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RESPONSE OF APPLICATION OF DIFFERENT SOURCES OF NUTRIENTS AS FERTILIZER ON GROWTH AND YIELD OF CAULIFLOWER (*Brassica oleracea* L. var. *botrytis)* AND ITS RESIDUAL EFFECT ON SOIL

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Abstract

An experiment was conducted at Horticulture Farm of Institute of Agriculture and Animal Science, Paklihawa campus, Nepal during the period from September 24, 2015 to January 19, 2016 to study the effect of different sources of nutrients on the growth and yield of cauliflower. The experiment was conducted in the Randomized Complete Block Design (RCBD) with five replications of different nutrient sources as four treatments(Biofertilizers T1, Vermicompost T2, Farm Yard Manure T3 and mixture of three T4). Variety Pusa Kartiki was used in the experiment. The treatment response varied significantly for Plant height (PH), Biomass (BM) and leaf length. The plot treated with T1 and T3 yielded maximum i.e., 25.22 ton/ha and 25.14 ton/ha respectively. The treatment also had significant residual effect on soil Phosphorus and Potassium. Pearson's correlation analysis exhibited highly significant positive correlation of yield with biomass, curd weight, curd depth, curd diameter and the leaf length. Principal component analysis revealed plant height, plant spread, biomass, curd weight, leaf number, leaf breadth, leaf length and yield contributing in the first component. Cluster analysis revealed three distinct clusters of the treatments in which T3 and T4 were placed in the same group. Among the four treatments used T1 is considered to be the best in regards of response on plant as well as on its residual effect on soil.

Key words: Cauliflower, Biofertilizer, Vermicompost, FYM, PusaKartiki.

Introduction

Cauliflower (*Brassica oleracea*L. var. *botrytis* sub var. *caulifloracv*. 'PusaKartiki') is a cole crop and belong to the family Cruciferae. They are commonly grown in the vegetables producing countries like Nepal, USA, UK, New Zealand, Italy, China, India, Egypt, Israel, Thailand and Bangladesh etc. Cauliflower is thought to be originated from Mediterranean region or

Southern Europe and possibly was developed from Broccoli (Pepper, 1949).

Cauliflower is one of the major vegetable crops of Nepal. It is cultivated in an area of 34065 hectare (ha)The crop has the production of 54205 metric tons (mt) with the productivity of 15.4mt/ha. (MoAD, 2013). It is cultivated both on season and off season. The demand as well as the price of cauliflower is also high; both in the national and international market.

Cauliflower cultivation requires proper supply of plant nutrients. The requirement of these plants nutrients can be provided by applying inorganic fertilizer or organic manure or both. However, farmers are now expressing interest in organic farming because of, they are more aware about the residual effect of chemical substances used in the crops field (Rashid, 1999). The statistics of annual sales of chemical fertilizers in Nepal shows the sales of 108553 mt of Urea, 65722mt of DAP and 2688 mt of Potash; in an increasing trend as compared to the previous years (MoAD, 2013); which is turning out to be a serious threat. The use of chemical fertilizer in haphazard manner causes serious environmental degradation and the increasing cost of the fertilizer is also a constraint for the farmers. The excess application of inorganic fertilizer causes hazard to public health and to the environment. But the application of combination of both organic and inorganic fertilizers, can improve the yield as well as keep the environment sound (Hsieh *et al.*, 1996). Considering the above points, the present experiment was undertaken with the objective to assess the effect of different sources of nutrients on the yield of cauliflower and to determine the residual effect of those nutrients on soil health with the aim to select the best treatment or combination of treatments which could be both environmentally friendly as well as cost economic.

Materials and Methods

The field experiment was conducted at the Horticulture farm of Institute of Agriculture and Animal Science, Pakhlihawa Campus, Pakhlihawa, Nepal from September 24, 2015 to January 19, 2016. An early season variety of cauliflower Pusa Kartiki was used in the experiment. Three sources of nutrients were used as fertilizers as treatment. The sources of fertilizer used were FYM, Bio-organic fertilizer and vermicompost which were locally available.The treatments used in the research are presented in Table 1. The field was laid out in randomized block design with five replications. 20 plots of 5 x 5 m^2 were allotted. Each plot was separated from others by 50 cm bunds. Cauliflower was cultivated in 10 rows with the spacing of 50cm *50 cm. The seedling of Pusa Kartiki variety (20 days old), were uprooted and transplanted nearly 10 cm height and 4-5 leaf stage. Earthing up and hoeing was carried out after 30 days of transplanting. Weeding was carried out at 30 and 60 days after transplanting. Harvesting of cauliflower was done when the curd attained a proper size and compactness. Harvesting was done periodically.

