

Effect of Vermicompost and Foliar Application of Methanol on Cauliflower Plants Grown in Sandy Soil

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Abstract: Two field experiments were conducted during the winter seasons of 2017-2018 and 2018-2019 at the Agricultural Production and Research Station, National Research Centre (NRC), Nubaria Province, Egypt. The experiments aimed to study the effect of vermicompost and foliar application of methanol on growth, quantity and quality yield and nutritional status of Cauliflower plants (*Brassica oleraceae* var. *snowball* L.). Five rates of vermicompost (1, 2, 3, 4 and 5 ton fed⁻¹) were added before seedlings were planted and the soil preparation. While the different concentrations of methanol (0, 20, 30 and 40 %) were sprayed after planting the seedlings three weeks and the spraying was repeated three times. The results indicated that the increase in the addition of vermicompost from 1 to 5 ton per feddan resulted in a significant increase in yield parameters (head height and diameter, plant length, number of leaves and head yield). The values of the cauliflower yield components improved significantly with the spraying of plants with methanol during two growth seasons. The highest values of the previous yield parameters were obtained when the plants were sprayed with a concentration of methanol equal to 40%; especially when spraying was combined with vermicompost at (3 ton fed⁻¹). However, with the spraying of plants by different concentrations of methanol under various additions of vermicompost led to significantly increased both vitamin C and protein in the curd and of course also increased the chlorophyll content of the leaves. The highest value of vitamin C, protein and total chlorophyll could be achieved with spraying the highest concentration of methanol (40 %) combined with fourth rate of vermicompost (5 ton fed⁻¹). Moreover, spraying cauliflower plants with different concentrations of methanol under various additions of vermicompost led to enhance nutrients content (N, P and K) in cauliflower curd. Therefore, it can be said that spraying plants with methanol solution, especially high concentrations, greatly helps to increase the yield and quality of the crop, especially when fertilized with vermicompost, which was made from animal manure.

Key words: Cauliflower plants • Vermicompost • Methanol • Yield • Quality • Quantity

INTRODUCTION

Cauliflower (*Brassica oleraceae*) is the second most paramount inflorescence vegetables after globe artichoke and before broccoli in many places of the world. It is a cheap winter yield and can be used as a fresh or frozen vegetable. In Egypt, cauliflower's curds are used cooked, fried, boiled and pickled. It is well known that, cauliflower have massive nutritional and medicinal values because to its high contents of vitamins, dietary fibers, folic acid and nutrients such as K, Mg, P, Zn and Fe [1].

Vermicomposting is a simple biotechnological process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better product [2].

Vermicompost is made up primarily of C, H and O and contains macronutrients such as N, P, K, Mg and S and micronutrients such as Fe, Zn and Mn which exhibit similar effects on plant growth and yield as inorganic fertilizers applied to soil [3]. Moreover, vermicompost contains a high proportion of humic substances (that is, humic acids, fulvic acids and humin)

which provide numerous sites for chemical reaction; microbial components known to enhance plant growth and disease suppression through the activities of bacteria (*Bacillus*), yeasts (*Sporobolomyces* and *Cryptococcus*) and fungi (*Trichoderma*), as well as chemical antagonists such as phenols and amino acids [4].

Methanol is one of the substances that boosts CO₂ fixation in C₃ plants. As well as an opulent of carbon can be in the absence of respiration. With enhancing CO₂ concentrations in plants and rising the adequacy of photosynthesis, carbon fixation part of the losses to compensate by photosynthesis [5]. Methanol is product through destination pectin in the cell wall [6]. Among other characteristics of methanol is doing in plant is faster output of sugar and amino acids in plant compared with the rate of carbon dioxide [7].

The paper aimed to study the addition of different rates of vermicompost and spray with varied concentrations of methanol and its effect on the yield quality and quantity as well as the nutritional status of Cauliflower plants (*Brassica oleraceae* var. *snowball* L.) grown in sandy soil.

