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Efficacy of Organic and Inorganic Fertilizers on Growth, Yield and Nutrient Uptake of Cauliflower in Acidic Soil of Bangladesh

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ABSTRACT

Soil acidity is considered as one of the limiting factors in agricultural production because it affects plant growth and development by reducing the availability of essential nutrients. Therefore, a field trial was carried out at the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh from September 2021 to January 2022 to evaluate the effect of various organic and inorganic fertilizers on the growth, yield, and nutritional quality of cauliflower. The experiment was carried out in randomized complete block design with seven treatments viz. Control, Recommended dose of chemical fertilizers (RDF), Poultry Manure (PM) (3 t ha^{-1}) + RDF, Vermicompost (VC) (3 t ha^{-1}) + RDF, Cowdung (CD) (5 t ha^{-1}) + RDF, Rice Husk Biochar (1 t ha^{-1}) + RDF and Household waste compost (3t ha^{-1}) + RDF with three replications. Among different treatments, the highest value for plant height (49.25 cm), number of leaves plant^{-1} (21.50), curd circumference (39.87cm), curd diameter (18.07 cm), marketable curd weight (777.57g plant^{-1}), marketable curd yield (32.41 t ha^{-1}), N, K, S content (1.92%, 1.87% and 0.33 % respectively) and K and S uptake (79.57 kg ha^{-1} and 13.92 kg ha^{-1}) were recorded from the Household waste compost (3t ha^{-1}) + RDF whose effect was statistically similar to the treatment Poultry Manure (PM) (3 t ha^{-1}) + RDF. The maximum value for curd height (11.10 cm), N uptake (81.81 kg ha^{-1}) and P content and uptake (0.32% and 13.97 kg ha^{-1} respectively) were recorded from poultry manure along with RDF. Whereas, the minimum value for all growth parameters, yield attributes, nutrient content and uptake were observed from unfertilized control. Therefore, integrated application of organic manures with synthetic chemical fertilizers can be practiced for attaining higher yield and better-quality curds compare to the sole application of inorganic fertilizers in acid soils of Bangladesh.

Keywords: Cauliflower, Growth, Manures, Nutrient content, Soil acidity.

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I. Introduction

Globally soil acidity has significant influences on crop production because about 50 percent of arable lands are affected by different levels of acidity [1]. Acidic soils have toxic accumulation of A^{13+}, Fe^{3+}, and Mn^{2+} and limiting effects on the primary nutrients (N, P, K) and bases availability that restrict the growth and development of the plant [2]. Consequently, acidic soil reduces crop yield directly or indirectly by encouraging nutrient deficiency due to its profound effects on nutrient availability and microbial activity. Hence, the effective management strategies for amelioration of soil acidification become urgent for better crop production in such degraded soil and ensuring food security.

Sustainable management practices become an effective tool for crop production in acidic soil. Although fertilization plays a major role on crop yield, but farmers of Bangladesh use huge quantity of chemical fertilizers without adequate knowledge on soil reaction, often leads to increase soil acidity [3]. Besides, excessive uses of chemical fertilizers may result in an increased yield in certain crops, however this yield will not endure for a longer period as inappropriate uses of these fertilizers depreciate soil health and create environmental pollution. For optimal plant growth and effective use of chemical fertilizer in acid soils, the addition of organic matter is required to avoid the toxic effects of Mn, H, Al, and Fe. Regular use of highly decomposed organic materials in acid soils is effective in preventing sudden changes in soil pH as

it ameliorates the buffering capacity of soils. Besides, it also increases phosphorus availability and reduces iron and aluminum toxicity in acid soils. Organic amendments are extremely advantageous for enriching soil fertility and productivity as they enhance chemical, physical and biological properties of soil [4]-[8]. On the other hand, organic manure alone doesn't meet the nutrient requirement of crops because of their slow releasing pattern [9] and excessive use of organic matter may lead to toxic effect of reduced metabolic intermediates [10]. Therefore, integrated application of organic and chemical fertilizers is considered a good way for sustainable crop production [11]-[13]. Thus, judicious application of fertilizers from both organic and inorganic sources is mostly recommended to obtain significant yield of crops as well as preserve soil fertility in a sustainable way [14]-[17]. Cauliflower is one of the vital vegetables among the cole crops grown in Bangladesh. It is highly nutritious as it contains significant amount of protein, dietary fiber, riboflavin, potassium, phosphorus, manganese, vitamin B6, vitamin C, vitamin K, folate, and pantothenic acid. Devkota *et al.* [18] reported that integrated application of organic and inorganic fertilizers not only enhanced cauliflower growth, development and yield but also improved soil properties. Considering the above-mentioned facts, present experiment was undertaken to evaluate the response of different types of organic and inorganic fertilizers on growth, yield, nutrient content, and uptake by cauliflower.