Data were collected for different quantitative agronomic characters of plants and from the soil sample collected after the harvest for assessing the residual effect of the treatments in the soil.

Observed traits of plant

Plant height, plant spread, biomass, curd weight, curd weight biomass ratio, curd depth, curd diameter, total leaf numbers, leaf length,

leaf breadth and yield were recorded for each plots.

Observed soil characteristics

Soil sample of each plot were taken for analysis of the soil for different characters and nutrients to determine the residual effect of the treatments in the soil of the plots. Soil samples were analyzed to determine Soil pH, Organic matter %, total Nitrogen %, available Phosphorus (ppm) and available Potassium (ppm) for any residual effect of treatments on soil of the treated plots.

On the basis of individual plant observations, the population mean for each character was computed. The analysis of variance for different characters was carried out by using the mean data. The data entry was done through MS Excel 2016. The analysis was further conducted with the help of R-Studio 3.1.1. The cluster analysis and principal component analysis was done using Minitab 15 and Pearson's correlation coefficient was obtained with the help of IBM SPSS 21.

Results and Discussion

Mean performance

Significant variation was found among the plant height, biomass, weight biomass ratio and total leaf length. The mean value of all the studied traits are presented in Table 2. The significant effect of treatments on plant growth can be observed through the graphs (Fig 1) which presents the response of plant height, biomass, weight biomass ratio and leaf length against the treatments.

Correlation Coefficient Analysis

Pearson's correlation coefficient between the analyzed traits are presented in Table 3. Yield of the crop was found to be positively and significantly correlated with Biomass, Weight, Curd depth, Curd diameter and leaf length.

Cluster Analysis

The clustering of all the treatments based on the effect on different variables noted in the research are presented in Fig 2. Based on similarity percentage and related characters, three clusters were constructed. Most similarly related treatments were T3 and T4, whereas T2 and T1 were the most distant treatments with least similarity. T1 belonged to the cluster I. it was observed with high value of traits like plant height, plant spreading, biomass, total number of leaves, leaf length and yield. Cluster II comprised T3 and T4, which was characterized by high value of curd weight biomass ratio, curd depth and curd diameter. In cluster III, T2 was grouped characterized by high value of plant height, plant spreading, leaf length and leaf breadth.

Principal Component Analysis

The PCA in general confirmed the grouping obtained through cluster analysis. Results of PCA are given in Table 4. The first two components with ≥1 Eigen value accounted for 88.4% of total variance. Individually, PC1, PC2 and PC3 contributed 68.8%, 19.5% and 11.6% of total variation respectively.

Residual effect on soil characteristics and soil nutrients:

The treatments showed significant effect in soil Phosphorus and Potassium as their residual effects in the soil samples collected and analyzed after the harvest of the crop. The mean value of all the traits are shown in Table no 5.

Crop wastes are produced in a huge amount through different agricultural activities. These organic wastes can be used as a rich source of nutrients for the plants as organic manure.

Table 1. List of Treatments used in the experiment.

Indication	Treatment	Recommended Dose
T1	NPK + Bio fertilizer	200:120:80 Kg NPK/ha + 15 ton/ha
T2	NPK + Vermicompost	190:110:70 Kg NPK/ha + 4 ton/ha
T3	FYM + NPK	180:100:60 Kg NPK/ha + 15 ton/ha
T4	FYM + Vermicompost + Biofertilizer + NPK	170:90:50 Kg NPK/ha + 5 ton/ha + 1.3ton/ha + 5ton/ha

Table 2 (a & b). Mean of all traits of cauliflower plant as response of the treatments under study.

