical conductivity	0.09 d S m^{-1}	Normal
4	Organic carbon	0.97 %	Medium
5	Cation exchange capacity	5.87 c mol (p+) kg^{-1}	Low
6	Available N	313 kg ha^{-1}	Medium
7	Available P	54.67 kg ha^{-1}	High
8	Available K	280 kg ha^{-1}	Medium
9	Available Ca	223 mg kg^{-1}	Deficient
10	Available Mg	69 mg kg^{-1}	Deficient
11	Available S	7.18 mg kg^{-1}	Sufficient
12	Available Fe	27.34 mg kg^{-1}	Sufficient
13	Available Mn	23.07 mg kg^{-1}	Sufficient
14	Available Zn	4.87 mg kg^{-1}	Sufficient
15	Available Cu	0.27 mg kg^{-1}	Deficient
16	Available B	0.11 mg kg^{-1}	Deficient

RESULT AND DISCUSSION

Plant growth parameters

Results generated from the experiment revealed that application of Ca, Mg and B as calcium chloride (1%) and borax (0.5%) foliar spray and $MgSO_4$ (20 g plant $^{-1}$) soil application, recorded the highest plant height (37.12 cm) which might be due to the combined application of Ca and B, that have promoted the mitotic activity in terminal meristem which in turn increased the plant height as reported by Rab and Haq, 2012.. The highest number of leaves per plant on vegetative (23.66), heading (32.33) and at harvest stage (28.33) of the crop, plant spread (59.21 cm), leaf area (699.12 cm^2), minimum number of days to head formation (50.66 DAT) and head maturity (85.33 DAT) in cabbage were also recorded in the same treatment. This is attributed to the effect of calcium, which is involved in numerous metabolic processes related to growth and development of plants such as cell division, differentiation and elongation and Ca and Mg might have also activated several enzymatic systems that can regulate leaf and root growth as reported by Hepler (2005). The influence of B in cell wall formation also played an important role in growth of new cells which in turn promoted the new growth of leaves. Asad et al. (2003) found that combined application of calcium and boron are more effective in increasing the number of leaves per plant. The application of magnesium would have also activated the enzymatic system and plant metabolism which in turn increased the number of leaves per plant as reported by Neuhaus et al. (2014) .The significant increase in leaf area may be attributed to the synergistic effect of B on N and P metabolism and Mg on P metabolism which were mostly responsible for initial root development and vegetative growth of plants. The influence of Ca in improving the leaf length and width also promoted enhanced leaf area as reported by Aswathy (2017).

Table 2: Effect of Ca, Mg and B on growth of cabbage

Treatments	Plant height (cm)	Plant spread (cm)	Leaf area (cm^2)	Days to head formation	Days to head maturity
T_1 : control	25.33	44.33	567.93	88.33	106.33
T_2: C_1+ M_1+ B_1	27.75	47.33	596.15	72.33	98.66
T_3: C_1+ M_1+ B_2	29.66	53.66	681.68	62.66	87.66
T_4 : C_1+ M_2+ B_1	29.08	49.16	670.36	65.66	96.66
T_5: C_1+ M_2+ B_2	31.33	54.33	690.09	70.33	92.66
T_6: C_2+ M_1+ B_1	30.01	49.83	623.78	60.33	89.66
T_7: C_2+ M_1+ B_2	37.12	59.51	699.12	50.66	85.33
T_8: C_2+ M_2+ B_1	30.66	49.66	684.25	63.33	92.33
T_9: C_2+ M_2+ B_2	31.68	54.16	698.57	50.66	85.66
SE $_m$(±)	0.467	0.834	11.291	1.064	1.064
CD (0.05)	1.402	2.480	33.871	3.187	3.187

