Influence of calcium fertilization on quality parameter, bioactive compounds and antioxidant activity of Cauliflower (*Brassica oleracea var. botrytis)*

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Abstract

Cauliflower has high health-promoting biochemical parameters and vitamins. The aim of this study is to determine the difference between the quality and biochemical parameters in response to different calcium treatments for two years. An open field experiment was conducted with different calcium fertilizer regimes in the cultivar Snow Mystique belonging to the green typology of cauliflower widely cultivated in acid soils of The Nilgiris to study the quality and bioactive compounds. Cauliflower showed a contrasting response to different calcium sources regarding quality and bioactive parameters for various fertilizers. High yield (268 q ha^{-1}), phenolic content (1055 mg 100 g^{-1}), total antioxidant activity, flavonoids, and carotenoids were highest in the treatment applied as limestone (125% LP) along with the spray of 0.4% $CaCl_2$, which is followed by calcium applied as Dolomite (125% LP) with 0.4 % $CaCl_2$ sprayed. No significant difference in the treatment is observed in TSS, whereas AA and TA are high in dolomite (100% liming potential) with 0.6% $CaCl_2$ spray. Snow Mystique performed well in yield and quality parameters, followed by other hybrids. Moreover, Our results indicate that applying adequate calcium fertilizers greatly influences quality factors of cauliflower, particularly carotenoids, flavonoids, and AA suited to acidic soil type.

Keywords: calcium, cauliflower, quality parameters, acid soil, antioxidant, limestone

Introduction

Calcium fertilization is essential to improve the quality, firmness, and economic yield of vegetables and other horticultural crops. In plants, calcium plays a major role in various structural, functional, and biochemical processes. Calcium plays an important role in signalling and conducting an intracellular messenger within the cytosol, functioning as a counter-cation for both organic and inorganic molecules in vacuoles, facilitating the permeability of cell wall membranes, and activating enzymes within the plant. Another function of calcium in plants is the formation of calcium pectate in the middle layer of cell walls, which aids in the germination of pollen and the growth of pollen tubes, which is core to producing fruit and seeds (Dayod, Tyerman, Leigh, & Gilliham, 2010). Fertilizing crops with calcium has gained considerable attention in recent years because it delays the onset of senescence and reduces physiological disorders, especially in vegetable crops. In studies such as (Angeletti et al., 2010; Poovaiah & Leopold, 1973), increasing the calcium content in plants can significantly impact senescence and other activities related to senescence such as respiration, protein content, chlorophyll concentration, and membrane fluidity. Postharvest calcium chloride spraying for fruits is widely followed in growing areas to lower respiration rates and reduce postharvest fruit rots.(Zhang, Dai, Jin, & Li, 2019). Calcium is translocated to other parts of plants mainly via xylem from a low redistribution rate for the flower, fruit, and seed development. The application of calcium by foliar means during pre-flowering is reported to increase seed production (da Silva, de Mello Prado, Tenesaca, da Silva, & Mattiuz, 2021; Salman et al., 2022) and increase the shelf life of leafy vegetables, though no studies have been conducted on soil calcium application.

Most acidic soils in hilly areas are deficient in calcium, mainly due to the leaching of bases, and exchangeable sites are filled with toxic Aluminium species. Cauliflower remains one of the most widely grown vegetables globally and is a common crop within the Nilgiris. Cauliflower is a high source of vital nutrients containing other phytochemicals such as polyphenolic compounds and vitamin-C, Vitamin-K which have health-promoting benefits and cancer-inhibiting qualities due to its glucothiocyanate concentrations (Antoshkina, Golubkina, & Bondareva, 2020). With high-quality vitamins and proteins, cauliflower is low in fat and is consumed all over the world. Several factors influence the nutritional value of cauliflower, such as growing conditions, cultivar type, fertilizer application, cultural methods, and light intensity during the growing season. Calcium application to cauliflower is a cultural practice used to reduce calcium deficiency symptoms in acid soils, but no specific dose concentration is formulated for hybrids cultivated in acid soils. Cauliflower with a calcium deficiency forms necrotic leaf margins and a claw-like appearance on the young leaves in the early stages. Later, the curd dies off, indicating the importance of Ca application to the cauliflower plant (Karthika, Philip, & Neenu, 2020). Studies have been scarce on cauliflower's quality and biochemical properties influenced by calcium application in calcium-deficient acid soils. Thus, this study aims to fill the research gap by analysing biochemical and quality parameters of the cauliflower cultivar grown commercially in the Nilgiris hill area, where common liming materials supply calcium administrated by both foliar and soil application.

