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Impact of sewage sludge and Dal weed compost on yield and quality attributes of kale (*Brassica oleracea* var. *acephala* L.) in Kashmir

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Abstract
A field experiment was carried out for two consecutive years during Rabi 2016 and 2017 at Experimental Farm SKUAST-Kashmir, Shalimar campus to study the "Impact of sewage sludge and Dal weed compost on yield and quality attributes of kale (*Brassica oleracea* Var. *acephala* L. in Kashmir Himalaya. The experiment was laid out in Randomized Complete Block Design with three replications. The experiment comprised of nine treatment combinations of sewage sludge, Dal weed compost and inorganic fertilizers viz., T1 (20% sewage sludge + 80% RFD), T2 (40% sewage sludge + 60% RFD), T3 (20% Dal Weed Compost +80% RFD), T4 (40% Dal Weed Compost +60% RFD), T5 (20% sewage sludge +20% Dal Weed Compost+ 60% RFD), T6 (100% Dal Weed Compost), T7 (100% sewage sludge), T8 (100% RFD) and T9 (no fertilizers). Observations were recorded on various aspects like yield, fresh and dry root biomass and quality attributes. The results show that plant yield (361.87 q/ha), root fresh biomass (35.12 g/plot), root dry biomass (11.46 g/plot)) and quality parameters viz., carbohydrates (4.10%), total chlorophyll (180.30 mg/100g) were significantly higher in the plots treated with T1 (20% sewage sludge + 80% RFD) which was at par with treatment T2 (40% sewage sludge + 60% RFD) and T8 (100% RFD) as compared to control. The study concludes with the findings that application of T1 (20% sewage sludge + 80% RFD) followed by T2 (40% sewage sludge + 60% RFD) exhibited higher quality yield in kale and an environment-friendly solution for disposal problems.

Keywords: Sewage sludge, chemical fertilizers, compost, yield, organic farming and kale

Introduction
Increasing population of the world has doubled the food demands and inundated the available land sources (Gandhi and Sivagama, 2012 [5]. The need of increased food production in most developing countries becomes an ultimate goal, to meet the dramatic expansion of their population Selvaraj *et al*. 2013 [11]. Among the major food crops, vegetables are the most important one by cultivation and consumption. The nutritional content of vegetables varies considerably as they contain a great variety of other phytochemicals and other antioxidant properties. Generally, commercial and conventional farming has been and is still relying on the use of inorganic fertilizers for growing vegetables. Injudicious use of chemical fertilizers and less dependence on organic materials has resulted in multidimensional environmental problems, reduction of soil organic carbon (SOC) contents, with a subsequent decline in agricultural soil quality and deterioration of the food value of the agricultural produce. Chemical fertilizers which are currently being used by farmers despite being expensive, cause eutrophication and raise the levels of greenhouse gases such as the oxides of carbon and nitrogen which leads to global climate change and environmental pollution (Chukwuka and Omotayo, 2008) [3]. During last few years, organic fertilizers is being promoted as an eco-friendly and sustainable solution for sustainable crop production mainly in vegetables' cultivation. Aquatic weed compost and sewage sludge are inevitable by-product of water bodies and wastewater treatment plants respectively. The use aquatic weeds and sewage sludge as organic fertilizers would be a better alternative to improve soil fertility, reducing the usages of chemical fertilizer, increase crop yield and quality attributes of crops (Mandal *et al.* 2007) [9]. This study was conducted in order to determine the effects of different doses of municipal sewage sludge and Dal weed compost on yield and some quality parameters of kale (*Brassica oleracea* var. *acephala* L.).

Material and Methods

Study area

A field experiment was carried out for two consecutive years during Rabi 2016 and 2017 at Experimental Farm SKUAST-Kashmir, Shalimar campus. In this research, the kale (*Brassica oleracea* var. *acephala* L. Was examined in two separate years and field trials were established. Climatically the experimental site is in mid to high altitude temperate zone characterized by hot summers and very cold winters. The average annual precipitation is 812 mm (average over past twenty years) and more than 80 per cent of precipitation is received from western disturbances.