MATERIALS AND METHODS

This study was carried out at the Experimental Station of the National Research Centre, Beheira Governorate (north of Egypt), during the two winter season of 2017-2018 and 2018-2019 to investigate the response of Cauliflower to different vermicompost rates and foliar application of methanol on growth, quantity and quality yield and nutritional status of Cauliflower plants. Seeds of Cauliflower (*Brassica oleracea* L. var *snowball* L.) were sown in the nursery in foam trays on 5th of October. Forty day-old seedlings were field transplanted, then healthy transplants 40 days age were selected. The area of the experimental plot was 16.8 m² consisted of three rows; each row was 8 m length and 0.7 m width. Cauliflower transplants were sown 0.5 m apart on one side of the irrigation line, one seedling was adjacent to every irrigation eye. Ditches of 20 cm width and 20 cm depth were prepared besides every irrigation line. Calcium super phosphate and agricultural sulphur at a rate of 100 kg per feddan were spread through the ditches and covered by sand. Drip irrigation lines were established over the ditches and soil was irrigated continuously three days before transplanting. The recommended horticultural practices of growing

cauliflower were followed according to Ministry of Agriculture. Nitrogen source of mineral fertilizer (ammonium sulfate 21.5% N) at a rate of 100 kg N /fed. and potassium sulfate (48% K₂O) at a rate of 60 kg K₂O /fed were applied through irrigation system all over the growing season and stopped two weeks before harvesting.

Some physical and chemical properties of the soil used in the experiments are shown in Table (1) using the standard procedures outlined by Cottenie [8].

The experimental design used was split plot with three replications. The rates of vermicompost were in the main plots and rates of foliar application of methanol treatments were in the sub plots with three replications. Five rates of vermicompost (1, 2, 3, 4 and 5 ton fed⁻¹) were added before seedlings were planted and the soil was prepared for growing and different concentration of methanol (0, 20, 30 and 40%) were sprayed after planting the seedling three weeks and the spraying was repeated three times. The vermicompost used in this experiment was made of horse and cow manure, which has been digested by the Earthworm called *Eisenia fetida*. Vermicompost analyses was determined (Table 2) using the standard procedures outlined by Cottenie [8].

Measured Parameters

Vegetative Plant Growth: A random sample of three plants were taken at 45 days after planting to measure plant length, number of leaves / plant, head height, head diameter. All Cauliflower heads of each plot were harvested at the mature stage and weighed to determine yield per plot and per feddan.

Nutritional Status: Total nitrogen content was estimated by modified Kjeldahl's methods [9]. The percentages of phosphorus and potassium in the acid digested samples of cauliflower dry heads were determined. Phosphorus was determined calorimetrically by NH₄-Metavanadate method [9]. Potassium was flame-photometrically estimated [9].

Vitamin C contents: Vitamin C contents (mg/100 gm F.W) were determined in heads (fresh weigh basis) according to A.O.A.C. [10]. The total chlorophyll were determined in representative fresh leaves samples according to [11]. Total protein percentage in heads of cauliflower: a factor of 6.25 was multiplied by total nitrogen concentration to obtain protein percentage.

Table 1: Some physical and chemical properties of the soil used

Soil property	Value	Soil property	Value
Particle size distribution %		pH (1:2.5 soil suspension)	7.70
Sand	92.65	EC (dS m ⁻¹), soil paste extract	1.60
Silt	5.07	Soluble ions (mmol L ⁻¹)	
Clay	2.28	Ca ⁺⁺	8.02
Texture	Sandy	Mg ⁺⁺	3.23
-----	-----	Na ⁺	3.92
CaCO ₃ %	2.20	K ⁺	0.91
Saturation percent %	22.50	CO ₃ ⁻	nd
Organic matter%	0.11	HCO ₃ ⁻	2.20
Available N (mg kg ⁻¹)	20.2	Cl ⁻	3.98
Available P (mg kg ⁻¹)	3.50	SO ₄ ⁻	9.90
Available K (mg kg ⁻¹)	66.4	CEC (cmol kg ⁻¹)	7.00

Table 2: Some chemical properties of vermicompost used:

Analyses	Vermicompost
pH	6.90
EC (dS m ⁻¹)	2.00
Moisture content (%)	15.00
Organic matter (%)	50.30
Organic carbon (%)	29.20
Ash (%)	49.70
C/N ratio	1:24.30
N (%)	1.20
P (%)	0.50
K (%)	0.80

Statistical Analysis: All data were subjected to statistical analysis using Mstatc software. The comparison among means of the different treatments was determined, as illustrated by Snedecor and Cochran [12]. Means of the treatments were compared by the Least Significant Differences Test at (0.05) level of significance.

RESULTS AND DISCUSSION

The results in Table (3) appeared that the increase in the addition of vermicompost rate from 1 to 5 ton per feddan resulted in a significant increase in growth parameters (plant length, number of leaves) and yield parameters (head height and diameter and head yield). However, the significant increase in the yield characteristics of cauliflower was obtained vermicompost was applied at a rate of 3 ton fed⁻¹, where it gave the highest values obtained for each head height, head diameter, plant length, number of leaves and head yield in both seasons.