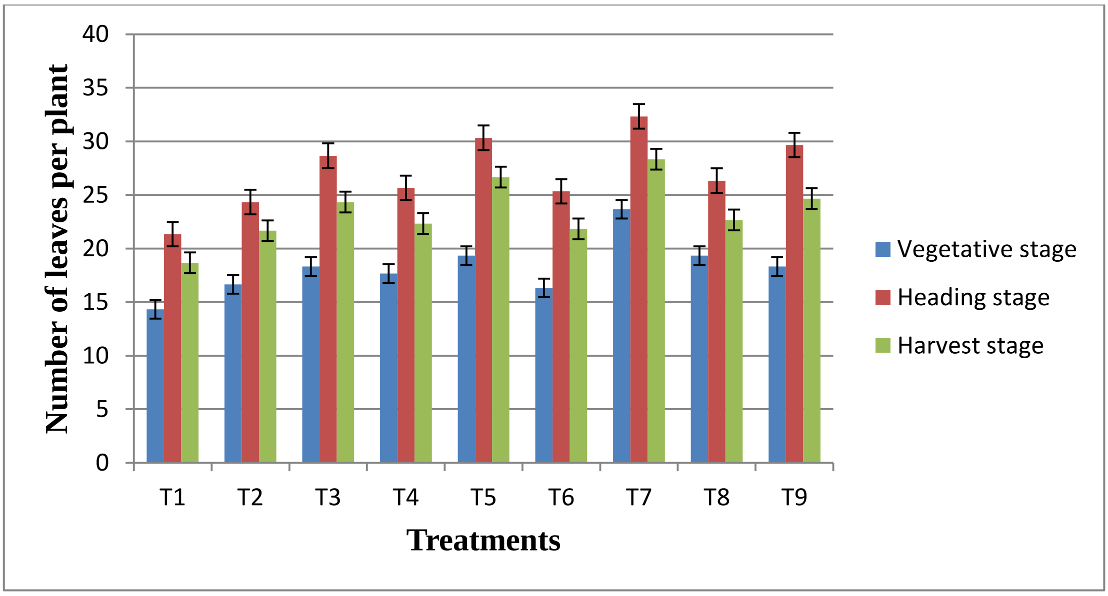

Fig. 1: Effect of Ca, Mg and B on number of leaves in cabbage

Nutrient availability in soil

The results on available nutrient status of soil (fig.2 and table.3) revealed that available nitrogen was the highest in T_6 (397.22 kg ha $^{-1}$). The increase in available nitrogen in soil might be due to the positive influence of Mg and B on enhancing the available N status in soil are in accordance with the findings of Berman et al. (2014).

The treatments did not significantly influence the available P and K content of soil. The reason might be due to the negative influence of applied calcium on soil available K as reported by Ananthanaryana and Hanumantharaju (1992).

With regard to the available calcium in soil the treatment T_5 (C_1+ M_2+ B_2) registered the highest value of 452 mg kg^{-1} which was on par with T_2 and T_7. In all treatments sufficient amount of available calcium (>300 mg kg^{-1}) was recorded where as it was found to be deficient in initial soil (223 mg kg^{-1}) before the application of treatments. The highest available calcium may be due to the reason that the added calcium in soil in the form of $CaCO_3$ might have helped to increase the available calcium status of the soil from deficiency to sufficiency level as suggested by Aswathy (2017).

The highest available Mg content of 215 mg kg^{-1} was recorded in T_7 (C_2 + M_1+ B_2) which was on par with T_5 and T_3. This significant increase might be due to the soil application of $MgSO_4$. In all the treatments sufficient level of available magnesium (> 120 mg kg^{-1}) was obtained when compared to initial soil (69 mg kg^{-1}) where it was found to be deficient as reported by Hardter et al. (2003).

Available S was the highest in T_7 (11.69 mg kg^{-1}) which was on par with T_2, T_3 and T_6. This indicates that the sulphate from magnesium sulphate might have contributed to the increased available sulphur in soil similar to the findings of Barman et al. (2014). The highest available boron content of 1.32 mg kg^{-1} was observed in T_6. Critical level of sufficiency (more than 0.5 ppm) was attained in all treatments where borax was given either as soil or foliar application. Soil application of boron in the form of borax would have increased the boron availability in soil from deficient to sufficiency level as reported by Nimora and Brown (1997).

The highest concentration of available Fe (44.18 mg kg^{-1}) was registered in T_2 (soil application of Ca, Mg and B) treatment. Available zinc in soil was also found to be the highest in T_2 (6.95mg kg^{-1}) which was on par with T_6 and T_8. However the effect of treatments on available manganese and copper in soil was found to be non significant. These findings are in line with those reported by Aswathy (2017).