Materials and Methods

Plant materials and growing condition

The open-field experiment was conducted at the State Horticultural Farm, Kattery, Coonoor, India (11^0 19' N, 760 48' E) from mid of August to November, 2021 and April to June, 2022 with the cauliflower cultivar Snow Mystique grown commercially around this area. The hills of Nilgiris offer a cool, moist climate conducive to cauliflower cultivation, a vegetable commonly cultivated for food and seed production. Four cultivars grown in the Nilgiris area are selected and cultivated by applying calcium carbonate, rock phosphate, dolomite, and Ca-EDTA as calcium fertilizer sources and other major nutrients. The pH of the initial soil is 4.95, which is amended with different liming materials at different levels to make the soil desirable for cauliflower cultivation at around 6.5. Based on the soil liming potential, calcium carbonate, rock phosphate, and dolomite are applied as basal and Ca-EDTA and $CaCl_2$ are applied as foliar and the treatment details are T_1- control, T_2-LS (100% LP)+0.6% $CaCl_2$, T_3- RP (100% LP)+0.6% $CaCl_2$, T_4- Dolomite (100% LP)+0.6% $CaCl_2$, T_5- LS (100% LP)+1 % Ca-EDTA, T_6- LS (125% LP)+0.4% $CaCl_2$, T_7- RP (125% LP)+0.4% $CaCl_2$, T_8- Dolomite (125% LP)+0.4% $CaCl_2$. Based on the results of the pre-planting soil tests, other macronutrients were applied following standard cultivation practices. Cabbage seedlings are grown in portrays and transplanted into the main field after 25 days. Spacing of $45cm^2$ was followed between the seedlings, and the entire experimental design was followed in a Factorial Randomized block design (FRBD) with three replications. Rainfall averages 207 mm during the growing season, and the average monthly temperature ranges between 10.1^0C and 21.3^0C. In the plots treated with Ca-EDTA, phosphorus deficiency is seen only in the cauliflower foliage, and there were no pest or disease outbreaks during the entire growth period.

Characteristics of Hybrids.

For this experiment, we used four hybrids, namely Snow Mystique, Suhasini, Dhaval 043, and Cauliflower 155, which exhibit semi-erect, dome-shaped, produces pure white to creamy white curd suitable for the temperate region of Nilgiris, with early maturing characteristics. In addition, the hybrids have moderate heat tolerance and dark green leaves, except for cauliflower 155, which has dark blue-green leaves. All plants are ready to harvest within 50-55 days after transplantation.

Dry matter, firmness measurement

After harvesting, the yield for the individual hybrids is calculated plot-wise. Freshly harvested cauliflower is carefully transported from the laboratory of Soil Science and agricultural chemistry laboratory, TNAU, and Coimbatore to analyse quality parameters. Florets of cauliflower were cut into bite-sized portions mixed well, and divided into portions for analysis. All the analyses were done in triplicate and pooled the means. For dry weight measurement, the whole plant is maintained at 65^0 C in a hot air oven until the constant weight is reached. The firmness of the cauliflower head was analysed using the Fruit texture analyser given by (Nasrin et al., 2022), and the maximum penetration force was used as the firmness value of cauliflower.

Measurement of ascorbic acid, titrable acidity, and TSS

The ascorbic acid content in the cauliflower curd was estimated by titration method using Tillman's reagent (Horwitz, 2000). These involve reducing Tillman dye (2, 6-dichlorophenol indophenol) from blue to colourless by ascorbic acid in alkaline conditions. First, the plant sample was grounded to paste using 3% metaphosphoric acid and then filtered. Then the filtrate was titrated against Tillman's reagent until the pink colour was obtained, which persisted for 15 seconds, and estimated ascorbic acid content by using the below formula.

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Vol made up} \times 100}{\text{Weight of sample} \times \text{mL of aliquot pipetted.}}$$

Titrable acidity of cauliflower is determined titrimetric method suggested by (AOAC, 1990). It involves samples homogenized with distilled water and filtered. Then the filtrate is titrated with 0.1N NaOH with a phenolphthalein indicator, and the following formula calculates the percentage of citric acid.

$$\text{Titrable acidity} = \frac{\text{Titre vol.} \times \text{Normality of NaOH} \times \text{Vol.Made up} \times \text{eq.wt of acid)}}{\text{(aliquot of sample} \times \text{vol.of sample} \times 1000)}$$

Total soluble solid was determined using a handheld refractometer (Labart EHS-10) by placing a grounded cauliflower juice on the prism and obtaining a direct reading of the instrument expressed as ^{o}Brix (AOAC, 1990).

Determination of Total Flavonoids

Total flavonoids in the plant sample were measured according to the Dowd method (Meda, Lamien, Romito, Millogo, & Nacoulma, 2005). The procedure involves that sample from the aerial part of cauliflower is mixed with methanol to extract the methanolic solution (0.4 mg/mL). This was combined with 5 mL of 2% aluminium tri-chloride and allowed to stand for 10 min to colour development. After that, the absorbance was measured at 415 nm in a UV-VIS spectrophotometer (Lab India UV-VIS 3092) measured against a blank sample made only with 5 mL of sample extract and 5 mL of methanol. For the standard, catechin was used to develop the curve. Total flavonoid content in cauliflower was expressed as mg of catechin equivalents per one g of dry matter of aerial parts of cauliflower.

Total Carotenoid determination

Total carotenoid is determined by the procedure suggested (Yuan, Sun, Yuan, & Wang, 2009). It involves cauliflower homogenized with acetone and petroleum ether (1:1 v/v) and obtaining the colourless solution in the separating funnel. Then the crude waste is washed several times in water and made the volume using petroleum ether. This solution is used for carotenoid determination by recording the absorbance at 451 nm in a spectrophotometer, and the value is indicated by mg/100g DW.

