

Effects of Different Fertilizers on Yield and Vitamin C Content of Cauliflower (*Brassica oleracea var. botrytis*) – A Review

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Authors' contributions

This work was carried out in collaboration between both authors. Author PB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author LB managed the analyses of the study, managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Cauliflower is an important winter crop in Nepalese farming community and consumed all over the world. The yield and vitamin C content of cauliflower depends on many factors such as its genotype, cultural practices, environment in which it is growing on and storage after harvesting etc. But among them, the availability, dose and types of fertilizers used play an important role in yield and the amount of vitamin C content in cauliflower. The vitamin C is one of the major Phytochemicals we obtained from cauliflower and it plays an important role in our physical health. The disease like scurvy is caused due to the lack of ascorbic acid known as vitamin C. It has been proved that consumption of fruits and vegetables rich in vitamin C helps in prevention of cancer and heart disease because it act as a source of antioxidant. The number of studies conducted in the past revealed that the fertilizers having higher amount of nitrogen leads to the formation of less vitamin C on the cauliflower and vice versa.

Keywords: Cauliflower; fertilizers; yield; vitamin C.

1. INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis*) is derived from Latin words "Caulis" meaning stalk and "Floris" meaning flower. It belongs to the family Brassicaceae or Cruciferae and to be originated from the Mediterranean region [1]. It is an important annual vegetable that reproduce by seed and grown largely in winter season. Cauliflower grows its best between the latitudes 11-60°N with average temperature ranging from 5-8°C to 25-28°C and may tolerate temperatures from -10°C to 40°C for a few days during the vegetative growth period [2]. It requires enough amount of nutrient with soil pH of 6.0 to 7.0 for its better growth and development [3,4]. In nutritional composition it has a high proportion of water, up to 91%, sugar in an amount of 4.5%, protein 2.5%, crude fiber 1.8%, and only 0.3% fat [5]. "Curd" is known to be an edible part of cauliflower which consists of a shoot system with short internodes, branches apices, and bracts [6]. The color of the curd is usually white but can also be yellow, green or purple because of the special combination of phytochemicals called carotenoids, tocopherols, and ascorbic acid [2].

Cauliflower is consumed not only for food purpose but also believed to be equally important for medicinal purpose and therapeutic effects because of the high concentration of glucothiocyanate, which works effectively in the inhibition of carcinogenesis [7]. Fruits and vegetables in human diets supplied more than 90% of vitamin C [8]. Vitamin C is stated to reduce the risk of arteriosclerosis, cardiovascular diseases and some type of cancer as an antioxidant [9,10]. It also contains high quality of protein, and is rich in diverse nutrients, vitamins and minerals such as vitamin-A [11], vitamin-B1, vitamin-C, carbohydrate, fat (less amount in comparison to others), calcium, potassium, magnesium, sodium, iron, phosphorous, sulphur, copper, carotenoids and β -carotene [12]. In clinical expression, vitamin C deficiency shows scurvy; which is a lethal condition unless appropriately treated [13]. The content of vitamin C in fruits and vegetables can be influenced by various factors such as genotypic differences, fertilizers used, preharvest climatic conditions, cultural practices, maturity, harvesting methods, and postharvest handling procedures [14,15,16]. But it is said that higher the intensity of light during the growing season, the greater is vitamin C content in plant tissues [17,18].

Number of studies based on effect of fertilizers and its doses on yield and vitamin C contents of Cauliflower have been done in the past. So, in order to analyze these studies and to come up with concrete conclusion these past studies have been evaluated.