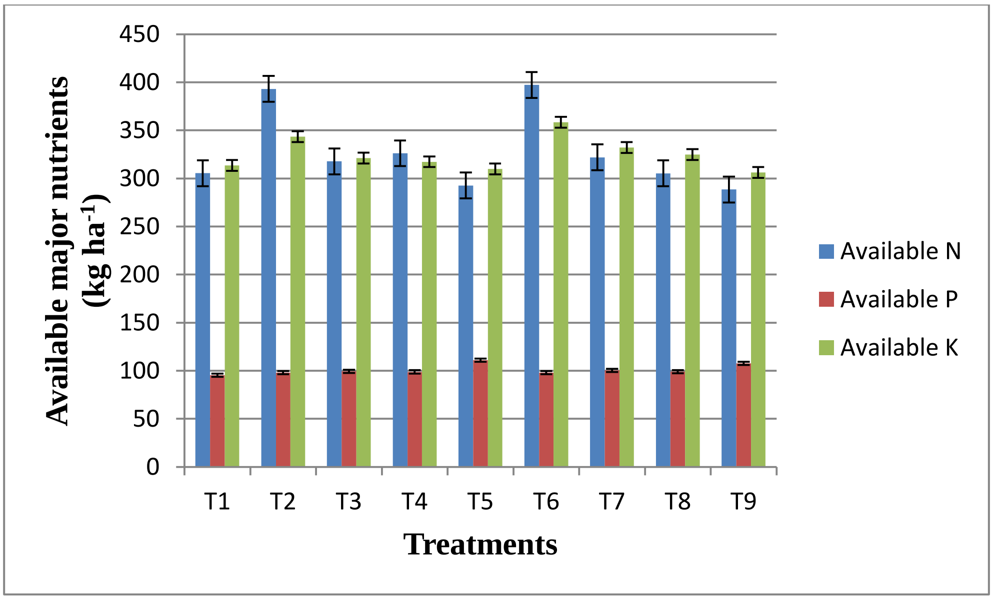

Fig. 2: Effect of Ca, Mg and B on available N, P and K in soil

Table 3: Effect of Ca, Mg and B on availability of secondary and micronutrients in soil

Treatments	Av. S (mg kg^{-1})	Av. Ca (mg kg^{-1})	Av. Mg (mg kg^{-1})	Av. Fe (mg kg^{-1})	Av. Mn (mg kg^{-1})	Av. Cu (mg kg^{-1})	Av.B (mg kg^{-1})	Av.Zn (mg kg^{-1})
T_1 : control	7.11	235	95	31.31	26.37	0.69	0.05	5.73
$T_2 : C_1+ M_1+ B_1$	9.88	355	141	44.18	29.39	0.81	0.76	6.95
$T_3 : C_1+ M_1+ B_2$	10.22	337	156	32.68	24.52	0.46	0.37	3.31
$T_4 : C_1+ M_2+ B_1$	8.74	328	129	33.43	27.14	0.49	0.68	5.69
$T_5 : C_1+ M_2+ B_2$	8.61	367	121	31.98	27.38	0.65	0.58	4.96
$T_6 : C_2+ M_1+ B_1$	9.78	316	154	38.37	29.19	0.62	0.88	6.63
$T_7 : C_2+ M_1+ B_2$	11.69	355	173	32.55	24.98	0.47	0.44	3.99
$T_8 : C_2+ M_2+ B_1$	9.83	322	133	33.18	27.16	0.56	0.71	6.16
$T_9 : C_2+ M_2+ B_2$	8.58	307	130	31.41	26.83	0.61	0.49	4.84
$SE_m(\pm)$	0.719	4.015	4.756	1.619	0.954	0.092	0.723	0.592
CD (0.05)	2.157	12.036	14.183	4.852	NS	NS	2.157	0.997

Content and uptake of nutrients in cabbage

The treatment (T_7) receiving calcium and boron as foliar and magneaium as soil application has produced the highest N content in leaves (2.28 %) and in cabbage head (2.02 %) and there by uptake also (1.912 g plant^{-1}). The nitrogen content was found to be higher in cabbage leaf than in head. This might be due to the specific effect of B on the activity of enzyme nitrogen reductase which permits the translocation of nitrogeneous compounds and hence improved the nitrogen utilization and also due to the positive influence of B in enhancing the nitrogen metabolism (Bonilla et al., 1980).

The treatment (T_5) receiving Ca as soil application, Mg and B as foliar recorded the highest P content (0.23 %) and uptake (0.141 g plant^{-1}) in leaves where as in cabbage head T_7 treatment (calcium and boron as foliar, magnesium as soil application) recorded the highest P content (0.31 %) and uptake (0.082 g plant^{-1}). With respect to total uptake, T_7 recorded the highest value (0.223 g plant^{-1}). The influence of Mg in activating most of the reactions involving phosphate transfer and also the function of B in the regulation of ions in plant membrane and the ATP ase in P transport in plants attributed to the increased content and uptake of phosphorous. (Ananthanaryana & Hanumantharaju, 1992).