(a) Treatment	Plant Height (cm)		Plant Spread (cm)	Biomass (kg)		Curd Weight (kg)	Weight Biomass Ratio	
T1 (NPK + Biofertilizer)	72.84	a	88.84	2.04	a	0.63	31.01	b
T2 (NPK + Vermicompost)	66.34	b	74.21	1.46	c	0.58	40.24	a
T3 (FYM + NPK)	70.23	ab	85.22	1.71	bc	0.57	33.43	b
T4 (FYM + Vermicompost + Biofertilizer + NPK)	70.30	ab	84.88	1.92	ab	0.63	33.14	b
Grand mean	69.928		83.288	1.783		0.603	34.456	
CV	4.398		10.51	12.341		10.294	10.464	
F-value	*		ns	**		ns	**	
LSD	4.2379			0.0484			4.968	

(b) Treatment	Curd depth (cm)	Curd diameter (cm)	Total leaf number	Leaf length (cm)		Leaf breadth (cm)	Yield (ton/ha)
T1 (NPK + Biofertilizer)	11.82	14.08	17.42	52.64	a	16.96	25.22
T2 (NPK + Vermicompost)	11.71	14.25	13.76	46.75	b	15.76	23.40
T3 (FYM + NPK)	11.43	14.00	14.76	50.47	ab	16.80	22.80
T4 (FYM + Vermicompost + Biofertilizer + NPK)	11.43	13.55	14.33	52.51	a	17.01	25.14
Grand mean	11.597	13.969	15.066	50.593		16.632	24.14
CV	5.04	6.48	14.457	5.544		6.828	10.29
F-value	ns	ns	ns	*		ns	ns
LSD				3.865			

Table 3. Pearson' s Correlation coefficient among different traits of cauliflower plant under study.

Subjects	Plant height	Plant Spread	Biomass	Weight	Weight Biomass Ratio	Curd depth	Curd diameter	Total leaf number	Leaf length	Leaf breadth	Yield (ton/ha)
Plant height	1										
Plant Spread	0.633**	1									
Biomass	0.631**	0.617**	1								
Weight	0.432	0.239	0.649**	1							
Weight Biomass Ratio	-0.516*	-0.643**	-0.822**	-.125	1						
Curd depth	0.403	0.092	0.264	0.486*	0.000	1					
Curd diameter	0.504*	0.073	0.195	0.536*	0.113	0.762**	1				
Total leaf number	0.272	0.323	0.684**	0.233	-0.742**	0.088	-0.035	1			
Leaf length	0.836**	0.624**	0.736**	0.530*	-0.598**	0.309	0.390	0.231	1		
Leaf breadth	0.314	0.562**	0.564**	-0.047	-0.783**	0.012	-0.053	0.436	0.483*	1	
Yield (ton/ha)	0.432	0.239	0.649**	1.000**	-0.125	0.486*	0.536*	0.233	0.530*	-0.047	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4 (a & b). Statistics of Multivariate analysis of different response of plant to the treatments under study.

(a) Eigen analysis of the Correlation Matrix				
Eigenvalue	7.5722	2.1489	1.2789	0
Proportion	0.688	0.195	0.116	0
Cumulative	0.688	0.884	1	1
Variable	PC1	PC2	PC3	
PH	0.347	-0.081	0.243	
PS	0.343	0.041	0.286	
BM	0.362	-0.049	-0.056	
Wt	0.275	-0.164	-0.536	
Wt/BM	-0.348	-0.055	-0.243	
Cdep	-0.004	-0.678	-0.095	
Cdiam	-0.204	-0.494	0.354	
Totleaf	0.269	-0.416	0.254	
Leaflen	0.359	0.11	0.004	
Leafbre	0.34	0.21	0.149	
Yld	0.275	-0.164	-0.536	

(b) Cluster Centroids				
Variable	**Cluster1**	**Cluster2**	**Cluster3**	**Grand Centroid**
PH	72.840	66.340	70.266	69.928
PS	88.840	74.208	85.052	83.288
BM	2.039	1.465	1.815	1.783
Wt	0.631	0.585	0.599	0.604
Wt/BM	31.012	40.241	33.286	34.456
Cdep	11.816	11.710	11.432	11.597
Cdiam	14.082	14.246	13.775	13.970
Totleaf	17.420	13.760	14.543	15.066
Leaflen	52.642	46.750	51.491	50.594
Leafbre	16.960	15.764	16.904	16.633
Yld	25.219	23.399	23.973	24.141

Table 5. Effect on soil characteristics and soil nutrients as residual effect of different treatments under study.