Experimental design

The experiment was conducted using a complete randomized block design with three replications in 9 plots, each measuring $4m^2$ (2 m x 2 m). The plants were irrigated, in accordance with their water demand. The water level was made up as and when required. Each plot was randomly assigned to receive one of nine treatments as follows:

T_1= 20% Sewage Sludge + 80% Recommended fertilizer dose
T_2= 40% Sewage sludge +60% Recommended fertilizer dose
T_3= 20% Dal weed compost +80% Recommended fertilizer dose
T_4= 40% Dal weed compost + 60% Recommended fertilizer dose
T_5= 20% Dal weed compost + 20% Sewage sludge + 60% Recommended fertilizer dose
T_6= 100% Dal compost
T_7= 100% Sewage sludge
T_8= 100% Recommended fertilizer dose
T_9= Absolute control (without fertilizers)

Sewage sludge and Dal weed compost properties

Some characteristics of sewage sludge and Dal weed compost used in the experiment are given in Table 1. In general, the sewage sludge was rich in nitrogen, phosphorus and potassium

Table 1: Characteristics of Dal weed compost and sewage sludge used in the study

Parameters	Sewage sludge	Dal weed compost
pH	6.95	6.79
Organic Carbon (%)	4.89	2.05
Total Nitrogen (%)	1.26	0.67
Total Phosphorus (%)	1.08	0.82
Total Potassium (%)	0.82	0.54
Micro nutrients		
Zn (ppm)	15.87	9.67
Cu (ppm)	4.98	2.03
Fe (ppm)	59.57	47.34
Mn (ppm)	29.46	19.45
Heavy metals		
Cd (ppm)	1.03	0.57
Pb (ppm)	6.9	3.4

Plant observations

Observations were recorded on various aspects like yield and quality parameters of kale on 9 randomly selected plants from each treatment, in each replication, for both the years and their means were worked out for statistical analysis, as well as on pooled basis.

Plant yield

Plants were harvested at different intervals. Total weight of plants (kg/plot) at each picking was added to obtain the total yield per plot and expressed as quintals per hectare (q/ ha).

Analysis of the plant materials

At the end of the experimental period, samples were rapidly washed in the tap water and dried in an air-oven at 70ºC to determine fresh and dry weights as well as to carry out the chemical analysis. The contents of chlorophyll-a, chlorophyll-b and total chlorophyll were determined according to the method given by Hiscox and Isrealstam (1979) [8] using Dimethyle Sulphoxide (DMSO). 100g of fresh leaves were homoginised in 10ml of DMSO and after keeping it in oven for half an hour at 40-50ºC. The absorption of solution was noted at 480, 510 and 645 nm on double beam UV spectrophotometer. The total carbohydrate content in the leaves of the test crops was estimated by following the Anthrone method of Hedge and Hofreiter (1962) [7].

Statistical analysis: Data recorded during the experiment were subjected to ANOVA, followed by least significant difference (LSD) test at $p \leq 0.05$ using R software statistical package (Gomez and Gomez, 1984) [6].

Results and Discussion

Residual effect of treatments on yield and fresh and dry root biomass parameters of kale

The perusal of data pertaining to the effect of different treatments on yield, fresh and dry root biomass of kale at harvest stage is depicted in Fig. 1, 2 and 3 respectively. Among different treatments, integration of organic sources with chemical fertilizers proved superior to sole application of organic sources and inorganic fertilizers. Application of T_1 recorded significantly highest yield of 361.87 q/ha and was statistically at par with plots treated with T_2 and T_8.On the other hand lowest plant yield of 245.55 q/ha was recorded in T_9 Control plots. The results revealed that in kale, application of T_1 recorded fresh and dry root biomass of 35.12 and 11.46 g/plot, respectively which were significantly higher than all other treatments. The treatment T_1 was followed by T_2 which was at par with treatment T_8. Significantly lowest fresh and dry root biomass of 22.10 and 6.46 g/plot respectively were recorded in the treatment which received no sludge or fertilizer dose. In the present study, the increase in yield as a result of sewage sludge application along with inorganic fertilizers may be due to the increase in organic matter, macro-and micronutrients in the sewage sludge where beneficial nutrients improved the metabolic activities and hence the vegetative growth. Similar findings have also been reported by Jamil *et al*. (2002). Andres *et al*. (2010) [1] also reported that higher yield in crop may be due to different doses of sewage sludge over the recommended doses of fertilizer. Asghar *et al*. (2006) [2] showed that integrated use of organic waste and recommended dose of inorganic fertilizer caused more promising results and increased almost all the growth parameters like fresh and dry biomass, and yield in case of radish which is in accordance with our findings.

