Journal of Phytology 2009, 1(6): 353–360

ISSN: 2075-6240
Available Online: www.journal-phytology.com

REGULAR ARTICLE

UTILIZING COMPOSTED *JATROPHA*, NEEM CAKE AND TOBACCO WASTE TO SUSTAIN GARLIC YIELDS IN INDO-GANGETIC PLAINS

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SUMMARY

The effect of composted *Jatropha* de-oiled cake, neem de-oiled cake and tobacco waste on morphological parameters like maximum leaf length, number of leaves, fresh and dry weight of bulb and yield was studied for Garlic (*Allium sativum* L.). Trials were conducted on field plots under the RBD design. The parameters recorded for plants grown on soil treated with composted organic fertilizer treatments were compared to those recorded for plants grown on chemical fertilizer treated soil and control. The results showed that the application of 2 tones per hectare mixture of composted *Jatropha* cake and tobacco waste (in ratio 2:1) resulted in an increase of 22.88 % in fresh bulb weight, 29.52% in dried bulb weight per plant and 18.3% in average yield of bulb as compared to control. This yield enhancement was significantly higher than control and comparable to that recorded for plants grown on soil treated with chemical fertilizers. The significant increase in garlic yield on application of composted *Jatropha* cake and tobacco waste is due to the availability of higher amount of nutrients, especially the macronutrients like nitrogen and potassium. Thus, *Jatropha* cake and tobacco waste based organic fertilizer application enables sustainable agriculture with yield enhancements and is a viable alternative to synthetic inorganic fertilizers.

Keywords: *Jatropha* cake, Tobaco waste, Neem cake, Compost, Urea, Garlic.

Shivani Chaturvedi et al. Utilizing Composted *Jatropha*, Neem Cake and Tobacco Waste to Sustain Garlic Yields in Indo-Gangetic Plains. J Phytol 1 (2009) 353-360

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1. Introduction

Organic farming is not an end in itself, but it is one of the ways to maintain soil health while retaining the productivity levels. The era after green revolution has witnessed rising levels of environmental pollution due to excessive use of agrochemicals and fertilizers, threatening our fragile ecosystem. Therefore, to make farming sustainable, it is essential that eco-friendly technologies, which can maintain soil health and increase the agricultural productivity, are developed and made available to the farmers. Organic farming conserves soil fertility and contains soil erosion through implementation of appropriate sustainable conservation principles.

Organic farming is a method of farming which avoids or largely excludes the use of harmful chemicals such as chemical fertilizers, pesticides and herbicides and depends on use of natural resources such as organic matter, minerals and microbes to achieve enhanced productivity levels while preserving the environment and ecological balance. Organic farming systems rely on large scale application of animal wastes or FYM, compost, crop rotation, crop residues, green manure, vermicompost, biofertilizers VAM, bio pesticides and biological control. Recently, one of the co-author reported the better role of vermicompost over fym in increasing biomass yield and also supported the role played by co-inoculation of Azotobacter and arbuscular mycorrhizal (AM) fungi in alleviating salt stress in *Jatropha curcas* [1]-[2].

The de-oiled seed cake of *Jatropha* is a major by-product of the Bio-diesel extraction process. It is estimated that each hectare of *Jatropha* plantation will produce 1000kg seedcake/ hectare crop Mahanta et al., [3]. The cake is rich in nitrogen (3.2%) and phosphorus (1.4%) & potassium and can be used as manures [4]-[5]. Similarly, the de-oiled seed cake of neem has also been associated with significant improvement in the growth of mungbean and chickpea [6] and when combined mahua resulted in improvement in plant growth of pea [7]. Waste from tobacco industry could be mixed with inorganic fertilizers or used as raw materials in composting [8] and its addition to tomato crop enhanced its growth [9].

Even though the above mentioned bio-wastes have shown tremendous potential for being used as organic fertilizers, but there is a dearth of studies on their impacts on commercial crops like garlic. Further, lack of tailored crop specific recommendations have also limited their commercial exploitation. If crop specific organic fertilizer formulations are developed that can enhance yields comparable to inorganic fertilizers, then they can be used as viable alternatives to inorganic fertilizers.