Foliar application of Mg and B and soil application of Ca (T_5) recorded the highest K content in leaves (2.49 %) and in cabbage head (2.82 %). The same treatments showed the highest K uptake in leaf (1.403 g plant^{-1}) and in cabbage head (1.403 g plant^{-1}) and the total uptake (2.156 g plant^{-1}). These findings are in line with the findings of Ali et al. (2015).

The highest Ca content of 2.42% in leaves , 0.99% in cabbage head and Ca uptake in leaf of 0.936 g plant^{-1} and total uptake of 1.115g plant^{-1} was recorded from treatment (T_7). With respect to uptake in cabbage head (0.276 g plant^{-1}) T_5 recorded the highest value. This significant increase in calcium content and uptake might be due to the foliar application of calcium in the form of calcium chloride. Ramon et al. (1990) reported the Ca-B interaction as B tends to keep calcium in soluble form within the plant.

With regard to the magnesium uptake T_5 treatment recorded the highest leaf, head and total uptake This clearly indicates the positive influence of foliar application of Mg in enhancing the Mg content in plant (Venkataramana, 2014).

With respect to content (leaves -0.43% and in cabbage head -0.34%) and uptake of sulphur (0.308 g plant^{-1}) T_4 recorded the highest value .The sulphate available to the plant due to the application of $MgSO_4$ might have increased the sulphur content in plant as observed by Lopez (2010) in mustard.

The highest B content in leaves (43.89 mg kg^{-1}) and cabbage head (28.55 mg kg^{-1}) was obtained from T_5. The highest uptake of B in leaf, head and total uptake was obtained from T_7 .This significant increase might be due to the foliar application of 0.5 % borax at 15 and 45 DAP (Debnath & Ghosh , 2012) .

The highest value of iron content in leaves (395.73 mg kg^{-1}) and head (369.33 mg kg^{-1}), iron uptake in leaf (0.756 g $plant^{-1}$), head (0.733 g $plant^{-1}$) and total uptake (1.489 g $plant^{-1}$) was noticed from T_6 treatment. This indicates a synergistic effect of Ca, Mg and B on improving the iron content in plant as reported by Aswathy (2017).

Table 3: Effect of Ca, Mg and B on nutrient content in cabbage leaf

Treatments	N %	P %	K %	Ca %	Mg %	S %	B %
T_1 : control	1.61	0.14	1.96	0.79	0.33	0.31	12.02
$T_2 : C_1+ M_1+ B_1$	1.78	0.19	1.82	0.97	0.43	0.34	16.53
$T_3 : C_1+ M_1+ B_2$	2.18	0.21	2.31	1.17	0.51	0.35	22.54
$T_4 : C_1+ M_2+ B_1$	2.21	0.17	2.37	1.19	0.65	0.43	20.74
$T_5 : C_1+ M_2+ B_2$	2.11	0.23	2.49	1.44	0.86	0.39	31.56
$T_6 : C_2+ M_1+ B_1$	1.89	0.18	1.94	1.81	0.49	0.33	18.03
$T_7 : C_2+ M_1+ B_2$	2.28	0.22	2.14	1.86	0.57	0.37	27.35
$T_8 : C_2+ M_2+ B_1$	2.03	0.15	2.24	1.69	0.71	0.42	24.64
$T_9 : C_2+ M_2+ B_2$	1.96	0.19	2.26	1.68	0.68	0.41	29.75
$SE_m(\pm)$	0.138	0.042	0.265	0.123	0.048	0.026	2.606
CD (0.05)	0.407	0.099	0.753	0.354	0.126	0.073	7.777

Table 4: Effect of Ca, Mg and B on nutrient content in cabbage head

Treatments	N %	P %	K %	Ca %	Mg %	S %	B %
T_1 : control	1.11	0.21	2.51	0.21	0.61	0.18	5.07
$T_2 : C_1+ M_1+ B_1$	1.36	0.24	2.39	0.67	0.79	0.24	15.66
$T_3 : C_1+ M_1+ B_2$	1.87	0.28	2.58	0.85	0.81	0.27	21.04
$T_4 : C_1+ M_2+ B_1$	1.72	0.24	2.66	0.81	0.97	0.34	19.83
$T_5 : C_1+ M_2+ B_2$	1.98	0.29	2.82	1.36	1.14	0.32	28.55
$T_6 : C_2+ M_1+ B_1$	1.23	0.23	2.43	0.96	0.77	0.24	19.53
$T_7 : C_2+ M_1+ B_2$	2.02	0.31	2.75	0.99	0.88	0.27	25.33
$T_8 : C_2+ M_2+ B_1$	1.66	0.25	2.61	0.93	0.96	0.29	21.94
$T_9 : C_2+ M_2+ B_2$	1.69	0.27	2.72	0.91	1.02	0.33	24.95
$SE_m(\pm)$	0.113	0.021	0.173	0.064	0.046	0.029	1.612
CD (0.05)	0.302	0.064	0.509	0.167	0.216	0.075	4.731