II. Materials and Methods

A field experiment was carried out in the experimental field of the Department of Soil Science of BSMRAU, Gazipur during the period of September 2021 to January 2022. Geographically the experimental location was situated at 24º02′16.3″ North Latitude and 90º23′52.6″ East latitude with an elevation of 8.2 m from mean sea level [19]. The soil of the study area is shallow red brown terrace soil (salna series) under the AEZ 28 (Madhupur Tract) which is classified as inceptisols. The pH value of the study site was 5.70. Experimental field soil contained 0.07% total nitrogen (N), 0.212 meq $100g^{-1}$ soil exchangeable potassium (K), 4.57 ppm available phosphorus (P), 0.75% organic carbon (OC) and 1.30% organic matter (OM). The experiment was laid out in a randomized complete block design having seven treatments and each replicated three times. Treatments of the study were Control, Recommended dose of chemical fertilizers (RDF), Poultry Manure (PM) at the rate of 3 t ha^{-1} + RDF, Vermicompost (VC at the rate of 3 t ha^{-1} + RDF, Cowdung (CD) at the rate of 3 t ha^{-1} + RDF, Biochar at the rate of 3 t ha^{-1} + RDF and Household waste compost at the rate of 3 t ha^{-1} + RDF.

TABLE I: Chemical Composition of Cowdung, Poultry Manure, Vermicompost, Rice Husk Biochar and Household Waste Compost

Organic matter	Total N (%)	P (%)	S (%)	K (%)	pH	C (%)
Cowdung	1.02	0.76	0.30	0.96	7.21	21.45
Poultry manure	1.20	0.77	0.47	0.98	6.78	17.62
Vermicompost	1.58	1.22	0.49	1.93	7.10	18.10
Rice husk biochar	0.54	0.15	0.22	0.52	7.60	43.05
Household waste compost	0.76	0.65	0.51	1.01	8.28	22.04

All of the organic fertilizers were analyzed for determining of their chemical properties (Table I) and applied on the top 10 cm soil before planting of cauliflower. Complete dose of phosphorus, potassium, sulphur and fifty percent of nitrogen fertilizer were applied just before planting and the remaining fifty percent of nitrogen fertilizer was applied 30 days after planting. BU Fulkopi 1, a high yielding cauliflower variety was used as test crop. Thirty-five days old seedlings of cauliflower were transplanted into the field at first week of November 2021, with a spacing of 60×40 cm in 4×2.5 m^2 plot size adjusting 42 plants per plot. Distance between replication and plot was 1 m and 50 cm respectively. Growth parameters of cauliflower such as, plant height and number of leaves per plant were recorded at 15, 30, 45 days after transplanting (DAT) and harvesting stage. Major yield attributes such as curd height, curd circumference, curd diameter, curd yield was recorded at harvesting time of the crop (8-9 weeks after transplanting). The representative cauliflower curd samples were collected from each plot at the time harvesting for chemical analysis. Manures and plant samples were prepared by drying in an oven at 80 ºC for 48 hours and then grinding was done by a grinder machine. After that, the samples were sieved and kept in poly bags and finally preserved in a desiccator before analysis of nutrient elements, like N, K, P and S. Total N was determined by Kjeldahl method [20] and P in digested samples was estimated following vanadium molybdenum phosphate yellow color method [21] using a spectrophotometer at a wavelength of 440 nm. Potassium in aliquot was determined using a flame photometer after appropriate dilution [20]. The sulfur content in the digest was estimated by addition of an acid solution and subsequent precipitation with $BaCl_2$, and the turbidity was measured calorimetrically at a wavelength of 420 nm [22].

The nutrient uptake by marketable cauliflower curd was measured by using the following formula:

$$Nutrient\ Uptake\ \left(kg\ ha^{-1}\right) = \frac{\%\ Nutrient\ in\ sample \times Y\ \left(kg\ ha^{-1}\right)}{100}$$

where
Y (kg ha^{-1}) = Total dry matter production by cauliflower curd.
Recorded data were subjected to an analysis of variance (ANOVA) using Statistics Version 10.0 software to observe the significant difference among treatments. Means and standard errors were calculated, and mean separation was done by using Least Significant Difference (LSD) test [23].

