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Effect of Liquid Manure and Fish Oil Emulsion on the Growth, Yield and Quality of Broccoli (*Brassica oleracea* var Italica) vc KTS-1

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Abstract A field experiment was conducted to study the effect of liquid manure and fish oil emulsion on the growth, yield and quality of broccoli (KTS-1) with 9 treatments comprising waste management practices by utilizing liquid manure from kitchen waste and fish oil emulsion from fish waste, laid out in CRD with four replications under Lucknow subtrolical conditions. The basic aim was to reduce environmental pollution by waste management and utilization for sustainable agriculture development. The data revealed that treatment T_4 [Soil + Compost + Liquid manure (1:15)] as pot soil mixture performed significantly superior in most of vagetative growth parameters (plant height–37.75 cm, plant spreading east to west–23.00 cm, north to south–22.25 cm, length of leaves–18.67 cm, basal diameter–6.18 cm and width of leaves–17.75 cm) and in yiekd (with gourd leaves–34.94 t/ha and without gourd leaves–28.89 t/ha) and quality parameters (TSS–8.02°B, Vit C- 70.95 mg/100g, total sugars–2.84%, reducing sugar–1.99% and non-reducing sugar–0.41%) comparison to all other treatments. Interaction effect of different organic manures as well as liquid manure, compost, fish oil emulsion and soil was found significant and was the best among the all treatment combination under Lucknow sub-tropical environment. However, the effect of fish oil emulsion was not good for the crop.

Keywords Broccoli, Fish oil, Liquid manure, Quality, Yield.

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Introduction

Broccoli (*Brassica oleracea* L. var italica) is an important winter season vegetable colecrop after cabbage and cauliflower from the family Brassicaceae. It is cherished for its delicious taste, flavor and nutritivevalue and has been reported to prevent cancer. It is a nutritionally important crop grown all over the world containing vitamins, antioxidants, glucosinolates and anticarcinogenic compounds [1—3]. Broccoli is semi-strong against coldness [4] and has good market value [5]. Inorganic nitrogen fertilization plays an essential role in increasing broccoli

Table 1. Effect of fish oil emulsion and liquid manure on the vegetative growth of broccoli.

	Plant height (cm)			Plant spreading E-W (cm)			Plant spreading N-S (cm)			Basal diameter (cm)		
Treatments	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T_1	16.50	29.25	32.75	15.50	21.25	24.50	12.25	17.75	23.00	5.03	5.35	5.33
T_2	19.25	31.25	35.25	13.25	22.50	25.25	13.75	20.75	24.75	5.03	6.20	6.03
T_3	17.00	30.50	33.50	12.00	19.75	24.25	12.50	20.50	24.50	5.00	6.25	5.93
T_4	19.50	35.25	37.75	14.50	23.00	27.25	14.75	22.25	27.00	5.03	5.83	6.18
T_5	18.00	33.75	36.75	14.25	22.75	23.75	14.00	21.00	24.50	5.15	6.00	6.10
T_6	15.50	27.25	30.00	13.75	18.75	21.75	11.75	14.75	16.75	4.78	5.33	5.25
T_7	17.75	29.50	30.50	12.50	21.25	23.50	12.25	19.75	20.25	5.10	5.60	5.93
T_8	16.00	30.50	35.00	14.00	22.75	24.75	12.25	18.75	22.00	4.90	5.50	5.90
T_9	18.75	26.75	31.50	12.75	22.75	22.75	13.25	17.75	22.25	4.35	5.15	5.45
SEm (±)	2.269	0.962	3.294	1.569	0.225	3.912	1.403	2.965	2.211	1.243	0.152	1.010
CD (p=0.05)	NS	1.953	6.687	3.185	0.458	NS	2.848	6.019	4.488	2.523	0.310	NS

yield and quality [6]. But organic manure plays an important role in plant growth as a source of major micro and macro nutrient in available forms during mineralization and impairing the physical and physiological properties of soil. Organic production also improved the growth of crop product [7]. The waste management and conversion of them to organic manures is now getting popularity as well as for environmental pollution concern. Several researchers are going on this management of waste from industry as well as household. In the present study, we have planned to use the fish waste by converting into fish oil emulsion and to make liquid manure with very easy method and from very common materials like leaves of legumes, grasses and cow dung as well as known kitchen waste. In some cases, it was observed that plant grow rapidly and vigorously with fish fertilizers application [8]. Detrimental effects of fish farming on the marine environment in particular have become an issue of public concern [9]. Abbasi et al. [10] stated that foliar applications of neem oil and fish emulsion, derived from neem seed and menhaden fish, respectively, were tested for their ability to reduce bacterial spot of tomato and bell pepper under both greenhouse and field conditions.