Total phenol determination

The Folin-Ciocalteu reagent was used to determine the total phenolics in the sample (Drabińska, Ciska, Szmatowicz, & Krupa-Kozak, 2018). Two grams of cauliflower sample were homogenized in 80% ethanol, followed by centrifugation at 1000 rpm at 4^0 degrees Celsius for 15 minutes. Using the same procedure, the solution is de-extracted twice, and both supernatants are pooled, evaporated to dryness, and dissolved in 5 mL of distilled water. Next, 0.1 mL of this extract was diluted in 3 mL of water with 0.5 mL Folin-Ciocalteu reagent after 3 minutes with 3 mL of 20% sodium carbonate. The contents were mixed and allowed to stand for 60 minutes. Then the absorbance was measured at 755 nm. Based on the standard curve for gallic acid (GAL), the phenolic content of the cauliflower was calculated, and the results were indicated as mg of Gallic acid equivalent per 100g DW.

Measurement of Antioxidant activity

The total antioxidant activity of cauliflower floret was measured using the DPPH assay (Brand-Williams, Cuvelier, & Berset, 1995). The procedure involved raw cauliflower floret was homogenized with 100mL methanol for 1 min and centrifuged for 10,000 ppm for 4^0 C for about 15 minutes. Collect the supernatant in a glass bottle and measure the antioxidant activity immediately using the DPPH assay. Then the same sample is added with 5 mL of DPPH reagent, and the absorbance is determined at 515 nm in UV-VIS spectrophotometer after 30 min of incubation time, and the inhibition percentage of absorbance was calculated as

$$\text{Inhibition } \% = \frac{(Abs\ t0 - Abs\ t30\ min)}{(Abs\ t0 \times 100)}$$

Statistical analysis

The sample analyses are conducted in triplicate, and the mean ± standard deviation is reported. Analysis of variance is done by one-way ANOVA using the statistical software SPSS (Build 1.0.0.1275)(Gomez & Gomez, 1984). In addition, Duncan's Multiple Range Test was used to compare the various treatments.

Results and discussion

Yield, the weight of cauliflower, and dry matter content

Statistically higher yield is obtained in the treatment of rock phosphate applied at 125% liming potential with 0.4% $CaCl_2$ (268 q ha^{-1}) spraying in Snow Mystique. In contrast, the lower yield is recorded in the control plot for all hybrids (Figure 1). In the control plot, a visible marginal crinkling and small curds were formed, while in the maturing stage, the curd turned brown, which did not meet the quality of marketability. These results align with the findings of (Sanderson, 2002) and (Nakada-Freitas et al., 2021). Among all hybrids, early flowering occurs in Dhaval 043 formed less inflorescence. High productivity is obtained in the Rock phosphate. Limestone treatments combined with calcium chloride spray compared with the dolomite may be due to adequate calcium availability in soil throughout the season. The highest yield of 268 q ha^{-1}, which goes along with the findings of (Cardoso, Claudio, Magro, & Freitas, 2016). In soybean, high plant yield and seed production were obtained by applying Calcium chloride (Seidel, Egewarth, Piano, & Egewarth, 2015). The above statement shows calcium's importance in the maturation phase for producing a good economic yield. A significantly high amount of dry matter was obtained in the hybrid Snow Mystique and Suhasini in the treatment of rock phosphate combined with 0.4% and 0.6% calcium chloride spraying.

Effect of calcium application on Ascorbic acid content, TSS, and TA

The most important and sensitive parameter in determining quality is ascorbic acid. The ascorbic acid content varied greatly among the four cultivars, but Snow Mystique had the highest content (Table 1). Cauliflower treated with 100% Liming potential dolomite with 0.6% $CaCl_2$ spraying yielded the highest ascorbic acid content at 85.6 mg 100 g^{-1} in Snow Mystique, followed by Suhasini (79.8 mg 100 g^{-1}), Dhaval 043 (76.2 mg 100 g^{-1}), and Cauliflower-155 (72.6 mg 100 g^{-1}) in the same treatment, followed by calcium applied as limestone (100% LP) and 1% Ca-EDTA spray (Table 1). Ascorbic acid concentrations in the control plots of all four hybrids were lower than those treated with calcium, with a reduction of 55.8%, 34.3%, 39.8%, and 22.6%, respectively, compared to those in the superior treatment. Calcium deficiency lowers the leaf ascorbic acid content, similar to the findings of (da Silva et al., 2021) and (Loekito, Afandi, Nishimura, Koyama, & Senge, 2022). Regarding TSS content, no significant differences were found between treatments or hybrids, but Snow Mystique had the highest TSS, followed by Cauliflower 155, Dhaval 043, and Suhasini. A report on calcium spraying did not affect TSS content in tomatoes (Rab & Haq, 2012), cauliflower, and cabbage (Torres et al., 2017). The titrable acidity content of Snow Mystique (0.31 mg 100 g^{-1}) is significantly high in the calcium applied as limestone combined with Calcium-EDTA spray, followed by limestone application (100% LP) and 0.4% $CaCl_2$ (0.29 mg 100 g^{-1}) in the same hybrid (Table 1). Those followed by Dhaval 043 (0. 28 mg 100 g^{-1}), Cauliflower 155 (0.28 mg 100 g^{-1}), and Suhasini (0.21 mg 100 g^{-1}) have high ascorbic contents in the same treatments. Therefore, titrable acidity is improved with the nano-calcium application in cauliflower, as reported by (Rachid, Bader, & Al-Alawy, 2020).