Such increments of cauliflower yield parameters could be attributed to the vermicompost characteristics where it is the product of composting or smashing down organic matter through the use of earthworms. It is opulent in fundamental plant nutrients and has the ability to reinforce the condition and increase the quality of the soil [13]. Bachman and Metzger [14] reported that significant

increase in growth characteristics of plants after using of vermicompost in the soil, because plant growth and development are strictly dependent on biological fertility factors. Earthworms may stimulate microbial activities and metabolism and also leverage microbial populations. As a consequence, more available nutrients and microbial metabolites are released into the soil [15]. Abul Kashem *et al.*, [16] showed that vermicompost played a paramount role in improving soil texture, aeration, soil compaction and thus foster more water and nutrients uptake by plants from their surrounding areas of root zone. There is much clue that the activity of earthworms speed up organic matter mineralization, decomposition of polysaccharides and increase the humus in the soil.

From the same table it is clear that the values of the cauliflower growth and yield components improved significantly with the spraying of plants with methanol during the first and second seasons. Increasing in the rate of spraying of methanol from zero to 40 % significantly increased the head height and diameter, plant length, number of leaves and head yield under all levels of vermicompost. The highest values of the previous yield parameters were obtained when cauliflower plants were sprayed with a concentration of methanol up to 40%; especially when the methanol application combined with vermicompost (3 ton fed⁻¹). The best values of yield parameters were obtained when spraying 40% methanol under 3 ton fed⁻¹ of vermicompost in both seasons and it was as follows: head height (23.0 cm), head diameter (25.0 cm), plant length (70.8 cm), number of leaves (14.3) and head yield (6.81 ton fed⁻¹) at first season (2017-2018). As well as head height (23.2 cm), head diameter (24.9 cm), plant length (71.9 cm), number of leaves (14.2) and head yield (6.82 ton fed⁻¹) at second season (2018-2019). The increase in these parameters could be attributed the synergetic effect of methanol on plants.

Table 3: Effect of different rates of vermicompost and methanol on plant growth and yield of culiflower plants during 2017-2018 and 2018-2019 seasons.

Vermicompost ton fed ⁻¹	Methanol %	2017-2018					2018-2019				
		Head height	Head diameter	Plant length	Leaves number	Head yields	Head height	Head diameter	Plant length	Leaves number	Head yields
		cm				ton fed ⁻¹	cm				ton fed ⁻¹
1	0	18.8	18.7	63.4	12.0	3.50	19.2	18.9	63.5	12.0	3.52
	20	18.1	18.3	65.8	13.3	4.41	18.4	22.0	65.9	13.4	4.45
	30	19.1	19.6	66.9	14.0	4.61	20.0	22.7	67.1	14.0	4.70
	40	19.2	20.6	67.9	14.3	4.81	21.2	23.6	67.9	14.2	4.91
2	0	18.1	18.6	60.5	9.70	4.50	18.2	18.9	61.6	10.0	4.60
	20	18.2	18.9	62.6	11.0	4.71	18.7	19.1	62.9	11.2	4.82
	30	18.9	19.9	63.7	12.0	4.74	18.6	19.5	63.9	12.0	4.78
	40	19.8	20.3	65.4	12.7	4.91	19.4	20.1	66.1	12.8	4.91
3	0	20.0	23.7	68.1	13.0	5.80	20.2	23.6	69.0	13.1	5.82
	20	20.6	23.7	69.9	13.3	6.11	20.8	23.8	70.1	13.3	6.20
	30	22.8	24.1	69.9	14.0	6.66	22.9	23.9	70.2	14.0	6.60
	40	23.0	25.0	70.8	14.3	6.81	23.2	24.9	71.9	14.2	6.82
4	0	17.5	20.3	57.7	12.3	5.21	17.8	20.3	59.0	12.2	5.25
	20	17.9	22.1	58.5	13.0	5.30	18.1	22.1	60.0	13.0	5.40
	30	18.1	22.9	59.9	13.3	5.50	18.3	22.8	60.2	13.5	5.50
	40	18.8	23.4	60.8	14.0	5.72	18.9	23.0	60.6	14.0	5.60
5	0	18.8	16.6	63.7	12.0	5.00	18.7	16.9	64.0	12.6	5.10
	20	19.1	16.9	67.0	13.0	4.82	19.0	17.1	67.5	12.9	4.90
	30	19.3	17.4	67.5	13.3	5.05	19.4	17.8	67.9	13.3	5.20
	40	19.4	17.6	67.2	14.0	5.11	19.6	17.9	67.4	14.1	5.30
L.S.D. _{-0.05}	0.73	1.23	1.18	2.23	1.02	0.73	1.22	1.18	2.23	1.02	