III. Results and Discussion

A. Plant Height

Integrated application of organic and inorganic fertilizers had significant effects on plant height of cauliflower (Table II). Among the treatments, highest plant height (16.91, 31.66, 37.33 and 49.25 cm at 15, 30, 45 and 60 DAT, respectively) was observed in household waste compost at 3 t ha^{-1} along with recommended dose of chemical fertilizer which was statistically identical with poultry manure at 3 t ha^{-1} along with recommended dose of chemical fertilizer.

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TABLE II: PLANT HEIGHT AND NUMBER OF LEAVES PER PLANT AT DIFFERENT GROWTH STAGES OF CAULIFLOWER AS INFLUENCED BY ORGANIC AND INORGANIC FERTILIZERS

Treatments	Plant height (cm)				No. of leaves plant^{-1}			
	15 DAT	30 DAT	45 DAT	At harvest	15 DAT	30 DAT	45 DAT	At harvest
Control	13.23 d	19.33d	24.67 c	35.71 e	7.80	10.44 c	12.65 c	15.53 e
RDF	13.72 cd	27.11c	33.50 b	41.06 d	7.93	12.55b	15.77 b	17.80 d
PM+RDF	16.25 a	30.21ab	36.33 ab	48.11 a	8.13	15.77 a	17.17 ab	21.10 ab
VC+RDF	15.07 b	28.55bc	34.00 b	46.15 b	7.93	14.66 a	16.83 ab	20.46 abc
CD+RDF	13.94 bcd	29.81b	34.50 ab	45.83 b	7.80	14.44a	17.00ab	20.06 bc
RHB+RDF	14.43 bc	29.44b	35.50 ab	44.48 c	7.67	14.99a	16.00 b	19.76 c
HW+RDF	16.91 a	31.66a	37.33 a	49.25 a	8.0	15.77a	17.67 a	21.50 a
CV (%)	4.46	3.70	5.49	1.52	4.14	6.16	5.57	3.54
SE	0.54	0.85	1.51	0.55	0.27	0.70	0.80	0.56
LSD	1.17	1.85	3.29	1.2	0.58	1.53	1.75	1.23

In each column, different letters indicate significant difference among the treatments whereas similar letters indicate a non- significant difference; RDF= Recommended dose of chemical fertilizers, PM= Poultry Manure at 3 t ha^{-1}, VC= Vermicompost at 3 t ha^{-1}, CD = Cowdung at 5 t ha^{-1}, RHB = Rice Husk Biochar at 1 t ha^{-1}, HW= Household waste compost at 3 t ha^{-1}; CV = Coefficient of variation; SE =Standard error; LSD= Least significant difference.

Among the different days after transplanting, the harvesting stage gave the topmost plant height which was 37.91% higher than the control treatment. The shortest plant height (13.23, 19.33, 24.67 and 35.71 cm at 15, 30, 45 and 60 DAT, respectively) was obtained from absolute control. Integrated use of fertilizers from both organic and inorganic sources caused an increased in plant height with the increasing number of days after transplanting. This might be due to the availability and steadily supply of nutrients to the plant from organic and inorganic sources together which increase the foliage of plants and thereby increase photosynthesis. Ali *et al*. [24] reported that integrated application of inorganic fertilizer and vermicompost significantly increased plant height of cauliflower at different growth stages.

B. Number of Leaves Plant^{-1}

Number of leaves plant^{-1} was markedly influenced from 30 DAT due to combined use of organic and inorganic fertilizers (Table II). At 30 DAT, both HW+RDF and PM+RDF produced highest number of leaves plant^{-1} (15.77). At 45 DAT and harvesting time, the maximum number of leaves plant^{-1} 17.67 and 21.50 were observed in HW at 3 t ha^{-1} with RDF which was statistically alike with PM at 3 t ha^{-1} along with RDF and VC at 3 tha^{-1} with RDF. On the contrary, the lowest number of leaves plant^{-1} (12.65 and 15.53 at 45 and 60 DAT, respectively) was obtained from unfertilized control. Ali *et al.* [24] stated that combined application of inorganic and organic fertilizer significantly increased number of leaves plant^{-1} at different growth stages of cauliflower. Similar result was also found in cabbage by Hasan and Solaiman [25].