Liquid manure is most advantageous for vegetable crops because the whole nutrient materials are in liquid form and plants can uptake them easily. Liquid manure is known as different names by their using materials, concentrations and uses e.g. Panchagavya, Jeevamruth and Beejamruth they contain macro nutrients, essential micro nutrients, many vitamins, essential amino acids, growth promoting factors like IAA, GA and beneficial microorganisms [11, 12]. Keeping these views the present experiment was designed to see the effect of liquid manure on fish oil emulsion on broccoli production.

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Materials and Methods

The experiment was conducted at Horticulture Research Farm of Babasaheb Bhimrao Ambedkar University Lucknow during the *rabi* season of 2014–2015. Experiment consisted with 9 treatments [T_1-Control (Water spray), T_2-Soil + Compost + Liquid Manure (1:5), T_3-Soil + Compost + Liquid Manure (1:10), T_4-Soil + Compost + Liquid Manure (1:15), T_5-Soil + Compost + Liquid Manure (1:20), T_6-Soil + Compost + Fish Oil (1%), T_7-Soil + Compost + Fish Oil (2%), T_8-Soil + Compost + Fish Oil (3%) and T_9-Soil + Compost + Fish Oil (4%)] CRD with four replications. 23 days

Table 2. Effect of fish oil emulsion and liquid manure on yield of broccoli.

Treatments	Length of leaves (mm) 30 DAP	60 DAP	90 DAP	Width of leaves (cm) 30 DAP	60 DAP	90 DAP	Yield/pot (g) With guard leaves	Without guard leaves	Yield (t/ha) With guard leaves	Without guard leaves
T_1	11.50	15.75	18.67	9.25	9.75	10.00	411.75	325.50	26.14	20.67
T_2	11.50	15.50	18.50	10.25	11.25	12.00	399.75	352.50	25.38	22.38
T_3	12.00	16.00	16.50	10.50	10.00	13.00	455.00	384.50	28.89	24.41
T_4	12.00	18.25	18.50	14.00	13.25	17.75	550.25	455.00	34.94	28.89
T_5	9.75	17.25	18.50	11.00	12.00	13.75	481.25	399.75	30.56	25.38
T_6	11.00	13.75	18.00	11.00	12.25	13.25	452.25	370.50	28.71	23.52
T_7	11.25	17.75	14.75	10.75	12.25	13.25	400.75	330.75	25.44	21.00
T_8	11.75	19.25	18.25	12.75	13.25	15.75	423.00	358.50	26.86	22.76
T_9	12.50	16.00	21.25	13.25	14.00	14.50	393.75	331.00	25.00	21.02
SEm (±)	1.243	0.408	0.408	1.128	0.693	0.910	42.75	23.49	2.651	1.491
CD (p=0.05)	2.523	0.828	0.828	2.290	1.408	1.847	86.78	47.69	5.383	3.028

old healthy and uniform seedling were transplanted in experimental pots on the planting material (seed) of broccoli was obtained from the Regional Research Station IARI, Katrain and cultivar which is used in the present experiment was KTS-1. For pot preparation the bulk surface of soil (0–15 cm) collected from Horticultural Research Farm of Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Lucknow and after through mixing with compost (1:1), 5 kg soil mixture was filled in each cleaned pot. Fish waste was collected from local fish market and washed thoroughly. After wasting dried under hot air oven at 80°C for 24 h and then about 66°C for seven days. Drying the oil released from fish waste was collected in bottles. The oil was then prepared to fish oil emulsion under normal room temperature before spraying. Whereas, liquid manure was prepared from the, Potato peel-700 g, Carrot peel-300 g, Legume leaf-400 g, Neem leaf-500 g, Tulsi leaf-400 g, chopped into small pieces and mixed in Cow dung - 2.8 kg, then fill into container with Water -10.0 liter. The composition were monitored every day and stirred in every three days interval. It started a bad smell indicating fermentation. Water was added as and when needed. It was ready after about 40–45 days of mixing. When it was ready, it was stirred well and filtered through a cloth. A sample was taken from each composition for macro and micro nutrients study. Then, the recommended ratio was made by adding water and applied as per treatment. Newly made liq-

Table 3. Effect of fish oil emulsion and liquid manure on the physical and chemical characters of broccoli.