Foliar application of methanol solutions on crops will improve their yields, accelerate ripening, reduce impacts of drought and decline crop water requirements, methanol application may stimulate growth through inhibition of photorespiration. One of the main advantages of methanol application is their preventing and reducing the effects of stresses induced due to their photorespiration which ultimately results in increasing the production of organic matter in a plant along with increasing its growth and yield [17]. Khosravi *et al.* [18] studied effects different concentration of methanol solution on purple cone flower (*Echinacea purpurea* L.) who reported that 40% (v/v) concentration of methanol spraying had a positive effect on growth parameters such as plant height, collar diameter of stem, leaf dry weight, stem dry weight, shoot dry weight and phytochemical and reproductive traits. Similar results have also been reported by Mahalleh Yoosefi *et al.* [19]. They reported that most average of number of seeds per pod, number of pods per plant and number of seeds per plant in bean (*Phaseolus vulgaris*) were obtained in treatment of 40% (v/v) methanol concentration. Sabokrow Foomany *et al.* [20] also expressed that foliar application of methanol at 40% (v/v) concentration significantly increased quality characters in tobacco (*Nicotiana tobacco*).

Data in Table (4) showed to the effect of each of the different additives of vermicompost (1, 2, 3, 4 and 5 ton fed⁻¹) and spray at different concentrations of methanol (0, 20, 30 and 40 %) on the content of cauliflower curd of vitamin C and protein, as well as the content of cauliflower leaves of total chlorophyll during both seasons. Increasing application rate of vermicompost from 1 to 5 ton fed⁻¹ resulted in significant increase of vitamin C, protein in the curd of the cauliflower and also the leaves content of chlorophyll without spraying methanol. Padamwar and Dakore [21] indicated that using vermicompost at 11.3 ton ha⁻¹ led to significant increase in per cent dry matter, protein, carbohydrate, vitamin C and calcium content of cauliflower curd. Thus, vermicompost may play an important role in increasing nutritive value of edible curd of cauliflower plants. Vermicompost is a rich source of enzyme, vitamins plant growth hormones such as IAA, gibberelins, cytokinins along with micro and macro nutrients, which enhance the growth of cauliflower plant and increasing quality of curd by increasing vitamin C and protein in cauliflower curd [22].

Similar effect was recorded with the spraying cauliflower plants with different concentrations of methanol under various additions of vermicompost and led to significantly increased both vitamin C and protein

Table 4: Effect of vermicompost and methanol on cauliflower yield quality during 2017-2018 and 2018-2019 seasons

Vermicompost ton fed ⁻¹	Methanol %	2017-2018			2018-2019		
		Vitamin C (mg/100g F.W.)	Protein/ (100 g D.W.)	Total chlorophyll (mg/g F.W.)	Vitamin C (mg/100g F. W.)	Protein %	Total chlorophyll (mg/g F.W.)
1	0	74.7	14.1	13.7	76.6	14.2	13.9
	20	76.9	15.5	14.8	77.2	15.6	15.2
	30	76.2	15.5	15.3	79.2	15.7	15.9
	40	79.3	16.2	16.6	80.3	16.3	17.0
2	0	82.5	14.2	14.5	84.5	14.4	14.8
	20	83.2	15.8	15.7	85.2	15.8	16.2
	30	85.0	15.7	15.9	86.0	15.9	16.9
	40	85.8	16.2	17.0	86.8	16.3	17.7
3	0	85.5	15.1	15.3	85.8	15.1	15.8
	20	85.8	16.2	16.6	86.0	16.2	17.2
	30	86.0	16.3	17.1	86.5	16.4	17.8
	40	86.5	17.0	18.1	86.9	17.1	18.8
4	0	86.0	15.2	15.8	86.5	15.3	16.2
	20	86.5	16.5	16.8	87.0	16.7	17.4
	30	86.6	16.6	17.6	87.2	16.7	18.2
	40	87.1	17.2	18.2	87.5	17.1	18.6
5	0	86.2	15.5	16.3	87.2	15.5	16.6
	20	86.6	16.8	17.3	87.6	16.8	17.8
	30	87.5	17.0	18.2	88.4	17.1	18.6
	40	88.2	17.4	19.1	88.7	17.4	19.5
L.S.D. _{0.05}		4.17	0.21	0.78	4.17	0.21	0.80

in the curd and as well as chlorophyll content of the leaves. The highest value of vitamin C, protein and total chlorophyll could achieved under higher concentration of methanol (40 %) combined with fourth rate of vermicompost (5 ton fed⁻¹).