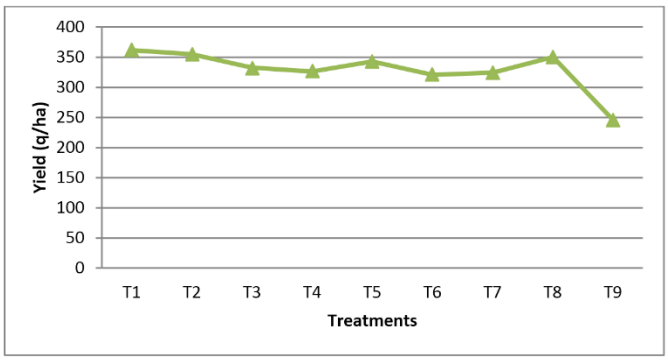

Fig 1: Impact of sewage sludge and Dal weed compost on yield (q/ha) of kale (pooled data of 2016 & 2017).

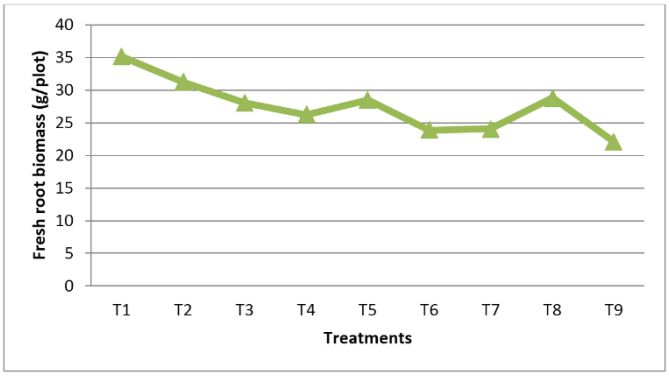

Fig 2: Impact of sewage sludge and Dal weed compost on fresh root biomass (g/plot) of kale (pooled data of 2016 & 2017).

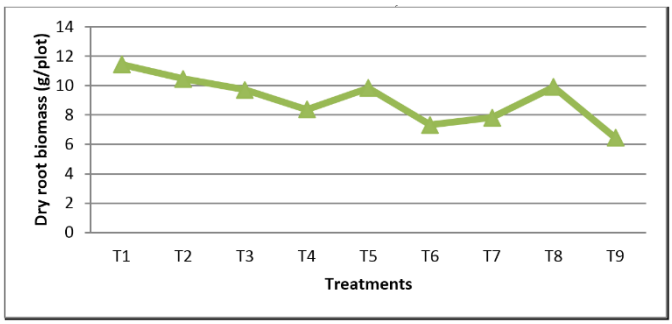

Fig 3: Impact of sewage sludge and Dal weed compost on dry root biomass (g/plot) of kale (pooled data of 2016 & 2017).

Residual effect of treatments on quality parameters of kale

It is inferred from the results presented in Fig. 4 that in kale application of T_1 recorded significantly elevated carbohydrate level of 4.10 per cent. However, the plots treated with T_1 and T_2 were statistically at par with each other. On the other hand a lowest carbohydrate content of 1.54 per cent in kale was recorded in the plots which served as control. The data pertaining to Chlorophyll-a, b and total chlorophyll content in kale are presented in Fig. 5, 6 and 7 respectively. Integration of organic sources with inorganics exhibit significantly higher chlorophyll content as compared to sole organic manures. It is evident from the data that in kale application of T_1 recorded chlorophyll a, b and total chlorophyll contents of 96.63, 80.01 and 180.30 mg/100g respectively and were found significantly higher than all other treatments However, treatment T_1 was at par with treatment T_2 and treatment T_8. The lowest chlorophyll-a, b and total chlorophyll contents of 44.36, 39.40 and 87.58 mg/100g in kale respectively were recorded under control treatment. Application of sewage sludge has positively affected the synthesis of photosynthetic pigments. The effect of sewage sludge in combination with inorganic fertilizer dose on chlorophyll content could be attributed to the fact that sewage sludge improves the rate of biosynthesis of chlorophyll-a, b and total chlorophyll. The results are in conformity with findings of lone *et al.* (2013) [4]. Pirdashti *et al.* (2010) [10] reported that application of sewage sludge to the soybean plots increased the leaf chlorophyll content compared to chemical fertilizer and other organic fertilizers plots. Yilmaz and Temizgul (2014) [13] in their pot experiment also reported that the chlorophyll content in wheat (*T. aestivum*) was significantly increased due to addition of sewage sludge compared to control. Zeid and Abou-El-Ghate (2007) [14] reported that total carbohydrate contents were higher in sewage water irrigated plants compared with controls. Yadav *et al.* (2006) [12] also reported that the carbohydrate contents were higher in the plots treated with doses of sewage sludge along with inorganic fertilizers.

