International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(2): 754-757

Received: 26-01-2019
Accepted: 27-02-2019

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Effect of bio-enhancers on growth and yield of cabbage (*Brassica oleracea* L. var. capitata)

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Abstract
The investigation was carried out during winter season of 2016-17 at Agricultural farm, School of Agricultural Sciences & Engineering, IFTM University, Moradabad (U.P.). The experiment was laid out in Randomized Block Design (RBD) with 7 treatments and was replicated thrice. Different combinations of *Panchgavya* (4%) *Jivamrita* (20%) and vermiwash (1:5 times dilution), RDF (N:P:K @ 120:30:30 Kg/ha) and control were used as treatments. On the basis of above study, it was found that RDF (N:P:K @ 120:30:30 kg/ha) was proved to be a superior treatment in terms of yield of cabbage (42.79 t/ha), but is was found to be significantly similar with T_4 (*Panchagavya* 4% + *Jivamrita* 20%) and T_5 (*Panchagavya* 4% + Vermiwash 1:5 times dilution). The yield levels recorded in T_4 and T_5 were 38.55 and 41.74 t/ha, respectively. These results show the importance of bio enhancers in increasing the yield of cabbage. Bio enhancers being completely organic in nature were capable of producing yield levels significantly comparable to that of RDF supplied through chemical fertilizers. Apart from yield they also have positive and significant effect on various physical, chemical and microbial properties of soil and environment.

Keywords: Bio-enhancers, *Panchagavya*, *Jivamrita*, vermivash, cabbage, growth, yield

Introduction
Vegetables are considered as protective food. They supply essential growth elements like vitamins and minerals, which are required by humans for their normal growth and development. Apart from health benefits, the production of vegetables improves the economy of a country as these are very good source of income and employment. Though, India is the second largest producer of vegetables in the world, but the calorie intake due to vegetables and fruits is only 10 % in urban population and only 1.89 % in rural population (Anonymous, 2017) [1]. Therefore, a great future exists in development of cost effective, safe and environmental friendly techniques of vegetable growing, so that it can fit into the pockets of poor rural household of our country.

Cabbage is one of the popular vegetable grown in the world with respect to area, production and consumption. India is the second largest producer of cabbage after China with a production of 8971 Thousand MT and it is grown on an area of 407 Thousand ha (Anonymous, 2017) [1]. Cabbage (*Brassica oleracea* L. var. capitata) is a herbaceous annual or biennial vegetable that belongs to family crucifereae and it is mainly grown for edible head. Cabbage is a potent medicinal food that has anti cancerous properties mainly due to high concentrations of antioxidants, anti inflammatory compounds and glucosinolates. It is also a rich source of vitamin K1 and B vitamins and it is known to heal stomach ulcers (Mercola, 2013) [13].

Indiscriminate use of agrochemicals has adversely affected the soil fertility, crop productivity, product quality and environment and the vegetables are no exception to that. Excessive use of chemicals in the agriculture is posing a serious hazard to the nature. A number of agricultural products grown in India are rejected and banned in markets such as US, Vietnam, EU, Saudi Arabia, Japan etc. due to presence of higher levels of chemical residues and pests, than the approved levels. The export of food materials from India is facing rejections on grounds of lack of compliance with food safety and health standards (Source: The Hindu, dated-08.01.2018) [14]. Organic farming which is a holistic production management system for promoting and enhancing the health of agro ecosystem, has gained wide recognition as a valid alternative to harmful chemicals as it is capable of ensuring the supply of safe food for

humans. Different types of organic products such as *Panchagavya, Jivamrita* and vermiwash etc. are playing a dual role of improving the soil health as well as improving the productivity and quality of crops. Panchagavya is an important organic material obtained from various products of cow and it is beneficial in enhancing the biological efficiency of crop and the quality of fruits and vegetables. It also increases the soil fertility (Swaminathan *et al.,* 2007) [18]. *Jivamrita* popularized by Sh. Subhash Palekar, is considered to be a panacea for the prosperity of small farmers. It is important to provide a congenial environment to microorganisms that help in making available essential nutrients for plant growth, viz. nitrogen, phosphorus and potassium (N, P and K) to the plants. *Jivamrita* provides an environment to beneficial microbes (Trivedi *et al.,* 2016) [20]. Vermiwash has great growth promoting as well as pest killing properties (Sinha *et al.,* 2010) [17]. So, the present study was carried out to validate the response of cabbage crop to these bio enhancers.

Materials and Methods

The response of cabbage crop to bio-enhancers was studied with the help of a field experiment conducted during winter season of 2016-17 at Agricultural Farm, IFTM University, Moradabad. Moradabad is situated between 28º 21' to 28º 16' North Latitude and 78º 4' East Longitude at an altitude of 250 m above the MSL. The soil of the experimental site was sandy loam soil with a neutral pH reaction (Jackson, 1973) [7] and the organic carbon content of the experimental site was 0.6 % (Walkley and Black, 1934) [23].