In present work, the effect of application of *Jatropha* cake, neem cake, tobacco waste and FYM on growth and productivity of Garlic crop was investigated along with a comparative analysis with soil, which was unfertilized (control) and treated with chemical fertilizer. The objective was to develop tailored organic fertilizer formulations from bio-wastes for garlic crop for use in farms as a commercially viable alternative to chemical fertilizers.

2. Materials and Methods

Waste used and processing methods adopted

Jatropha and Neem cakes were procured from a local bio-diesel extraction expeller unit situated at NBRI (National Botanical Research Institute), Lucknow. The dried tobacco waste was obtained from a local processing unit 'Sanjay Jarda Factory' situated at Chottashah Alamroad, Shahdatganj in district Lucknow, Uttar Pradesh, India. Prior to use, the dried *Jatropha*, neem and tobacco waste were composted by grounding with a hammer mill and then allowed to decompose in separate containers for one year. Watering was done at ten days intervals in winters and five days intervals in summers. During watering, turning of the wastes was also carried out. Composting was carried out to facilitate rapid release of nutrients to the crop.

Location of Experiment and description of composts use for treatments of soil

The study was conducted during winters of 2006-07 at NBRI, Lucknow, India (27.10°N and 81.13°E) in Randomized Block Design (RBD). The four different organic fertilizer and nitrogenous fertilizer (120 kg per ha of urea) treatments were applied on soil of Aurawan, Luknow. A control (unfertilized) soil was also used for the experiment.

The composted form of *Jatropha* cake, neem cake and tobacco waste of various formulations were applied at 2 tonnes per hectare and FYM was applied at 12 tonnes per hectare on the Garlic crop. The application of 120 kg ha-1 of urea as chemical inorganic fertilizer was based on the recommendation of National Botanical Research Institute, Lucknow, booklet and the doses of composted formulations and FYM were in a manner that they would provide equivalent amount of nitrogen to the soil. The organic waste composition used under various treatments is given in Table 1.

Table 1. The de-oiled quantities used in each treatments used for crop of Garlic

Treatment	The organic fertilizer formulations	The Nitrogen Availability (Kg per hectare)
T1	Control, normal garden soil without any fertilization	
T2	Farm yard manure (FYM) 12 tonne ha-1 crop-1	60
T3	*Jatropha* de-oiled composted cake 2 tonne ha-1 crop-1	59
T4	Neem de-oiled composted cake 2 tonne ha-1 crop-1	54
T5	*Jatropha* de-oiled composted cake+ Tobacco waste (in ratio 2:1) 2 tonne ha-1 crop-1	54
T6	Urea 120 kg ha-1 crop-1	55

The field plots of 6 m2 (3m x 2m) were prepared and three such plots were used for each of the treatment (i.e. altogether 18 plots). Garlic seedlings were planted at a spacing of 15 x 10 cm and two crops were taken. The urea fertilizer as well as organic fertilizers treatments was given as top dressing after five weeks of planting. The plots were manually weeded on third, fifth and eighth weeks after planting. Watering was carried out once in ten days.

Measurement and Analysis

The *Jatropha* cake, neem cake, tobacco waste and FYM were analyzed for their respective nutrient contents. Soil samples were randomly taken from the entire field at depths of 0-15 cm and 15-30 cm respectively before planting or fertilizer application. They were stored in polythene bags, air dried and sieved with a 2 mm sieve for routine analysis. The soil pH was determined with the help of a pH meter.

Acidity was measured from 0.1 M HCl extracts by titrating with 0.1 M NaOH. The percentage of nitrogen was determined using kjeldahl method [10], phosphorous using a Spectrophotometer, potassium and calcium using flame photometer and micronutrients using an Atomic Absorption Spectrophotometer [11] .

Out of the available 80 plants plot-1 (on an average), 5 plants were selected randomly from each plot for measuring and recording morphological parameters like maximum leaf length in cm (from stem base to the end of lamina), leaf numbers per plant and fresh bulb yield. The garlic bulbs were harvested at fresh marketable stage after 18 weeks of planting. This was done by lifting the complete crop from the soil using hoe and then air drying for 9 weeks under shade. The average fresh bulb and dry yield were determined from data of the complete plot recorded after the harvest.