Treatments	Number of slip per curd	Number of frauds curd	Curd diameter (cm)	TSS (°B)	Vit C (mg/100 g)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)
T_1	22.50	12.50	13.25	7.20	70.42	2.31	1.54	0.37
T_2	24.25	12.25	12.25	7.17	69.02	2.51	1.44	0.28
T_3	23.25	12.50	12.50	6.50	68.27	2.23	1.80	0.36
T_4	25.50	13.00	13.25	8.02	70.95	2.84	1.99	0.41
T_5	24.75	12.63	12.25	6.05	70.05	2.66	1.57	0.30
T_6	24.50	12.63	12.75	6.58	67.70	2.24	1.58	0.25
T_7	24.00	12.38	12.25	6.65	69.32	2.44	1.47	0.26
T_8	23.50	12.70	12.50	6.69	67.75	2.06	1.61	0.26
T_9	24.00	12.80	12.00	7.01	68.82	2.39	1.83	0.31
SEm (±)	1.043	1.085	0.452	1.316	0.316	0.427	0.322	0.044
CD (p=0.05)	2.117	NS	0.949	NS	0.756	NS	NS	0.089

Table 4. Elemental status of pot soil as influenced by different treatments.

Treatments	C	O	Mg	Al	Si	K	Ca	Ti	Fe	Zr	Na	Pt	Zn
T_1	28.13	33.13	1.02	6.03	18.17	4.61	1.06	0.33	6.04	0.93	0.00	0.00	0.00
T_2	0.00	41.08	0.00	11.57	37.00	1.46	0.00	0.00	2.77	0.00	4.06	2.07	0.00
T_3	0.00	35.05	2.10	13.52	27.64	6.41	0.00	0.69	14.58	0.00	0.00	0.00	0.00
T_4	34.98	19.69	0.65	5.11	17.00	4.77	1.84	0.66	14.08	1.32	0.00	0.00	0.00
T_5	0.00	41.35	0.00	11.20	37.84	0.46	1.26	0.00	0.89	0.00	4.44	1.56	0.00
T_6	76.79	5.19	0.00	11.52	0.25	0.00	0.00	0.00	0.00	0.00	0.00	6.26	0.00
T_7	0.00	44.11	1.69	4.82	36.45	2.04	1.21	0.00	6.48	2.89	0.00	0.00	0.31
T_8	0.00	40.35	2.02	10.01	26.02	5.75	1.48	1.01	9.82	0.00	1.59	1.95	0.00
T_9	26.12	26.23	1.02	10.26	12.02	5.23	1.25	0.84	10.45	1.56	3.12	0.64	1.26

uid manure is very strong so, it needs dilution. Liquid manure was sprayed two times at fortnight interval with the specified ratio i.e.-Liquid manure and water (1:5), Liquid manure and water (1:10),Liquid manure and water (1:15) and Liquid manure and water (1:200. The observed data were statistically analyzed using analysis of variance as formulated Panse and Sukhatme [13] at 5% level of significance.

Results and Discussion

Effect of liquid manure and fish oil emulsion on the vegetative growth of broccoli

Use of fish oil emulsion and liquid manure was found to increase plant height significantly at 60 and 90 DAT of crop growth (Table 1). The maximum plant height at 30, 60 and 90 days after transplanting (DAT) was 119.50 cm, 32.25 cm and 37.75 cm respectively was recorded under treatment T_4 [Soil + Compost + Liquid manure (1:15)]. Whereas, the least mean plant height values noted at 15.50 cm, 26.75 cm and 30.00 cm at 30, 60 and 90 DA, respectively was recorded in T_6 and T_9. Increased plant growth was also found by the application of organic manures and was supported by the work of Singh et al. [14] in broccoli. At the all three stages i.e. 30, 60 and 90 DAT the plant height was found decreased by the application of fish oil even lower than control. But effect of fish oil was not clear and it did not follow a specific pattern. Because fish oil 1% (T_6) decreased plant height at 30 DAT but, fidsh oil 3% (T_8) increased height at 60 and 90 DAT. The plant spreading in the direction of East to West was significantly maximum (15.50 cm) at 30 DAT in T_1 (control) whereas, it was maximum under T_4 both at 60 and 90 DAT. Although, effect was non-significant at 90 DAT. Plant spreading in north-south direction also followed the similar pattern and found maximum spreading at 30, 60 and 90 DAT under the treatment T_4.