Phenolic content and antioxidant activity

Phenolic content directly contributes to the plant's antioxidant activity. A positive correlation exists between phenolic content and antioxidant activity in the four cultivars of cauliflower studied. Calcium application caused a significant increase in total phenolic content of cauliflower where the plot received no calcium having the phenolic content of 712.78 mg 100g^{-1} of an average of four hybrids where the highest phenolic content of 1055 mg 100 g^{-1} ($p<0.05$) were determined in both in Snow Mystique and cauliflower 155 cultivars in the treatment of limestone applied with 125% liming potential and calcium chloride (0.4%) spraying with the percent increase in 48% compared with the control (Figure 2). Vegetables contain soluble and insoluble phenolic compounds, often combined with cell wall complexes. The phenolic content of the cell wall increases with calcium application. By using the DPPH scavenging method, antioxidant activity can be measured by measuring the decrease in absorbance as the radical receives electrons or hydrogen from an antioxidant molecule. The percentage inhibition of antioxidant activity is highest in the limestone (125% Liming potential) with $CaCl_2$ (0.4%) spraying and limestone (100% liming potential) and $CaCl_2$ (0.6%) treatment with the mean value of 62.1% ($p<0.05$%) and no difference is observed among the four cauliflower cultivars (Figure 3). Similar results were obtained in lettuce grown in organic calcium application that had higher antioxidant and phenolic activity (Drabińska, Jeż, & Nogueira, 2021; Rigueira, Bandeira, Chagas, & Milagres, 2016)

Effect of treatments on flavonoids and carotenoids content

Plant flavonoids have a wide range of functions such as enzyme inhibiting, anti-bacterial, apoptosis-inducing, and cell proliferation–inhibiting effects. In addition, flavonoids have a wide range of clinical properties such as anti-viral, anti-atherosclerotic, and anti-tumour effects. Figure 4 shows the effect of calcium treatment on plant flavonoids. Total flavonoid content is highest in the treatment of calcium applied as limestone (125%) and $CaCl_2$ (0.4%), with a highly significant value of 321.1 mg CE 100 g^{-1} ($p \leq 0.05\%$). Total flavonoids were significantly decreased by decreasing calcium content, where highly significant flavonoids concerning calcium treatment were observed in three cultivars such as Suhasini, Snow Mystique, and Cauliflower 155 except Dhaval 043 (Table 1). Zu et al. (2020) found that flavonoids increase in *P.notoginseng* with calcium application (Ahmad et al., 2016) in Chickpea at Cd stress condition.

Carotenoids are the pigments in plant parts responsible for the colour of vegetables or fruits. Figure 5 illustrates the effect of different calcium fertilizers on total carotenoid content in cauliflower. The results reveal that calcium application increased the plant carotenoid content was recorded at a significantly high value of 135.7 mg CE 100 g-1(on a dry weight basis) at the T6 treated plot in Snow Mystique. It is 13% higher compared with the control plot. Similarly, the same treatment results in higher carotenoid content in all four cultivars with a percent increase of 15.9%, 23%, and 21% in Suhasini, Dhaval-043, and Cauliflower 155, respectively, compared with the control. In general, calcium application increase lycopene and β-carotene in tomato (Kazemi, 2014) and pepper grown in greenhouse condition (Flores, Navarro, Garrido, Rubio, & Martínez, 2004). In contrast, there are previous reports available that calcium nitrate application did not significantly improve carotenoid content in sweet pepper (Buczkowska, Michalojc, & Nurzynska-Wierdak, 2016)

Conclusion

As a result of this study, applying different calcium fertilizers, both soil and foliar, increased the yield and quality parameters compared with those not calcium treated. Soil application of limestone combined with foliar spraying of $CaCl_2$ significantly increased flavonoids, carotenoids, phenol, and antioxidant content, followed by dolomite combined with calcium chloride. In contrast, calcium application did not significantly change total soluble solids or titrable acidity. Among the four cultivars used, Snow Mystique performed well in terms of yield and quality parameters in calcium-deficient acidic soil conditions.

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Disclosure statement

No potential competing interest was reported by the authors

Data availability statement: The data that supports the findings of this study are available on request from the corresponding author (P.A)

References

Ahmad, P., Abdel Latef, A. A., Abd_Allah, E. F., Hashem, A., Sarwat, M., Anjum, N. A., & Gucel, S. (2016). Calcium and potassium supplementation enhanced growth, osmolyte secondary metabolite production, and enzymatic antioxidant machinery in cadmium-exposed chickpea (Cicer arietinum L.). *Frontiers in Plant Science, 7*, 513.

Angeletti, P., Castagnasso, H., Miceli, E., Terminiello, L., Concellón, A., Chaves, A., & Vicente, A. R. (2010). Effect of preharvest calcium applications on postharvest quality, softening and cell wall degradation of two blueberry (Vaccinium corymbosum) varieties. *Postharvest Biology and Technology, 58*(2), 98-103.

Antoshkina, M., Golubkina, N., & Bondareva, L. (2020). Effect of foliar sodium selenite biofortification on cauliflower yield, nutritional value and antioxidant status. *Ovoŝi Rossii*.