C. Curd Height (cm)

The data relating to curd height are presented in Table III revealed that application of organic materials and chemical fertilizers had remarkable positive effect on curd height of cauliflower. The highest curd height (11.10 cm) was obtained from RDF along with poultry manure at 3 t ha^{-1} which was statistically similar with RDF with household waste compost at 3 t ha^{-1}. The lowest value for curd height of cauliflower (8.70 cm) was obtained from untreated control. Reza *et al*. [26] reported that combined application of organic and inorganic fertilizers increased the head height of cabbage.

D. Curd Circumference(cm)

Result presented in Table III showed that highest curd circumference (39.87 cm) was obtained from household waste compost at 3 t ha^{-1} with RDF-which was statistically similar with poultry manure at 3 t ha^{-1} + RDF and cowdung at 5 t ha^{-1} with RDF. The lowest value for curd circumference of cauliflower (25.93 cm) was obtained from unfertilized control. Due to the incorporation of organic and chemical fertilizers, the building up of reserved materials in leaves increased which advanced curd size. Reza *et al*. [26] also stated that integrated use of organic and inorganic fertilizers improved the head circumference of cabbage.

E. Curd Diameter(cm)

Data presented in the Table III revealed that curd diameter was notably varied among the treatments. It is evident that the highest curd diameter (18.07) was attained from HW at 3 t ha^{-1} with RDF which was statistically alike with all the treatments except RDF and control treatments. The lowest value for curd diameter of cauliflower (10.33 cm) was obtained from untreated control. Integrated application of organic manures and inorganic fertilizers might produce higher curd of cauliflower due to synthesis of higher amount of photosynthate and their translocation from source (leaves) to sink (curd). Islam *et al*. [27] showed that there was a significant positive increased in curd diameter of cauliflower owing to the integrated application of organic and inorganic fertilizers. Mohanta *et al*. [28] observed similar result in broccoli.

F. Marketable Curd Weight (g plant-^{1})

A statistically significant difference was observed in marketable curd weight of cauliflower with the combined supply of different organic and inorganic fertilizers (Table III). The curd weight ranged from 771.57 g to 196.47 g. Among the treatments, the height marketable curd weight (771.57 g) was recorded in HW at the rate of 3t ha^{-1} with RDF which was 300.59 % higher than the untreated control treatment. The lowest curd weight (196.47 g) obtained from the control treatment. These findings are in harmony with the findings of Islam *et al*. [27] who stated that integrated application of organic and inorganic fertilizers showed a positive increased in curd weight of cauliflower. Adequate and satisfactory supply of nutrient from both organic and inorganic fertilizers stimulated vegetative and reproductive characters of the cauliflower which might enhanced improved curd weight and curd diameter.

TABLE III: CURD CIRCUMFERENCE, CURD DIAMETER, MARKETABLE CURD WEIGHT AND MARKETABLE CURD YIELD AT HARVESTING STAGE OF CAULIFLOWER AS INFLUENCED BY ORGANIC AND INORGANIC FERTILIZERS

Treatments	Curd Height (cm)	Curd Circumference (cm)	Curd Diameter (cm)	Marketable Curd Weight (g plant^{-1})	Marketable Curd Yield (ton/ha)
Control	8.07 e	25.93 d	10.33 c	196.47 f	8.25 f
RDF	9.43 d	36.10 c	15.66 b	597 .53 e	25.09 e
PM+RDF	11.10 a	38.90 ab	17.83 a	755.77 ab	31.74 ab
VC+RDF	10.17 c	36.63 bc	16.67 ab	745.43 b	31.31 b
CD+RDF	10.33 bc	38.40abc	17.17 ab	688.47 c	28.91 c
RHB+RDF	10.00 c	36.40 c	17.57 a	623.87 d	26.20 d
HW+RDF	10.60 b	39.87 a	18.07 a	771.57 a	32.41 a
CV (%)	2.02	3.72	6.43	1.73	1.73
SE	0.16	1.09	0.85	8.83	0.37
LSD	0.36	2	1.85	19.24	0.81