McGiffen and Manthey, [23] indicated that applying a 20% volumetric solution of methanol on leaves increased protein content of peanut seeds. Moreover, methanol application also can enhance plant photosynthetic capacity by delaying leaves senescence and therefore extending photosynthesis active course by increasing activity of FBPase, an important enzyme controlling photosynthesis [24]. Methanol is a carbon source therefore increases CO₂ concentrations in plants and enhances growth and yield because the most important factor that affects dry weight of plants is CO₂ assimilation through photosynthesis. Methanol molecule is smaller than CO₂ molecule, thus plants absorb methanol easier than CO₂ and it leads to photosynthesis increasing [25].

The data shown in Table (5) indicate that when vermicompost rate increased from 1 to 5 ton per feddan significantly increases in the content of nitrogen, phosphorus and potassium in the curd of cauliflower, without spraying with methanol. The third rate of vermicompost (3 ton fed⁻¹) resulted in the highest values

of nutrient content during growth seasons, where values were as follows: 2.49, 0.47, 3.46 % of N, P and K, respectively, at 1st season and 2.48, 0.48 and 3.47 of N, P and K, respectively, in the 2nd season.

Vermicompost was a nutritive 'organic fertilizer' rich in nitrogen (2-3%), phosphorus (1.55-2.25%) and potassium (1.85-2.25%), micronutrients such as Fe, Zn and Mn, beneficial soil microbes like 'nitrogen-fixing bacteria' and 'mycorrhizal fungi' [26]. Additionally, vermicompost contain enzymes like amylase, lipase, cellulase and chitinase, which continue to break down organic matter in the soil (to release the nutrients and make it available to the plant roots) even after they have been excreted [27]. The effects of vermicompost application were favorable than the effects of the application of chemical fertilizers in case of both yield and nutrients content of crops [28].

Similar effects on NPK contents in cauliflower curd were occurred by spraying the plants with different concentrations of methanol under various additions of vermicompost which led to enhance nutrients content (N, P and K) in cauliflower curd. The highest values for all nutrients were obtained at the high concentration of methanol 40% with the third level of vermicompost (3 ton fed⁻¹). It is proposed that methanol could also transport the nutrients in to the leaves effectively [29].

Table 5: Effect of vermicompost and methanol on N, P and K content of Cauliflower curdduring 2017-2018 and 2018-2019 seasons

Vermicompost ton fed ⁻¹	Methanol %	2017-2018			2018-2019		
		N	P	K	N	P	K
		-----%-----			-----%-----		
1	0	2.00	0.36	2.94	2.01	0.36	2.96
	20	2.19	0.39	3.23	2.19	0.39	3.22
	30	2.22	0.39	3.34	2.24	0.39	3.34
	40	2.36	0.39	3.34	2.37	0.40	3.35
2	0	2.02	0.37	2.97	2.02	0.37	2.98
	20	2.23	0.41	3.30	2.24	0.41	3.32
	30	2.31	0.42	3.31	2.32	0.43	3.33
	40	2.39	0.42	3.33	2.39	0.43	3.34
3	0	2.10	0.39	3.04	2.10	0.39	3.06
	20	2.28	0.44	3.37	2.29	0.45	3.39
	30	2.33	0.44	3.44	2.35	0.46	3.46
	40	2.49	0.47	3.46	2.48	0.48	3.47
4	0	2.13	0.37	3.14	2.12	0.39	3.12
	20	2.26	0.40	3.41	2.28	0.42	3.40
	30	2.31	0.42	3.44	2.32	0.44	3.42
	40	2.45	0.45	3.45	2.46	0.45	3.45
5	0	2.17	0.37	3.14	2.18	0.39	3.14
	20	2.26	0.41	3.42	2.28	0.42	3.42
	30	2.32	0.42	3.42	2.34	0.44	3.44
	40	2.45	0.43	3.44	2.46	0.45	3.44
L.S.D. _{0.05}		0.02	0.05	0.39	0.02	0.05	0.39

CONCLUSION

Spraying plants with methanol solution, especially high concentrations, greatly helps to increase the yield and quality of cauliflower crop, especially when fertilized with vermicompost, which was made from animal manure.

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