Treatment	Soil pH	Organic Matter (%)	Total Nitrogen (%)	Available Phosphorus (ppm)		Available Potassium (ppm)	
T1 (NPK + Biofertilizer)	8.18	1.19	0.06	355.92	a	90.24	a
T2 (NPK + Vermicompost)	8.20	0.96	0.05	273.93	b	50.64	b
T3 (FYM + NPK)	8.24	1.56	0.08	268.26	b	57.88	b
T4 (FYM + Vermicompost + Biofertilizer + NPK)	8.22	1.30	0.06	263.75	b	58.92	b
Grand mean	8.21	1.25	0.0636	290.46		64.42	
CV	1.63	41.3	41.291	16.75		26.889	
F-value	ns	ns	ns	*		*	
LSD				67.073		23.87	

Different experiments had been conducted to test the efficacy of such organic manures like vegetable waste, vermi compost and bio fertilizers. Thakur and Singh (2001) conducted a field experiment on Cauliflower. Pusa snow ball K-1 plants were tested with 0 (to), 600 (t1), 800 (T2) and (1000) (T3) Kg recycle commercial organic manure (ORGO)/ha to see the effect of ORGO on the seed yield of Cauliflower and reported that plant death was highest with T2 (11%) and lowest with T3 application (6%). Seed yield per plot and total yield were highest in plants supplied with T3 application (6%). seed yield per plot and total yield were highest in plants supplied with T2 (839.90 g / plot and 8.20 g/ha, respectively) and lowest in those supplied with T3. Rodrigues and Casali (1999) exhibited that the maximum estimated yields of 119.5,