2. EFFECTS OF DIFFERENT FERTILIZER ON YIELD AND VITAMIN C OF CAULIFLOWER

2.1 Vermicompost

It is the product of the decomposition process using different species of worms typically red wigglers, white worms, and other earthworms, to create a mixture of decomposing vegetable or food waste, bedding materials, and vermicast (also called worm castings, worm humus, worm manure, or worm feces). [19] reported that vermicompost is considered to be the most popular biodegradation and stabilization of organic materials which is produced through interactions between earthworms and micro-organisms. Vermicompost includes high microbial population activities, and also comprised of high levels of available NPK and plant growth hormones and enzymes [20,21]. [22] concluded vermicompost as a source of fertilizer that provides the best result in terms of yield, low nitrate content and high vitamin C content in crops like cauliflower. Application of vermicompost significantly increases the plant height and also helps in the improvement of soil physical properties particularly soil porosity, water holding capacity and supplied other plant growth promoting substances [23,24]. [25] revealed that, fertilizer sources significantly affect the yield of cauliflower. Thus, she has found curd weight of (484.43 g/plant) which was slightly higher with the application of vegetable wastes vermicompost compared to chemical fertilizers. The performance of cauliflower was found better when used vermicompost 1.5 ton per hectare with 100% RDCF [23] in the same research it was found that the effect of vermicompost was better in performance to conventional compost in the yield of cauliflower. Because of the application of vermicompost in cauliflower, there found early curd initiation and maturity it might be due to balanced plant nutrient and hormones in vermicompost. [26,27].

[28] reported that the vitamin C content in cauliflower was significantly higher in

vermicompost (10.92 mg/100 gm) followed by mustard oil cake (10.60 mg/100 gm). Similarly, [29] also found that among other treatments vermicompost showed the maximum influence of vitamin C content i.e. 33.09 mg/100 gm in cauliflower. The highest vitamin C content with vermicompost could be due to the essential elements present in it which enhanced vitamin C synthesis [30]. [31] found more calcium and vitamin C content in tomatoes grown in vermicompost in a hydroponic medium with chemical fertilizers. The high level of nutrient in vermicompost, leads to early flowering that induced lowest time to fruit setting [32]. The use of vermicompost influences the humic acid in soil which helps to increase number of flowers in a plant [33]. On the other hand, [34] agreed with the similar type of result that vermicompost boosted up the diameter of fruit in various crops like watermelon, tomatoes and sweet pepper. It was revealed from the chemical analysis that vermicompost contains huge amount of important nutrients for example, sodium, potassium, calcium, magnesium, copper, nitrate and chloride [35].

2.2 Mustard Cake

It is an excellent organic manure, which can be obtained after the extraction of oil from mustard seed. It is rich in nitrogen, phosphorus, potassium and several micronutrients and also have herbicidal effects too [36]. Mustard oil cake helps to improve plant health, productivity, and soil health. It helps to control weeds, insect pests, nematodes and pathogens [37,38,39]. [29] reported that among all the fertilizers which were used in research, the result of the mustard cake was excellent in three different parameters i.e. plant height, stem diameter, and yield. Application of mustard oil cake, 15 days before planting of cauliflower performs better in all growth parameter such as plant height, number of leaves per plant, largest leaf length (cm), largest leaf breadth (cm), days required for curd initiation, length of curd (cm), curd stem diameter (cm), curd weight (kg), curd diameter (cm), yield per plot (kg) and yield per hectare (ton) while minimum was found in unfertilized condition in all those parameters. Mustard oil cake maximized yield per plot (11.147 kg) of cauliflower while minimum yield per plot was (5.678 kg) in unfertilized condition [40]. In the same research the maximum yield per hectare was recorded (38.704 ton/ha) and minimum (19.717 ton/ha) in controlled condition.

Similar type of result was revealed by [41] where organic manure treatment gives better yield and curd diameter compared to others. The effect of mustard oil cake on vitamin C content of cauliflower was less in comparison to vermicompost whereas similar result in curd diameter and yield [42]. Research conducted in the eastern Nepal concluded vitamin C content was slightly higher in vermicompost (10.92 mg/100 gm) than mustard oil cake (10.60 mg/100 gm) [28].

2.3 Farmyard Manure

It is an organic fertilizer comprised of the waste products mainly dung and urine produced by farm animals most commonly cows and buffaloes. This waste product called manure is known to contain a wealth of nutrients, including the extremely important element that plant needs i.e. nitrogen. Farmyard manure has become one of the main sources of fertilizer for the most of the Nepalese farmers specially in the mid-hill and high hill of Nepal [43]. Cauliflowers supplied with organic manures, shows higher number of leaves per plant (17.8) as compared to those supplies with organic fertilizers (15.2) [44]. [45] concluded the effect of different organic manures and biofertilizers on cauliflower with reference to growth and yield attributes. He concluded that, cauliflower shows better response to the application of organic manures and biofertilizers. Through the application of organic fertilizers, plants are able to get nutrients for higher yield [46-51]. [42] & [52] reported lowest vitamin contents in cauliflower with the application of farmyard manure. The reason may be due to the slow release of essential nutrient, that contradicts the findings of [53]. In his finding, he disclosed organically grown vegetables may contain more than 25% of Vitamin C in comparison to those crops which are grown with inorganic nutrient sources.