In each column, different letters indicate significant difference among the treatments whereas similar letters indicate a non- significant difference; RDF= Recommended dose of chemical fertilizers, PM= Poultry Manure at 3 t ha^{-1}, VC= Vermicompost at 3 t ha^{-1}, CD = Cowdung at 5 t ha^{-1}, RHB = Rice Husk Biochar at 1 t ha^{-1}, HW= Household waste compost at 3 t ha^{-1}, CV = Coefficient of variation; SE =Standard error; LSD= Least significant difference

G. Marketable Curd Yield (t ha^{-1})

Results of the present study reveal that combined use of organic materials with chemical fertilizers had significant positive effect on marketable curd yield of cauliflower (Table III). Marketable curd yield varied from 8.25 t ha^{-1} to 32.41 t ha^{-1}. The highest marketable curd yield (32.41 t ha^{-1}) was observed in HW at 3 t ha^{-1} with RDF. In the present study, no statistical difference was found between the effect of HW at 3 t ha^{-1} with RDF and PM at the rate of 3 t ha^{-1} with RDF. Minimum curd weight (8.25 t ha^{-1}) was recorded in absolute control treatment. The significant increase of cauliflower yield might be achieved due to increased growth and development of curd resulted from better uptake of nutrient from suitable combination of organic and inorganic fertilizers. Our finding is at par with the results of Islam *et al*. [27].

H. Nutrient Content in Cauliflower Curd

Findings represented in the Table IV reveal that major nutrients content in cauliflower curd was significantly varied with integrated use of inorganic and organic fertilizers. Maximum nitrogen (N), potassium (K) and Sulphur (S) content (1.92%, 1.87% and 0.33 %) in cauliflower curd were obtained from treatment containing HW at 3 t ha^{-1} with RDF. In case of N and S content, the effect of the treatment HW at 3 t ha^{-1} with RDF was statistically comparable to the treatment PM at 3 t ha^{-1} with RDF. On the other hand, maximum phosphorus (P) content (0.32%) in cauliflower curd was obtained from treatment comprising of PM at 3 t ha^{-1} with RDF followed by HW at 3 t ha^{-1} with RDF.

Whereas. Minimum N, P, K, and S content (0.98%, 0.16%, 1.49% and 0.17% for N, P, K, and S respectively) was obtained from untreated control. When plants got nutrients from a combination of chemical and organic fertilizers under acid soil conditions, the highest percentages of N, P, K, and S were found in cauliflower curds. Organic manure can ameliorate soil acidity and increase the availability of major nutrient which might increase the nutrient content in cauliflower curd. Abdul Razak *et al*. [29] and Jahan *et al*. [30] demonstrated that the application of organic and inorganic fertilizers had pronounced influence on nutrient content in cauliflower.

TABLE IV: NITROGEN, PHOSPHORUS, POTASSIUM AND SULPHUR CONTENT IN CAULIFLOWER CURD AS INFLUENCED BY ORGANIC AND INORGANIC FERTILIZERS

Treatments	N (%)	P (%)	K (%)	S (%)
Control	0.98 d	0.16 e	1.49 e	0.17 e
RDF	1.78 c	0.22 d	1.64 d	0.23 d
PM+RDF	1.89 a	0.32 a	1.83 b	0.32 a
VC+RDF	1.81 b	0.26 c	1.73 c	0.27 bc
CD+RDF	1.84 b	0.25 c	1.76 c	0.26 c
RHB+RDF	1.81 bc	0.25 c	1.76 c	0.28 b
HW+RDF	1.92 a	0.29 b	1.87 a	0.33 a
CV (%)	1.01	5.00	0.99	2.98
SE	0.01	0.01	0.01	0.01
LSD	0.03	0.02	0.03	0.01

In each column, different letters indicate significant difference among the treatments whereas similar letters indicate a non- significant difference; RDF= Recommended dose of chemical fertilizers, PM= Poultry Manure at 3 t ha^{-1}, VC= Vermicompost at 3 t ha^{-1}, CD = Cowdung at 5 t ha^{-1}, RHB = Rice Husk Biochar at 1 t ha^{-1}, HW= Household waste compost at 3 t ha^{-1}, CV = Coefficient of variation; SE =Standard error; LSD= Least significant difference.