In the case of basal diameter the data was found significantly maximum (5.15 cm and 6.25 cm) at the 30 and 60 DAT under treatment $T_5$and T_3 respectively. The maximum under of leaves per plant was recorded at 30, 60 and 90 DAT (12.50, 19.25 and 21.25) under treatment T_9, T_8 and T_9, respectively. Therefore, it did not follow a specific pattern and the effects due to different treatments were variable at different stages of growth i.e. at 30, 60 and 90 DAT. The maximum length of leaves per plant was recorded maximum significantly at 30, 60 and 90 DAT (13.50 cm, 18.75 cm and 21.00 cm, respectively) observed in the treatment T_4 [Soil + Compost + Liquid manure]. Whereas, the least mean length of leaves noted at 30, 60 and 90 DAT were 10.00 cm, 11.75 cm and 12.50 cm respectively in the untreated control treatment (T_1). The width of leaves were also observed significantly maximum 14.00 cm at 30 DAT in T_4 but 14.00 cm at the 60 DAT in T_9 and 17.75 cm at the 90 DAT again under T_4. These better vegetative growth in respect of plant height, basal diameter, plant spreading, width of leaves and length of leaves was found under treatment T_4 [Soil + Compost + Liquid manure (2:15)] was corroborated with the finding of Muoneke et al. [15], Irshad and Javed [16]. However, no literature had been found to explain this factor. The growth of broccoli was increased mostly in combination of Soil + Compost + Liquid manure of (1:15) (T_4) and Soil + Com-

Table 5. Microbial study of rhizospheric soil sample.

Soil sample/treatment	CFU/g of soil
T_1	2.3×10^6
T_2	3.7×10^6
T_3	7.1×10^5
T_4	4.6×10^6
T_5	5.2×10^6
T_6	5.1×10^7
T_7	7.1×10^7
T_8	6.3×10^7
T_9	5.3×10^6

post + Fish oil (1%) (T_6) might due to fluctuation of temperature and moisture.

Effect of fish oil emulsion and liquid manure on yield and yield attributing characters of broccoli

The curd yield per pot and per ha was improved significantly due to different combinations of soil, compost, liquid manure and fish oil emulsion (Table 2). The maximum yield of broccoli was recorded with guard leaves (34.94 t/ha) and 28.89 t/ha as without guard leaves under treatment T_4. Minimum yield was recorded in guard leaves 25.00 t/ha under treatment T_9 and 20.67 t/ha without guard leaves under treatment T_1. Number of slips per curd was found significantly maximum (25.50) under treatment T_4 and maximum number of fraud curds (13.00) was also recorded under treatment T_4 followed by T_9 though the effect was non-significant. The result is also supported by Abbasi et al. [17] and Gagnon and Berrouard [18].

Effect of fish oil emulsion and liquid manure on quality parameters of broccoli

Among the physico-chemical characters of curd it was observed that the effects of various treatments were varied significantly for curd diameter (Table 3). However, most of the treatments minimized the curd diameter, the plants under control and T_4 showed maximum curd diameter. This similar pattern was also observed in case of ascorbic acid i.e. the treatments except T_4 caused lower ascorbic acid content in curd comparison to control (Table 4). Although, TSS and total sugars were maximum under T_4 and improved by other treatments but it was statistically non-significant. Reducing and non-reducing sugar were found maximum (1.99 and 0.41%, respectively) under the treatment T_4 and minimum observations were recorded in this case were 1.44 and 0.25% under the treatment T_2 and T_6 respectively. All quality parameters were increased significantly in the present experiment due to the good assimilation of nutrients and by better management of organic manuring.

No more literature was found in the case of fish waste management for the supporting of the result. Quality parameters of sprouting broccoli was increased significantly in present experiment might be due to the application of organic manure/liquid manuring. The increase in TSS might be due to the rate of assimilating export from the leaves; rate of import by fruits and the fruit carbon metabolism are factors that finally influence TSS of tomato. Govind et al. [19] was also found the significant effect on the quality parameters of garlic due to liquid manure application from waste materials.

Effect of fish oil emulsion and liquid manure on the soil microbes

After the analysis of microbes in the soil it was shown that the combination of soil + compost + liquid manure (1:15) [T_4] was more advantageous to the comparison of all the other treatments (Table 5). The population of soil microbes was increased might be due to the application of liquid manure. So, it may be said that the application of liquid manure is the very advantageous tool for the successful production of sprouting broccoli.

From the study, it was observed that overall performance the fish oil was not superior treatment for improving growth, yield and quality of broccoli. The better results were i.e. growth yield and quality was obtained by the application of liquid manure prepared from the locally available materials including kitchen wastes. Among the treatments it may be concluded that treatment T_4 [(soil + compost + liquid manure

(1:15)] was proved to be the best for broccoli production.

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