AOAC. (1990). Official methods of analysis. In: Aoac Washington, DC.

Brand-Williams, W., Cuvelier, M.-E., & Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. *LWT-Food science and Technology, 28*(1), 25-30.

Buczkowska, H., Michalojc, Z., & Nurzynska-Wierdak, R. (2016). Yield and fruit quality of sweet pepper depending on foliar application of calcium. *Turkish Journal of Agriculture and Forestry, 40*(2), 222-228.

Cardoso, A. I. I., Claudio, M. d. T. R., Magro, F. O., & Freitas, P. G. N. (2016). Adubação fosfatada na produção e qualidade de sementes de couve-flor. *Ciência Rural, 46*(8), 1337-1343.

da Silva, D. L., de Mello Prado, R., Tenesaca, L. F. L., da Silva, J. L. F., & Mattiuz, B.-H. (2021). Silicon attenuates calcium deficiency by increasing ascorbic acid content, growth and quality of cabbage leaves. *Scientific reports, 11*(1), 1-9.

Dayod, M., Tyerman, S. D., Leigh, R. A., & Gilliham, M. (2010). Calcium storage in plants and the implications for calcium biofortification. *Protoplasma, 247*(3), 215-231.

Drabińska, N., Ciska, E., Szmatowicz, B., & Krupa-Kozak, U. (2018). Broccoli by-products improve the nutraceutical potential of gluten-free mini sponge cakes. *Food chemistry, 267*, 170-177.

Drabińska, N., Jeż, M., & Nogueira, M. (2021). Variation in the Accumulation of Phytochemicals and Their Bioactive Properties among the Aerial Parts of Cauliflower. *Antioxidants, 10*(10), 1597.

Flores, P., Navarro, J. M., Garrido, C., Rubio, J. S., & Martínez, V. (2004). Influence of Ca2+, K+ and NO3− fertilisation on nutritional quality of pepper. *Journal of the Science of Food and Agriculture, 84*(6), 569-574.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research*: John wiley & sons.

Horwitz, W. (2000). Vitamin C (reduced ascorbic acid) in ready-to-feed milk-based infant formula (AOAC Official Method 985.33). *Official methods of analysis of AOAC International*.

Karthika, K., Philip, P. S., & Neenu, S. (2020). Brassicaceae plants response and tolerance to nutrient deficiencies. In *The Plant Family Brassicaceae* (pp. 337-362): Springer.

Kazemi, M. (2014). Effect of foliar application of humic acid and calcium chloride on tomato growth. *Bulletin of Environment, Pharmacology and Life Sciences, 3*(3), 41-46.

Loekito, S., Afandi, A., Nishimura, N., Koyama, H., & Senge, M. (2022). The Effects of Calcium Fertilizer Sprays during Fruit Development Stage on Pineapple Fruit Quality under Humid Tropical Climate. *International Journal of Agronomy, 2022*.

Meda, A., Lamien, C. E., Romito, M., Millogo, J., & Nacoulma, O. G. (2005). Determination of the total phenolic, flavonoid and proline contents in Burkina Fasan honey, as well as their radical scavenging activity. *Food chemistry, 91*(3), 571-577.

Nakada-Freitas, P. G., dos Santos, J. T., Hidalgo, G. F., dos Anjos, L. V. S., de Souza, E. P., Martins, I. R., . . . Catão, H. C. R. M. (2021). Calcium in the production and quality of cauliflower seeds. *Research, society and development, 10*(2), e44710212763-e44710212763.

Nasrin, T. A. A., Yasmin, L., Arfin, M. S., Rahman, M. A., Molla, M. M., Sabuz, A. A., & Afroz, M. (2022). Preservation of postharvest quality of fresh cut cauliflower through simple and easy packaging techniques. *Applied Food Research*, 100125.

Poovaiah, B., & Leopold, A. (1973). Deferral of leaf senescence with calcium. *Plant Physiology, 52*(3), 236-239.

Rab, A., & Haq, I.-u. (2012). Foliar application of calcium chloride and borax influences plant growth, yield, and quality of tomato (Lycopersicon esculentum Mill.) fruit. *Turkish Journal of Agriculture and Forestry, 36*(6), 695-701.

Rachid, A. F., Bader, B. R., & Al-Alawy, H. H. (2020). EFFECT OF FOLIAR APPLICATION OF HUMIC ACID AND NANOCALCIUM ON SOME GROWTH, PRODUCTION, AND PHOTOSYNTHETIC PIGMENTS OF CAULIFLOWER (BRASSICA OLERACEA VAR. BOTRYTIS) PLANTED IN CALCAREOUS SOIL. *Plant Archives, 20*(1), 32-37.

Rigueira, G. D. J., Bandeira, A. V. M., Chagas, C. G. O., & Milagres, R. C. R. d. M. (2016). Atividade antioxidante e teor de fenólicos em couve-manteiga (Brassica oleracea L. var. acephala) submetida a diferentes sistemas de cultivo e métodos de preparo.

Salman, M., Ullah, S., Razzaq, K., Rajwana, I. A., Akhtar, G., Faried, H. N., . . . Khalid, S. (2022). Combined foliar application of calcium, zinc, boron and time influence leaf nutrient status, vegetative growth, fruit yield, fruit biochemical and anti-oxidative attributes of “Chandler” strawberry. *Journal of Plant Nutrition*, 1-12.