2.4 Chemical Fertilizers (NPK)

It is an inorganic fertilizer containing most important crop nutrients. Most of the compound fertilizers contain three major elements which is essential for plant growth: NPK, which stands for nitrogen (promotes leaf growth), phosphorus (root, flower and fruit promotion) and potassium (stem & root growth and protein analysis) [54]. Supply of any of these nutrients in inadequate amount during crop growth is known to have a negative impact on the reproductive capability, growth and yield of plant [55,56] and supplementary amount of nutrients can be added

to soil in the form of inorganic fertilizer to correct inadequate supply of nutrients to the crop [57]. [58] & [59] revealed that with an increase in the fertilization dose from 80 to 120 kg N ha⁻¹ the content of nitrates rose by 44% in broccoli and 33% in cauliflower, confirming the role of nitrogen fertilization in the accumulation of these compounds. [60] concluded that crop yield and bioactive compounds (vitamin C, E1 and β -carotene) content in cauliflower, edible heads has shown positive effect by the application of nitrogen and Sulphur fertilizer.

Nitrogen and phosphorous are the major limiting nutrients for plant growths [61], deficiency of such elements in soil can be improved by their external supply. Increased nitrogen in the soil increased total nitrogen and nitrate contents but decreased amino acid concentrations and decreased the nutritive value of the crude protein judged on the basis of amino acid estimations. The application of NPK fertilizer improves the yield of cauliflower, also biologically active soils containing organic matter usually supply ample of these nutrients [62]. With the higher dose of nitrogen fertilizer, the dry matter content in cauliflower and broccoli was found slightly smaller but statistically significant differences were not determined [15,63,64].

Due to the effect of different doses of NPK there found much variation in total yield of cabbage where total yield per plot were maximum with 150 kg N + 100 Kg P₂O₅+ 150 kg K₂O combination (where P₂O₅ is Phosphorus Pentoxide and K₂O is Potassium Oxide) [65]. The application of chemical fertilizers (NPK) at different rates shows increment in curd diameter also, differences in curd yield per plot was observed in two different varieties, where White Angel F1 had highest yield in comparison to Snow White [66]. The higher doses of nitrogen reduce levels of vitamin C, content in cauliflower [67,68,69,70]. The application of NPK (100%) alone increases the yield of cauliflower curd [71]. A research conducted in Dang Nepal by [42] concluded that the contribution of NPK on the formation of vitamin C was very low (10.86mg/100g) compared to the mustard oil cake but higher than other nutrients [Fig. 1].

2.5 Poultry Manure

It is an organic waste composed of mainly feces and urine of chickens along with bedding materials. The poultry manure has greater amount of nutrients due to the collection of

poultry urine and solid feces together providing essential elements for the overall growth and development of plants [72]. In poultry manure, NPK concentration was found to be 1.6%, 0.8% and 1.2% respectively; in addition, organic matter content close to 48% [73], helps in nutrient uptake of plant [74,75]. Besides major nutrients, poultry manure also contains traces of micronutrients which are generally not supplied by the commercial fertilizer but essential for plant growth. With the increment in application of poultry manure from 42.4 quintals to 169.6 quintals helps to increase total yield (561.61q/ha), and curd weight (570gm) but the initiative period for the curd was delayed [76]. The application of poultry manure at 50 ton / acre results in increment of cauliflower yields as comparison with application of inorganic fertilizers alone but the combine effect of inorganic fertilizers with the poultry manure shows positive results on the yield [77]. The maximum curd yield per plot (3.72kg) was obtained from the treatment of (50% RDF +50% PM and the minimum (0.930kg) in no fertilizers [2]. The combination of organic and inorganic fertilizer helps to obtain the higher yield and maximum value of growth in cauliflower [78,79].

Economic recycling of the poultry manure could conserve and add nutrients by making it more valuable and useful for agricultural production. The application of poultry manure to cauliflower resulted in the increment of vitamin C, protein, calcium content, and a slight decrease in the amount of carbohydrate content, with the highest values at 170 Q/ha [75]. The use of poultry manure as fertilizers contribute 11.75mg/100g of vitamin C which is greater as compared to commercial NPK only contributing 10.86mg/100gm [42]. [30] also found higher vitamin C content in cauliflower head with the increased application of organic manure. The combination of RDF (25%) and Poultry manure (75%) result best in vitamin C content on broccoli [2].