The experiment consisted of 8 treatments with 3 replications and it was laid out in Randomized Complete Block Design. The treatments were: T_0-Control, T_1- Panchagavya 4%, T_2 – Jivamrita 20%, T_3 –Vermiwash (1:5 times dilution), T_4 – Panchagavya 4% + Jivamrita (20%), T_5 - Panchagavya 4% + Vermiwash (1:5 times dilution), T_6 – Jivamrita (20%) + Vermiwash (1:5 times dilution), T_7 – RDF (120:30:30 kg NPK/ha).

The nursery of cabbage crop was raised by using plug trays. Seeds of hybrid cabbage 'S-92' (improved) were used in the experiment. A well rotten mixture of FYM and soil was filled in the trays and then seed were sown @ 350-400 g/ha (on 21 October 2016). The trays were watered regularly and they were covered with a layer of dried grass and after germination the dried grass was removed. The nursery was kept weed free to avoid competition due to weeds. Four week old cabbage seedlings were transplanted in the main field (on 20th November 2016) after bringing the field to a fine tilth. The seedlings were transplanted at a spacing of 60 × 45 cm, thereby accommodating 12 plants in a plot of size 2.88 m^2. After sowing a general irrigation of 3 cm was applied to all the treatments and later on irrigation was provided on the basis of visual observations and critical stage approach.

In treatment T_7 RDF (N:P:K @ 120:30:30 k/ha) was applied as per package of practices and bio enhancers were applied four times in two different ways. Panchagavya and Jivamrita were drenched in the soil, whereas vermiwash was sprayed on the plants with the help of a knapsack sprayer. For supplying RDF fertilizers used were Urea, Single Super Phosphate and Murate of Potash and the bio enhancers (Panchagavya, Jivamrita and vermiwash) were prepared on the field itself by using the following procedures (Trivedi *et al.,* 2016) [20]. For preparing 20 litres of *Panchgavya*, 5 kg fresh cow dung and500 g cow's ghee were mixed thoroughly in a mud pot and kept for three days. This mixture was mixed twice a day. On the 4 day, cow's urine (3 litres), cow's milk (2 litres), cow's curd (2 litres), sugarcane juice (3 litres), tender coconut water (2 litres) and meshed ripened 6 banana fruits were mixed thoroughly. This solution was kept for 18 days with stirring twice a day for about 20 min to facilitate aerobic microbial activities. On the 19th day, the stock solution of *Panchgavya* was ready to use. The solution was kept under the shade and covered with a muslin cloth so that common fly could not sit on it and lay eggs. In the preparation of *Jivamrita*, the required quantities of fresh cow dung and cow urine were mixed thoroughly in 200 litres of water in a mud pot followed by addition of 4 litres of sugarcane juice, 2 kg pulse flour and 1 kg of virgin soil (chemical free soil). This solution was stirred well and kept for 3 days for fermentation under shade. The pot of *Jivamrita* solution was covered with a muslin cloth to avoid any undesirable contamination. After 3 days of fermentation, solution of *Jivamrita* was prepared and was used according to treatments. Vermiwash was prepared in a big plastic drum with capacity of 200 litres (provided with tap in bottom) that was placed in the shade. Five cm each of concrete and red sand was laid in bottom of pot for effective drainage. A layer of soften kitchen wastes and one week old dung was filled 30-40 cm in the pot and then 200-300 red worms (*Eisenia foetida*) were released in this organic waste and dung. After a week of worm inoculation, an earthen pot with minute hole in bottom from where water pours drop wise was hanged over drum. After 2-3 days, extract collected from tap provided in the bottom of pot/drum obtained as 'vermiwash' and was used in different concentrations.

Hand weeding was done to keep the crop free from weeds and the crop did not show incidence of any disease. Harvesting was done on 16th January 2016. For data collection five plants were selected from every plot and they were tagged and all the observations were recorded using the same plants. The data were analyzed using analysis of variance (ANOVA) technique as applicable for Randomized Complete Block Design (Rangaswamy, 2006) [16]. The results were interpreted on the basis of F- test and critical difference at 5% was used for calculating the significant difference between the means of two treatments (Gomez and Gomez, 1984) [6].