I. Nutrient Uptake

Application of different organic materials and inorganic fertilizers showed significant variations in nutrient uptake by cauliflower curd (Fig. 1). Highest nitrogen uptake (81.81 kg ha^{-1}) was obtained from the treatment receiving PM at 3 t ha-1 with RDF which was statistically similar with the treatment HW at 3 t ha^{-1} with RDF. Maximum phosphorus uptake (13.97 kg ha-1) by cauliflower curd was found from the treatment PM at 3 t ha^{-1} with RDF. The second maximum phosphorus uptake was (12.37 kg ha^{-1}) noted in the treatment comprising of HW at the rate of 3 t ha^{-1} with RDF. Both, highest potassium (79.57 kg/ha) and sulphur uptake (13.92 kg ha^{-1}) by marketable cauliflower curds were recorded in treatment consisting of HW at 3t ha^{-1} with RDF whose effect was statistically identical with the treatment PM at 3 t ha^{-1} with RDF. Whereas the lowest nitrogen, phosphorus, potassium, and sulphur uptake (9.89 kg ha^{-1}, 1.61 kg ha^{-1}, 14.99 kg ha^{-1}and 1.68 kg ha^{-1} respectively) were obtained from the untreated control. Integrated supply of nutrients from organic and inorganic sources enhances nutrient uptake by cauliflower curd compared to the sole application of chemical fertilizer or control due to adequate and continuous supply of nutrients. Combination of organic and inorganic fertilizers provides favorable conditions for microbial as well as chemical activities that improve the mineralization of nutrients and increase the availability of nutrient in the soil pool for plant uptake. Similar to this finding, Islam *et al*. [27] and Jahan *et al*. [30] also reported higher uptake of nutrient in cauliflower curds from combined supply of chemical

fertilizers and organic fertilizers. Results of the study are at par with findings of Choudary *et al*. [31]; and Wani *et al*. [32]. Therefore, the integrated nutrient management practice using organic and inorganic fertilizers will be helpful to improve the quality of cauliflower curd.

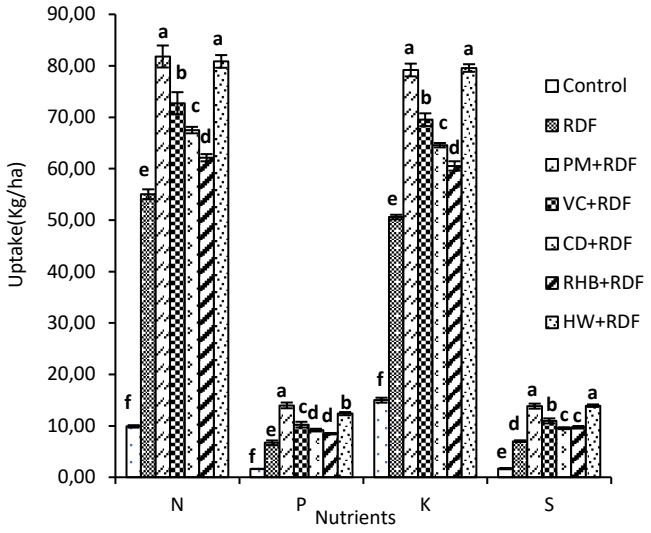

Fig. 1. Nitrogen, phosphorus, potassium and sulphur uptake by marketable cauliflower curd as influenced by organic and inorganic fertilizers (The mean values are shown in vertical bar along with standard error of mean; SE (n=3) and different letters above the bars indicate significant differences among the treatments at P<0.05).

IV. Conclusion

Growth parameter as well as yield of cauliflower in acidic soils can be enhanced by proper supply of plant nutrients from both organic and inorganic sources. From the findings of the present experiment, it can be concluded that the application of organic fertilizers in combination with recommended dose of inorganic fertilizers had significant positive effects on the growth parameters, yield attributes and yield of cauliflower, as well as on the content and uptake of major nutrients (N, P, K and S) in curds. Household waste compost produced higher yield of cauliflower when combined with RDF than RDF alone which might be attributed due to the higher availability of major nutrients in decomposed household waste. In most cases, effect of poultry manure in combination with synthetic chemical fertilizers are comparable with that of household waste compost + RDF. Overall, the integrated use of household waste compost at the rate of 3 t ha^{-1} with recommended dose of chemical fertilizers evidenced to be a good choice for enhancing cauliflower growth, yield and nutrition in acidic soils. The current results are based on a one-year research trial, so further research is needed to elucidate the effects of organic and chemical fertilizers on other vegetables in different acid prone areas of the country.

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Conflict of Interest

Authors declare there is no conflict of interest regarding this study.

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