Sanderson, K. (2002). *Broccoli and cauliflower response to supplemental soil sulphur and calcium.* Paper presented at the XXVI International Horticultural Congress: Toward Ecologically Sound Fertilization Strategies for Field Vegetable Production 627.

Seidel, E. P., Egewarth, W. A., Piano, J. T., & Egewarth, J. (2015). Effect of foliar application rates of Calcium and Boron on yield and yield attributes of soybean (Glycine max). *African Journal of Agricultural Research, 10*(4), 170-173.

Torres, J. L., Ciabotti, E. D., Gomes, F. R., Leal, A. L., Vieira, D., & Costa, L. L. (2017). Physico-chemical attributes of no-till Brassica crops cultivated after various cover crops. *Horticultura Brasileira, 35*, 252-257.

Yuan, G.-f., Sun, B., Yuan, J., & Wang, Q.-m. (2009). Effects of different cooking methods on health-promoting compounds of broccoli. *Journal of Zhejiang University Science B, 10*(8), 580-588.

Zhang, Q., Dai, W., Jin, X., & Li, J. (2019). Calcium chloride and 1-methylcyclopropene treatments delay postharvest and reduce decay of New Queen melon. *Scientific reports, 9*(1), 1-10.

Zu, Y., Mei, X., Li, B., Li, T., Li, Q., Qin, L., & Yang, Z. (2020). Effects of calcium application on the yields of flavonoids and saponins in Panax notoginseng under cadmium stress. *International Journal of Environmental Analytical Chemistry*, 1-12.

Table 1. Ascorbic acid, TSS and titrable acidity of four cauliflower hybrids grown in different calcium fertilizers treatments

	Suhasini								P	Dhaval 043								P
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	
Ascorbic acid	51.2^{e}	63.2^{d}	64.3^{d}	79.8^{a}	71.2^{c}	70.2^{c}	73.4^{bc}	77.1^{ab}	**	56.7^{e}	62.3^{d}	61.4^{de}	76.2^{a}	71.1^{bc}	72.1^{abc}	68.2^{c}	74.2^{ab}	**
TSS	6.6^{a}	6.9^{a}	6.8^{a}	6.8^{a}	6.7^{a}	6.8^{a}	6.7^{a}	6.8^{a}	NS	7.5^{a}	7.8^{a}	7.6^{a}	7.8^{a}	7.9^{a}	7.5^{a}	7.6^{a}	7.5^{a}	NS
TA	0.13^{c}	0.17^{b}	0.17^{b}	0.18^{b}	0.21^{a}	0.20^{a}	0.18^{b}	0.18^{b}	**	0.19^{d}	0.23b^{c}	0.24^{b}	0.23b^{c}	0.28^{a}	0.23^{bc}	0.23^{bc}	0.22^{c}	*
Flavonoids	223.1^{e}	254.6^{d}	265.7^{cd}	276.1^{bc}	275.1^{bc}	300.5^{a}	298.1^{a}	288.1^{ab}	**	246.6^{d}	278.9^{ab}	276.7^{ab}	270.2^{bc}	267.8^{bc}	290.2^{a}	251.2^{cd}	255.6^{cd}	*

	Snow Mystique								P	Cauliflower-155								P
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	
Ascorbic acid	61.2^{d}	67.8^{c}	68.9^{c}	83.1^{ab}	84.2^{ab}	85.6^{a}	79.0^{b}	80.2^{b}	**	59.2^{e}	60.1^{de}	67.2^{bc}	72.6^{a}	68.2^{abc}	64.5^{cd}	68.9^{abc}	70.1^{ab}	**
TSS	8.9^{a}	9.0^{a}	9.0^{a}	9.1^{a}	9.1^{a}	9.1^{a}	9.1^{a}	9.1a	NS	7.9^{a}	8.2^{a}	8.2^{a}	8.2^{a}	8.3^{a}	8.3^{a}	7.9^{a}	7.9^{a}	NS
TA	0.23^{d}	0.24^{d}	0.26^{b}	0.27^{c}	0.31^{a}	0.29^{b}	0.26^{c}	0.27^{c}	*	0.22^{c}	0.24^{b}	0.25^{ab}	0.26^{a}	0.22^{c}	0.24^{b}	0.24^{b}	0.25^{ab}	**
Flavonoids	244.4^{d}	278.2^{b}	267.3^{bc}	256.5^{cd}	311.0^{a}	321.1^{a}	271.3^{bc}	276.7^{b}	**	233.4^{d}	245.6^{cd}	254.3^{bc}	256.8^{bc}	263.1^{bc}	289.1^{a}	267.1^{b}	245.6^{cd}	**

*Values in the table are mean of three different replicate analysed twice independently and the different letters present along with the mean value indicate statistically significant differences between the samples (**p<0.01, *p<0.05, NS p>0.05)

Fig.1 Effect of different calcium treatments on cauliflower yield (q ha^{-1}) of four cauliflower cultivars