Results and Discussion

At 45 DAT, the maximum value of plant height was recorded in T7 (23.70 cm) which was significantly superior to all other treatments except for T5 (23.57 cm). This result clearly signifies the importance of Panchagavya and Vermiwash in cabbage production. The organic materials obtained from local field and farm animals were able to produce significant yield as that of recommended RDF. It may be attributed to the reason that, application of Panchagavya and Vermiwash may have increased the population of beneficial microorganisms, which in turn would have increased the uptake of beneficial nutrients and also through the release of growth promoting substances (Tilak, 1993, Kaushal, 2006 and Trivedi *et al*., 2016) [19, 9, 20]. Similar increase in plant height due to use of bio enhancers was also reported by Khomani (2004) [10] in Diffenbachia with vermiwash, Bhalla *et al.* (2006a) [3] and Kumar *et al.* (2010) [11] in gladiolus and Bhalla *et al.* (2006b) [4] and Dharma (2006) in carnation with *Panchgavya*. Similar trend was followed in number of non wrapped leaves per plant at 45 DAT, and it was also reported by Kumar *et al.* (2010) [11] in gladiolus, Karuppasamy and Lourdu (2013) [8] mulberry and Verma *et al.* (2013) [21] in carnation. This increase in number of leaves may be due to better uptake of

nutrient elements, solubilization and mobilization of insoluble form of phosphorous in the soil by organic acids.

In case where there is no application of bio-enhancers i.e. control (T0), the plant height and number of leaves were least (17.00 cm and 9.33, respectively), because there were no nutrients applied and also there were no bio-enhancers to increase the uptake of nutrients already present in the soil. The results obtained on various vegetative parameters confirm the suitability of organic farming for cabbage production.

Significantly, highest whole plant weight was observed in T7 (1291.33 g) as compared to other treatments, but it was statistically similar to T4 and T5 (1190.0 g and 1281.33 g, respectively). The similar trend was also followed in case of head weight and head diameter of cabbage. Maximum yield of cabbage was recorded with the application of RDF i.e. T7 (42.79 t/ha), but it was statistically similar to T4 and T5 (38.55 t/ha and 41.74 t/ha, respectively). These results may be attributed to the enormous benefits of application of bio enhancers. The above results are also corroborated with the findings of Khomami (2004) [10] in Dieffenbachia, Yelleshkumar *et al.* (2008) [24] in mango, Ansari (2008) [2] in spinach, onion and potato, Vidhya and Anjurani (2008) [22] in jasmine, and Radhakrishnan and Mahendran (2009) [15] in tea.

Table 1: Effect of bio enhancers on growth parameters of cabbage

Treatment	Plant height (cm)		No. of non-wrapped leaves per plant		Leaves width (cm)		Leaf length (cm)	
	30 DAT	45 DAT	30 DAT	45 DAT	30 DAT	45 DAT	30 DAT	45 DAT
T_0 :C	12.50	17.00	7.60	9.33	5.29	7.83	10.20	13.62
T_1: *P* (4%)	15.07	18.75	8.53	10.40	7.36	9.97	11.26	13.63
T_2:*J* (20%)	14.89	18.17	8.33	9.73	7.75	11.21	11.72	14.30
T_3:V (1:5 dilution)	14.62	18.82	9.27	10.60	6.36	8.74	11.59	14.90
T_4:*P* +*J*	15.53	19.07	9.73	11.87	8.71	11.55	12.00	15.29
T_5:*P*+V	21.48	23.57	13.07	16.40	12.13	14.67	16.57	19.51
T_6:*J*+V	15.49	19.01	8.53	11.67	8.61	11.23	11.89	15.06
T_7:R.D.F	21.65	23.70	13.12	16.60	12.15	14.76	16.58	19.55
SE(m)±	1.067	1.161	0.59	0.603	1.373	1.411	1.001	1.097
C.D.	3.27	3.56	1.82	1.847	4.204	4.320	3.066	3.361

Table 2: Effect of bio enhancers on yield and yield attributes of cabbage

Treatment	Whole plant weight (g)	Head weight (g)	Head length (cm)	Head diameter (cm)	Stem weight (g)	Stem diameter (cm)	Root weight (gm)	Yield (t/ha)
T_0 :C	850.67	612.00	10.97	10.38	23.60	2.53	20.77	25.55
T_1: *P* (4%)	1,058.00	838.67	11.77	12.60	28.13	2.87	23.13	29.72
T_2: *J* (20%)	1016.00	708.67	11.50	11.30	26.47	2.77	22.13	34.95
T_3:V (1:5 dilution)	1037.33	713.33	11.73	11.64	27.93	2.77	22.47	29.54
T_4:*P* +*J*	1,190.00	925.33	12.83	13.43	29.20	3.03	26.33	38.55
T_5:*P*+V	1,281.33	1,003.33	13.90	14.07	30.03	3.43	26.40	41.74
T_6:*J*+V	1,074.00	879.333	11.99	12.81	28.49	2.87	24.91	36.63
T_7:R.D.F	1,291.33	1,024.67	14.90	14.23	32.03	3.70	26.49	42.79
SE(m)±	69.240	37.104	0.548	0.449	0.316	0.231	0.534	1.56
C.D.	212.052	113.632	1.678	1.375	0.969	0.707	1.635	4.77

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