Table 5: Effect of Ca, Mg and B on total uptake of nutrients in cabbage

Treatments	N (g $plant^{-1}$)	P (g $plant^{-1}$)	K (g $plant^{-1}$)	Ca (g$plant^{-1}$)	Mg (g $plant^{-1}$)	S (g $plant^{-1}$)	B (g $plant^{-1}$)
T_1 : control	1.165	0.113	1.333	0.441	0.311	0.145	0.084
$T_2 : C_1+ M_1+ B_1$	1.383	0.156	1.603	0.628	0.395	0.166	0.115
$T_3 : C_1+ M_1+ B_2$	1.771	0.203	1.913	0.765	0.437	0.171	0.162
$T_4 : C_1+ M_2+ B_1$	1.773	0.153	1.896	0.759	0.537	0.308	0.145
$T_5 : C_1+ M_2+ B_2$	1.606	0.219	2.156	0.994	0.654	0.278	0.212
$T_6 : C_2+ M_1+ B_1$	1.457	0.176	1.716	1.096	0.397	0.178	0.127
$T_7 : C_2+ M_1+ B_2$	1.912	0.223	1.843	1.115	0.521	0.266	0.219
$T_8 : C_2+ M_2+ B_1$	1.618	0.143	1.716	1.043	0.484	0.273	0.173
$T_9 : C_2+ M_2+ B_2$	1.565	0.206	1.996	1.027	0.547	0.259	0.195
$SE_m(\pm)$	0.073	0.016	0.043	0.048	0.028	0.016	0.012
CD (0.05)	0.197	0.046	0.124	0.109	0.061	0.042	0.034

The highest chlorophyll content of 5.29 mg g^{-1} was observed from T_5. This might be due to the role of Mg on chlorophyll molecule that regulates photosynthesis in plants. This is also attributed to the influence of Ca in enhancing the rate of photosynthesis which in turn increased the chlorophyll content in plants (Aswathy, 2017).

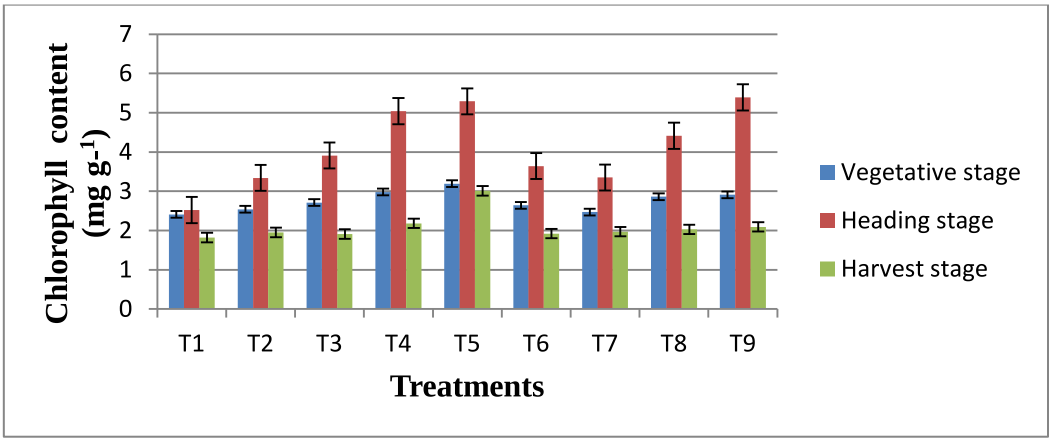

Fig. 3: Effect of Ca, Mg and B on chlorophyll content in cabbage leaves

Cabbage Yield, NUE and B:C ratio

The treatment (T_7) where calcium and boron were applied as foliar and magnesium as soil application recorded the highest fresh weight of plant(1.833 kg $plant^{-1}$) and head yield (1.216 kg plant $^{-1}$). Ilyas et al. (2014) found that both Ca and Mg are the vital nutrients for plant growth and involved in photosynthesis, enzyme activation and carbohydrate metabolism. The effect of Ca and B on pollen grain germination and pollen tube growth improved the reproductive growth and consequently the tomato yield

Significantly higher benefit- cost ratio (1.82) was obtained in treatment (T_7) .This result shows that the application of Ca, Mg and B significantly influenced the yield of cabbage and ultimately increased the benefit cost ratio as reported by Neethu (2013).