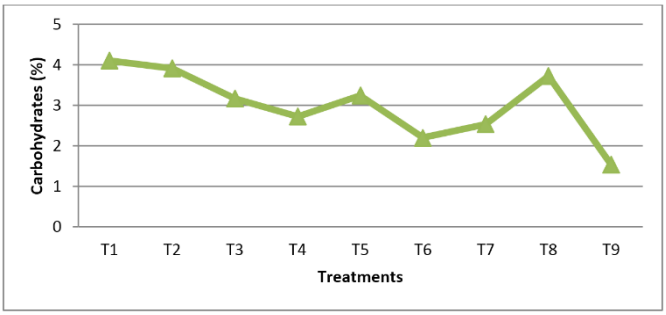

Fig 4: Impact of sewage sludge and Dal weed compost on Carbohydrates (%) of kale (pooled data of 2016 & 2017).

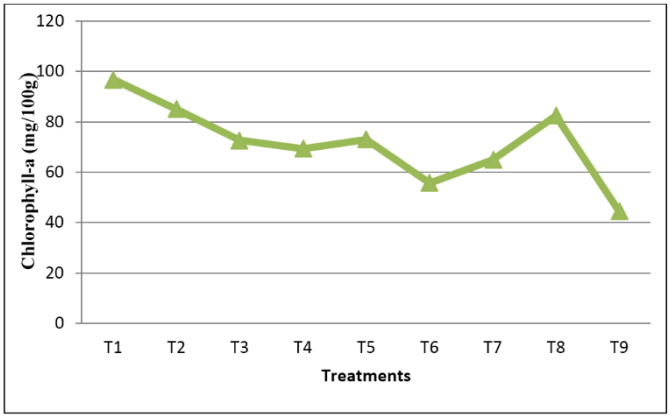

Fig 5: Impact of sewage sludge and Dal weed compost on chlorophyll-a (mg/100g) of kale (pooled data of 2016 & 2017).

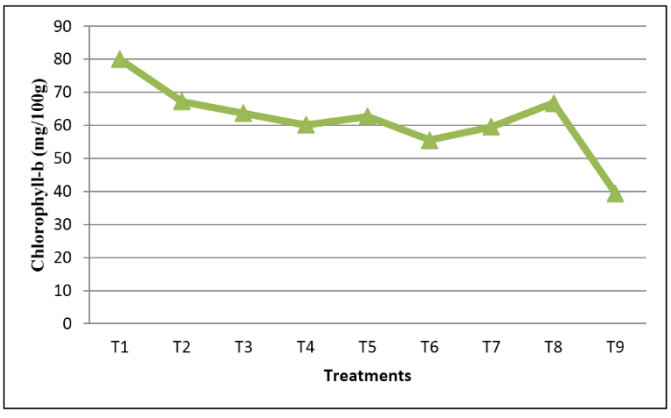

Fig 6: Impact of sewage sludge and Dal weed compost on chlorophyll-b (mg/100g) of kale (pooled data of 2016 & 2017)

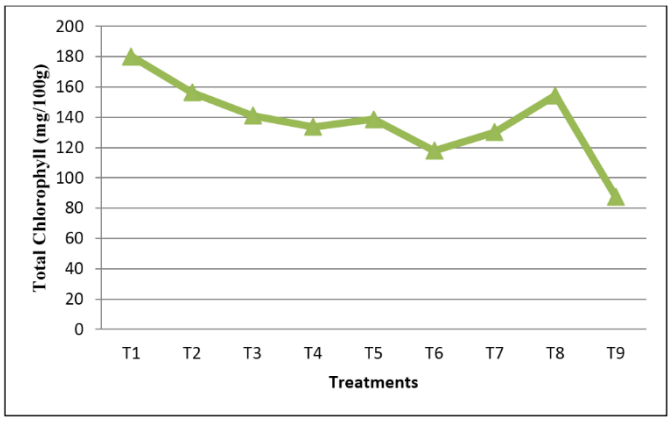

Fig 7: Impact of sewage sludge and Dal weed compost on total chlorophyll (mg/100g) of kale (pooled data of 2016 & 2017)

Conclusion

From the present study it was concluded that among 9 treatments under study, T1 (20% sewage sludge + 80% RFD) and T2 (40% sewage sludge + 60% RFD) proved superior over rest of the treatments with respect to improvement in yield, root biomass and quality attributes.

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