[Note: RDF = Recommended fertilizers dose, PM = Poultry manure]

2.6 Compost

It is an organic manure made from the mixture of decayed or decaying organic matter. It is usually made by gathering plant material, such as leaves, small and succulent branches like grass clippings, and vegetable peels, into a pile or bin and letting it rot. Cow dung manure and other substances are often added to enrich the mixture

or to speed its decomposition. The addition of compost in the soils helps to improve the physical, chemical and biological properties of the soil [80]. The use of compost and vermicompost improves plant growth and quality of cauliflower. The application of compost improves the Phyto-nutritional component of crops [51] and promote root formation, increase fruit setting and yield [81,82,26].

It has been reported that the use of compost increase plant dry mass [83,84]. The use of

compost manure results in curd diameter (15.13cm) which is close to result shown by the mustard cake (15.60 cm) & vermicompost(15.26cm) [42]. In the same research it concluded that the use of compost results in low vitamin C content (12.18 mg/100gm) in comparison to vermicompost that might be due to the slow release of nutrient and poor nutrient content in compost fertilizers. The application of organic compost (37.7t/ha) without mineral fertilizer maximizes the estimated yields of cauliflower (153.9 g) per plant [85].

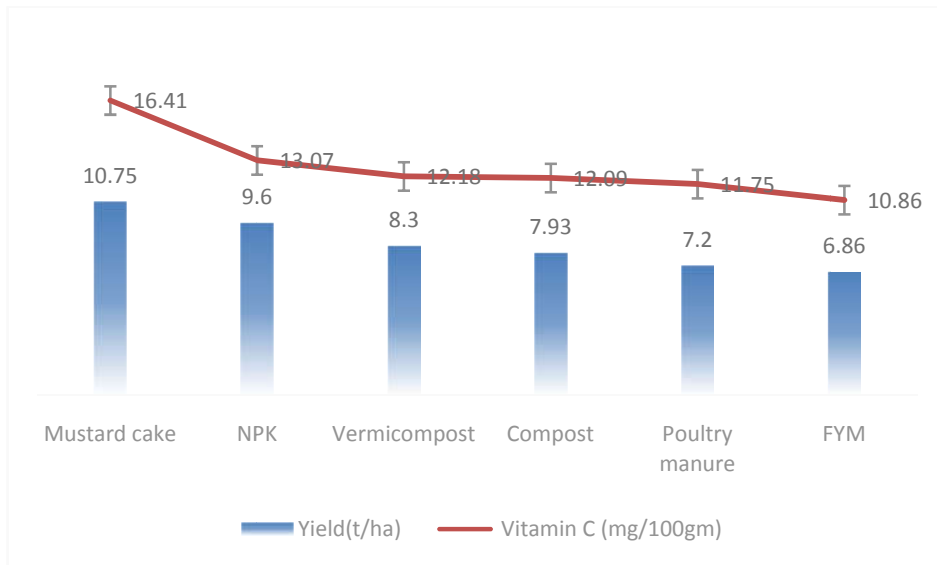


Fig. 1. Effect of different fertilizers on yield and vitamin C content
Data source: (Mishra et al., 2018)