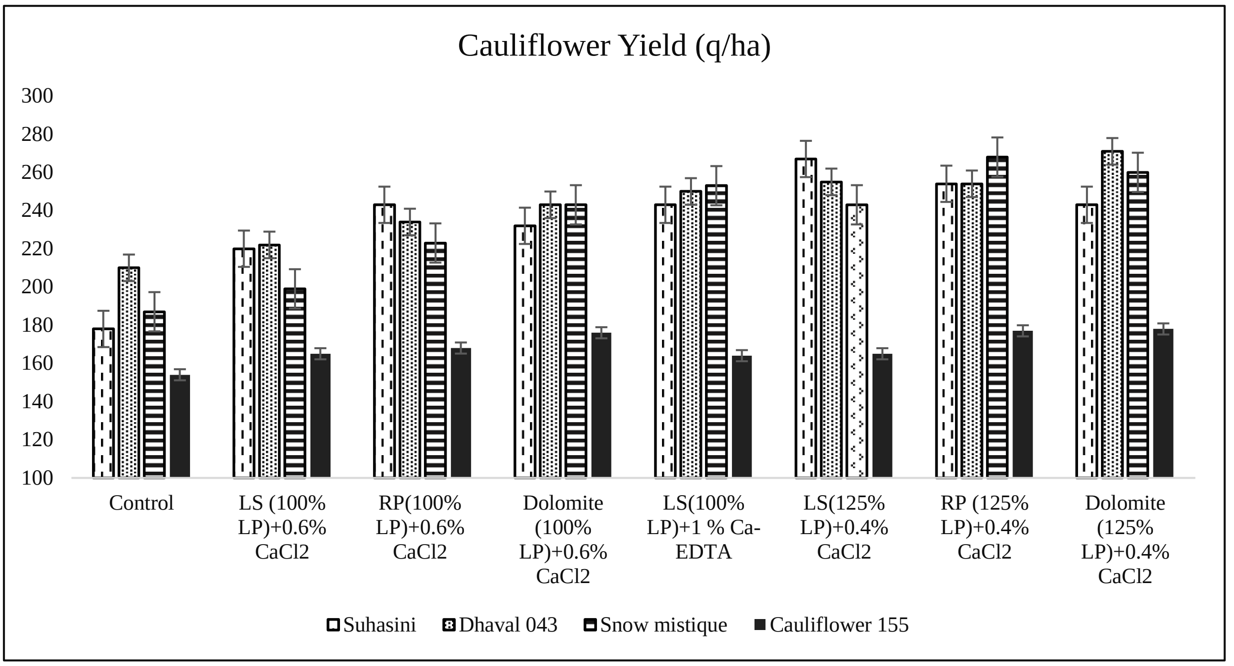

Figure.2. Effect of different calcium treatments on Total Phenolic activity (mg GAE/100g) of four cultivars of cauliflower

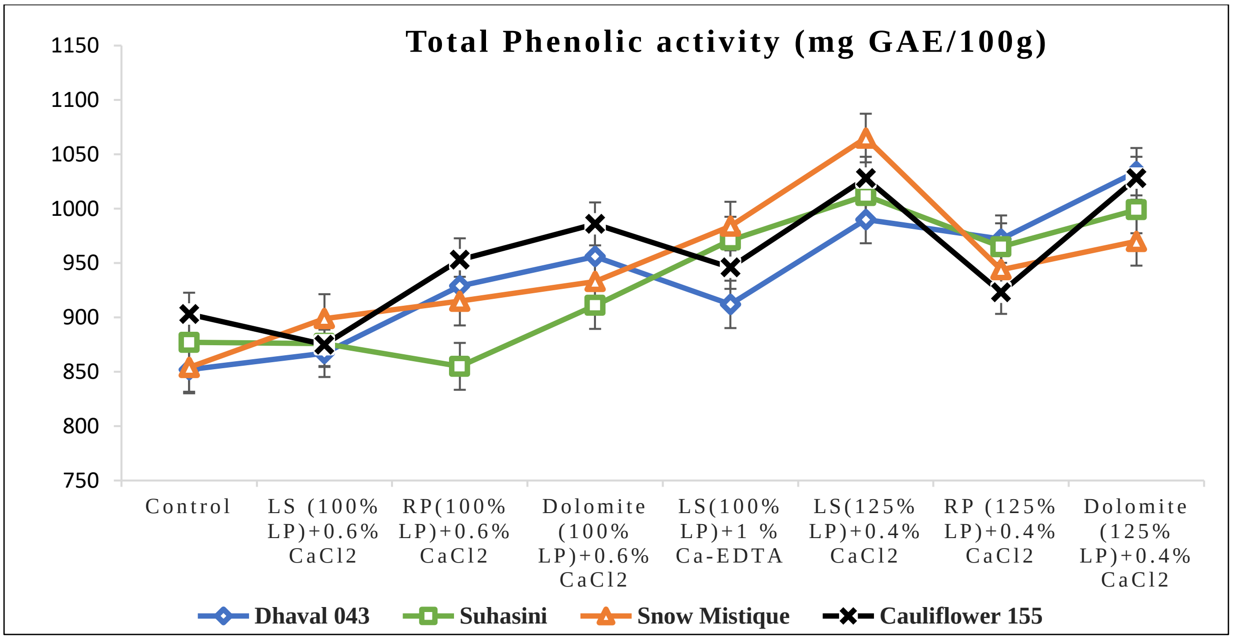

Figure.3 Effect of different calcium treatments on antioxidant activity (%) of four cultivars of cauliflower