With respect to nutrient use efficiency the treatment (T_7) registered the highest agronomic use efficiency for Ca (42.55) and B (85.66).With respect to nutrient use efficiency of Mg, T_9 recorded the highest value (27.82). The supply of Ca, Mg and B from various treatment combinations throughout the cropping period might have contributed to the increased yield which in turn has increased the efficiency similar to the findings of Geethalakshmi and Palaniappan (1992).

Table 6: Effect of treatments on yield of cabbage, NUE and B: C ratio

Treatments	Fresh weight of plant (kg $plant^{-1}$)	Head yield (kg $plant^{-1}$)	B:C ratio	NUE (g pot^{-1})		
				Ca	Mg	B
T_1 : control	0.983	0.616	0.58	-	-	-
T_2: C_1+ M_1+ B_1	1.168	0.833	1.04	2.71	10.83	54.16
T_3: C_1+ M_1+ B_2	1.451	1.016	1.56	5.21	20.12	80.09
T_4 : C_1+ M_2+ B_1	1.216	0.715	0.78	1.25	10.11	25.12
T_5: C_1+ M_2+ B_2	1.366	0.952	1.38	4.21	20.71	67.33
T_6: C_2+ M_1+ B_1	1.566	0.916	1.28	30.12	16.66	75.12
T_7: C_2+ M_1+ B_2	1.833	1.216	1.82	42.55	20.58	85.66
T_8: C_2+ M_2+ B_1	1.211	0.653	0.65	3.52	6.52	8.15
T_9: C_2+ M_2+ B_2	1.651	0.983	1.47	36.51	27.81	73.33
SE $_m$(±)	0.082	0.056	0.021	0.439	1.551	1.256
CD (0.05)	0.249	0.159	0.069	1.317	4.654	3.667

The highest protein content of 1.93 % and vitamin C content of 64.55 mg 100 g^{-1} .was recorded in T_7 treatment which received calcium chloride (1%) and borax (0.5%) as foliar and magnesium sulphate (20 g $plant^{-1}$) as soil application. This might be due to the influence of Mg on ribosome structure and the biosynthesis of hormones involved in protein synthesis.. The significant increase in protein content may be also due to the vital role of B in promoting protein and nucleic acid metabolism (Khalid, 2009). Pinskii et al. (2014) reported that boron improves the movement of assimilates and transfer of the ascorbic acid from the leaves to the upper plant parts like fruiting bodies which may contributed to the increased vitamin C content. The different treatment effects did not show any significant influence on oxalate and crude fibre content in cabbage head.

Table 7: Effect of treatments on quality of cabbage

Treatments	Protein (%)	Vitamin C (mg 100 g^{-1})	Oxalate (mg g^{-1})	Crude fibre (%)
T_1 : control	1.17	41.76	2.21	3.49
T_2: C_1+ M_1+ B_1	1.21	42.85	2.84	3.51
T_3: C_1+ M_1+ B_2	1.79	44.21	2.11	3.43
T_4 : C_1+ M_2+ B_1	1.47	46.91	2.60	3.44
T_5: C_1+ M_2+ B_2	1.59	50.02	2.01	3.41
T_6: C_2+ M_1+ B_1	1.37	57.58	1.96	3.54
T_7: C_2+ M_1+ B_2	1.93	64.55	2.11	3.45
T_8: C_2+ M_2+ B_1	1.52	53.52	1.95	3.43
T_9: C_2+ M_2+ B_2	1.65	59.43	2.41	3.47
SE $_m$(±)	0.642	0.811	0.664	0.511
CD (0.05)	1.919	2.397	NS	NS

CONCLUSION

From the present investigation it can be concluded that foliar application of calcium chloride @1% and borax @ 0.5% on 15^{th} and 45^{th} DAP and soil application of $MgSO_4.7H_2O$ @ 20 g $plant^{-1}$ in two equal splits on 15^{th} and 30^{th} DAP significantly increased nutrient availability in soil, plant growth, yield, nutrient content, nutrient uptake and quality of cabbage and also NUE and B : C ratio.

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