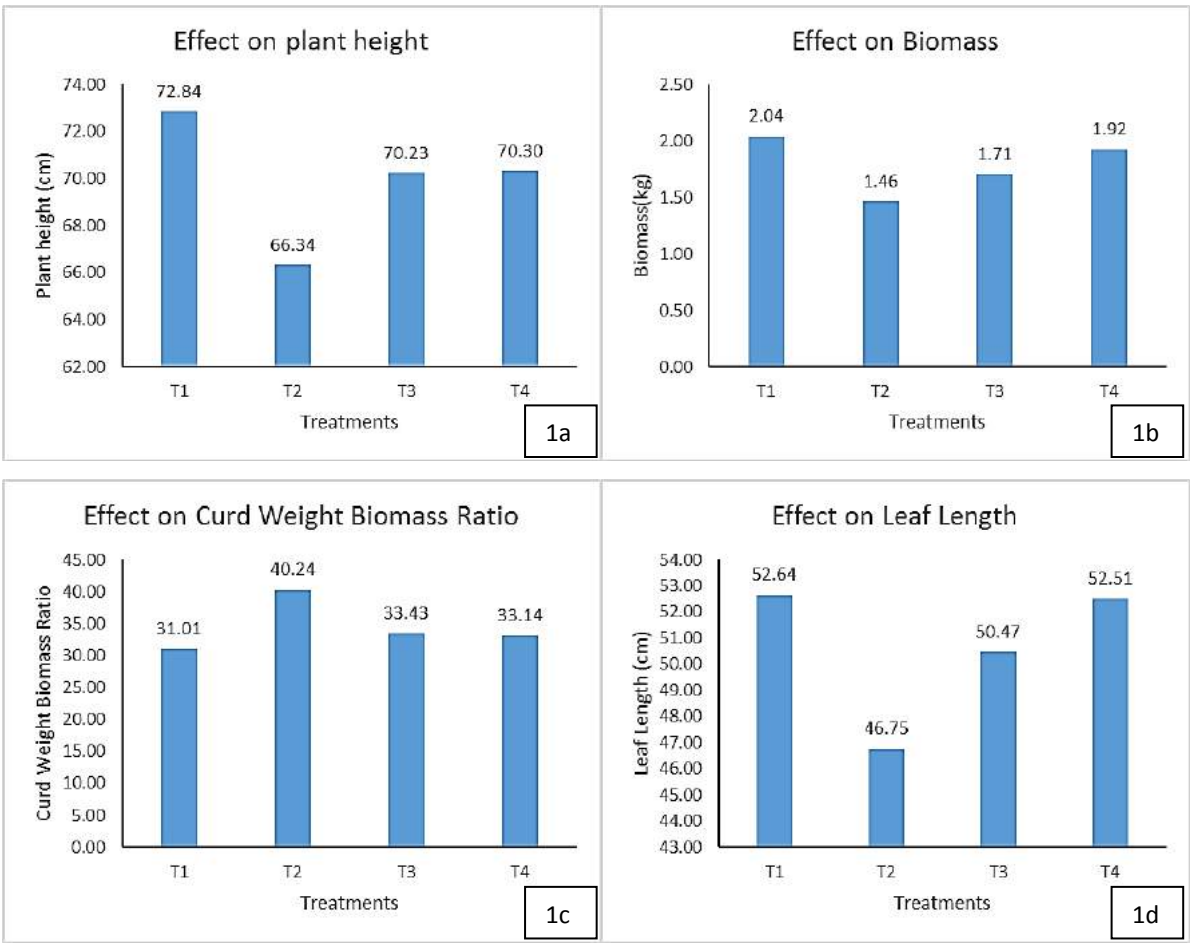

Figure 1 (a, b, c & d). Effect of Treatments on Plant height, Biomass, Curd Weight Biomass ratio and Leaf length of cauliflower under study.

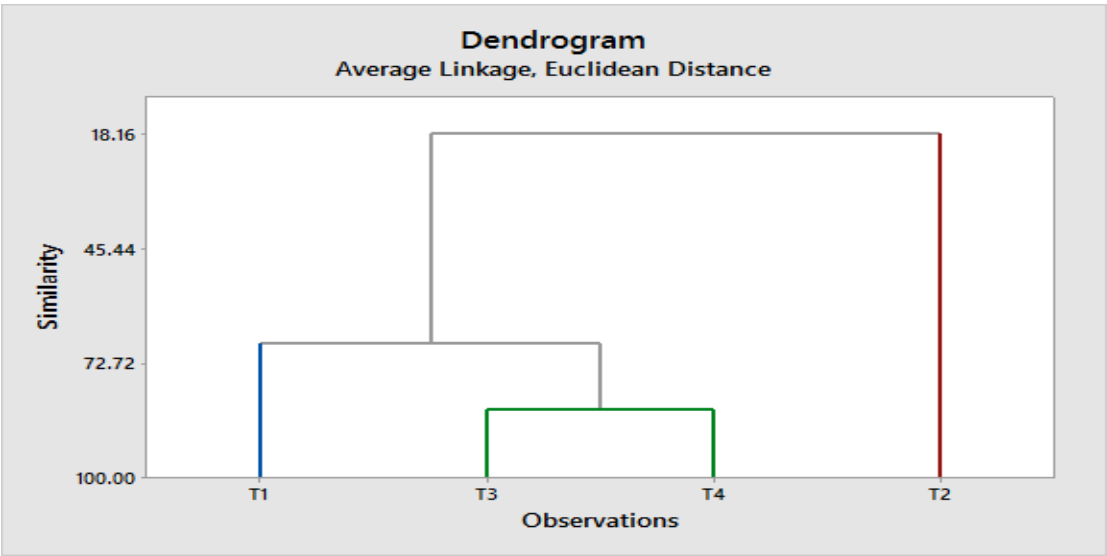

Figure 2: UPGMA clustering of 4 treatments of nutrient sources of fertilizers used under study.

119.4 and 153.9 g/plant were obtained with 37.7 t/ha organic compost/ha with no mineral fertilizer application, 18.9 t organic compost/ha with half the recommended mineral fertilizer rate and 13 t organic compost/ha with the recommended mineral fertilizer rate. Organic compost application resulted in lower foliar N and Ca concentrations and higher foliar P, K and Na concentrations compared with mineral fertilizer application.

In this experiment, the plant showed better response to treatment T1. The plots having T1 had greatest plant height, leaf length, biomass and curd weight biomass ratio. According to Table 3, yield had positive and significant correlation with biomass, curd weight and leaf length, which signifies that T1 promotes those responses in plant which ultimately plays a positive role to increase the yield. Similarly, T1 has also shown positive residual effects in soil (Table 5). The plots treated with T1 had soil samples higher in P and K significantly as compared to other treatments.

The data and research of one season and one year is not enough to provide any strong conclusion. But from this study we can conclude that the application of Bio fertilizers as a source of nutrient to plant, cauliflower in this case, results to better plant growth in terms of plant height, leaf length and biomass. It also provides fair improvement in yield of the crop as well. Not only it promotes plant growth, but also it leaves positive residual effects in the soil leaving higher amount of Phosphorus and Potassium which are major nutrients for plant growth. This residual effect enhances the growth and productivity of subsequently grown crop.

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