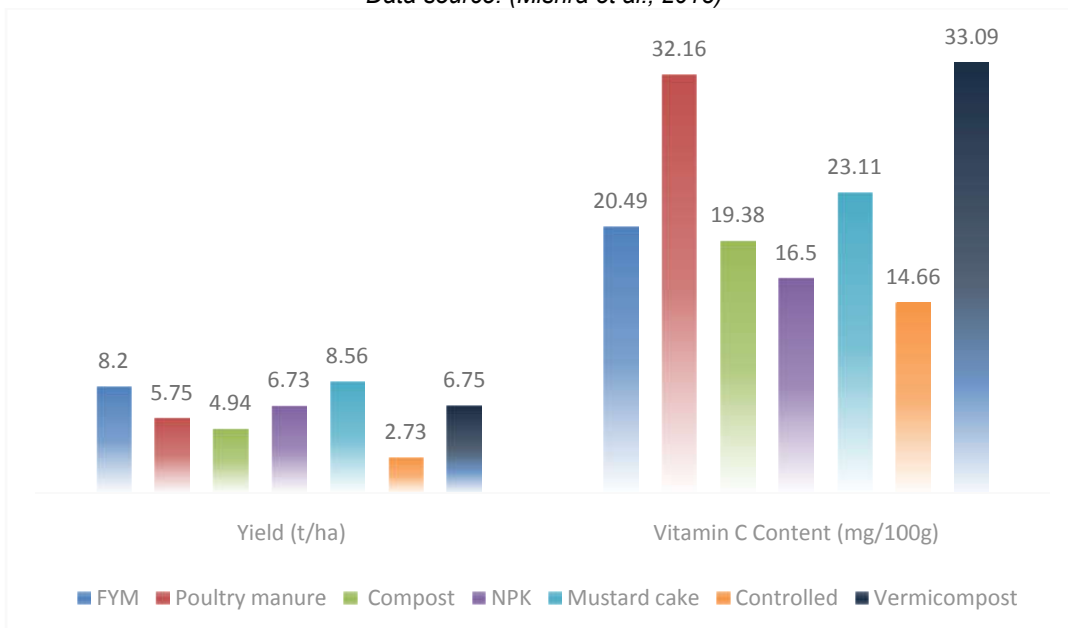


Fig. 2. Effect of different fertilizers on yield and vitamin C content
Data source: (Acharya et al., 2020)

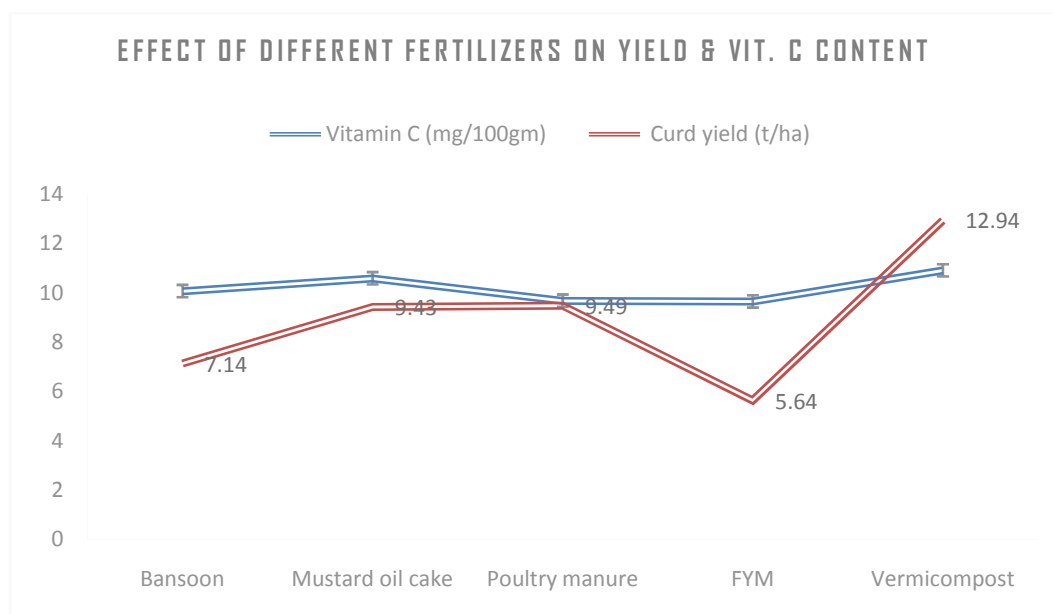


Fig. 3. Effect of different fertilizers on yield and vitamin C content

Data source: (Basnet & Shakya, 2016 and Basnet et al., 2017)

3. CONCLUSION

The use of different fertilizers and their doses shows different effect on the yield and vitamin C content of cauliflowers. It can be concluded that among all the treatment attempted, vermicompost shows the maximum influence in the vitamin C content of a cauliflower. The highest vitamin C content with vermicompost could be it consist of decomposed products by earthworm which contains various nutrients, essential elements, plant growth hormones and several enzymes present in it which influence vitamin C synthesis. Thus, application of vermicompost can be recommended in cauliflower to gain higher amount of vitamin C. Likewise, to obtain higher yield of cauliflower, mustard oil cake and vermicompost can be used. Also, the combination of poultry manure and chemical fertilizers shows better performance in case of yield of cauliflower.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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