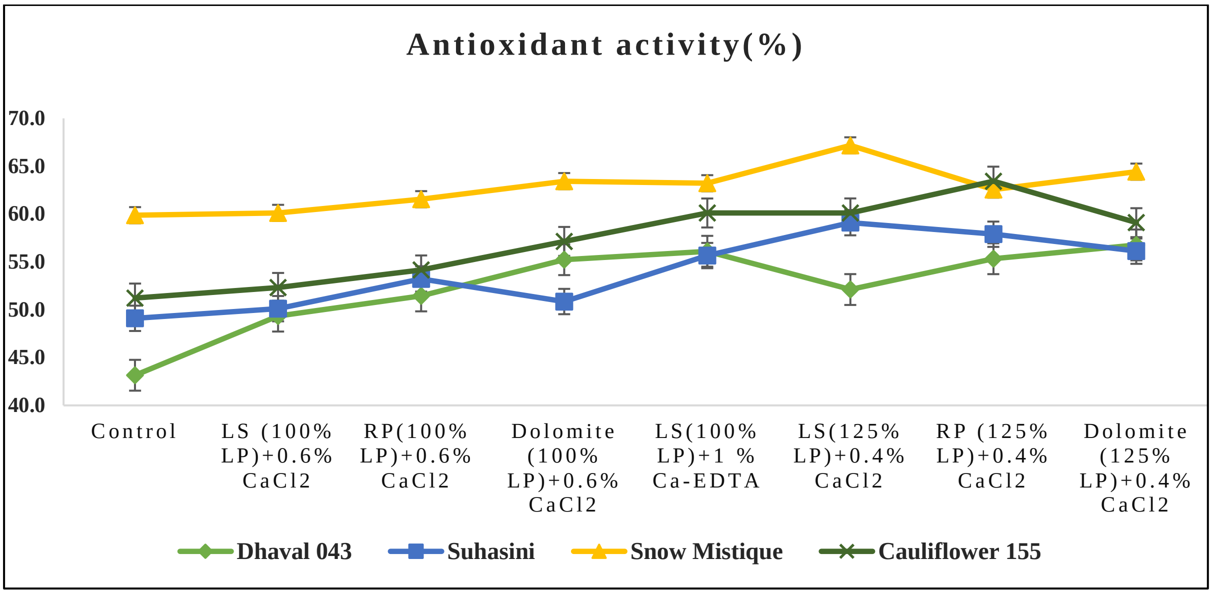

Figure 4. Effect of different calcium treatments on Flavonoids activity (mg CE/100g) of four cultivars of cauliflower

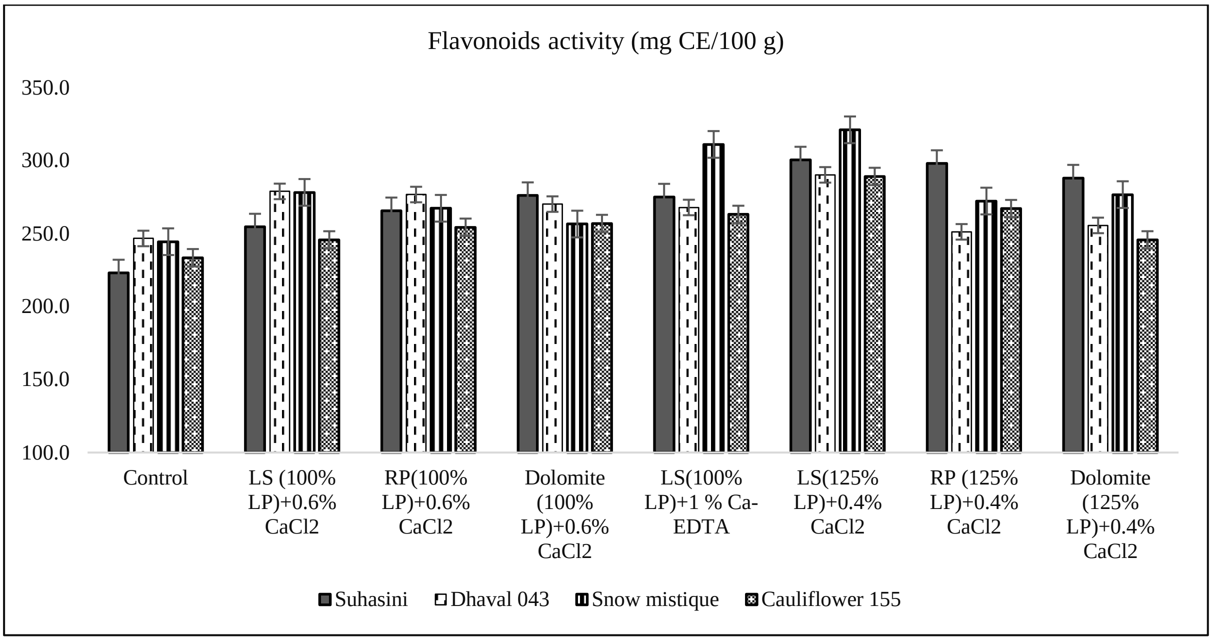

Figure 4. Effect of different calcium treatments on Carotenoid content (mg /100g) of four cultivars of cauliflower