Statistical Analysis

The data collected was subjected to statistical analysis by one way analysis of variance

(ANOVA) using SPSS Windows (version 10.0). Statistical significances were defined at 5 % level.

3. Results and Discussions

The nutrient composition of the organic fertilizers used for the experiments is given in Table 2. Further, the key nutrients supplied to soil under various treatments are given in table 1. The compost prepared from *Jatropha* cake and neem cake had the highest nutrient status with respect to NPK. Amounts of most micro nutrients differed between various composts. For instance, *Jatropha* cake is also relatively high in micronutrients like iron while tobacco waste is rich in calcium and copper. The chemical properties of the soil before the respective treatments are presented in Table 3. The yield and morphological parameters recorded for garlic crop under various soil treatments are given in Table 4.

Table 2. The chemical composition of organic waste used for cultivation of Garlic

Organic wastes	N %	P %	K (%)	Ca %	Fe µg/g	Zn µg/g	Cu µg/g
Jatropha de-oiled cake	2.95	0.83	1.0	0.65	785	47.5	26.4
Neem de-oiled cake	2.7	1.08	0.95	0.65	862	29.5	13.4
Tobacco waste	2.1	0.8	0.63	160	175	22	46

Table 3. Chemical characteristics of soil before planting Garlic crop

Soil parameters	Values
Soil pH	8.6 ± 0.10
EC millimose cm-1	0.19 ± 0.002
Organic matter (%)	0.59 ± 0.01
Total N (µg/g)	610 ± 0.015
Total P (µg/g)	615 ± 0.006
Total K (µg/g)	243.66 ± 7.76
Mg(µmolcg-1 soil)	3.3 ± 15.27
Ca (µmolcg-1 soil)	3.8 ± 2.00
Na (µmolcg-1 soil)	83.2 ± 10

Table 4. Yield and morphological parameters for Garlic crop under various treatments

Treatments	Average Maximum leaf length(cm)	Average leaf numbers	Average Fresh Weight per bulb(grams)	Average Dry Weight per bulb(grams)	Average Yield of fresh bulb (Quintals/ hectare)	Average yield of dry bulb (Quintals/ hectare)
T1	53.10	7.27	22.03	9.01	23.47	7.60
T2	52.73	7.33	23.78*	9.60	24.89	10.40
T3	54.60	7.60	24.68*	9.67	26.44*	7.40
T4	53.67	7.53	24.39*	9.134	21.39	9.20
T5	54.53	7.80	27.07*	11.67*	27.81*	9.30
T6	54.22	7.80	26.39*	10.82	26.53	8.70

Difference was significant as compare to the corresponding control values (T1) at 5% significance level

The percentage increase or decrease in the parameters recorded with respect to control is given in Figures 1 to 6. The results revealed that there were insignificant differences in average maximum leaf length and average leaf numbers per plant for various treatments as compared to the control.

Figure-1: Percentage change in Average Maximum leaf length for Garlic plants grown under various treatments as compared to control

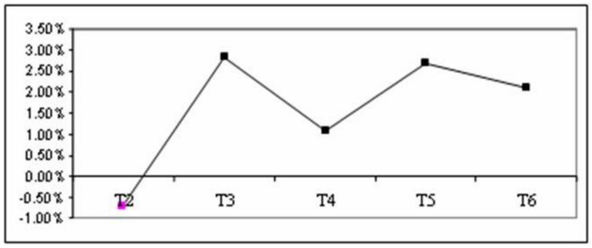


Fig. 2. Percentage change in Average Maximum leaf numbers for Garlic plants grown under various treatments as compared to control

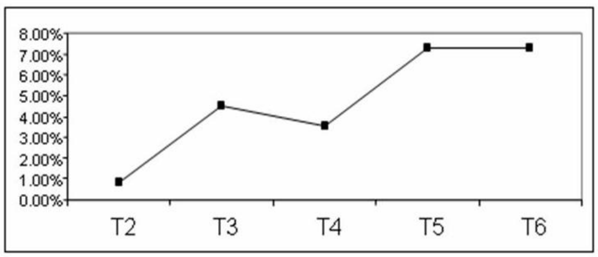


Fig.3. Percentage change Average Fresh Weight per bulb for Garlic plants grown under various treatments as compared to control

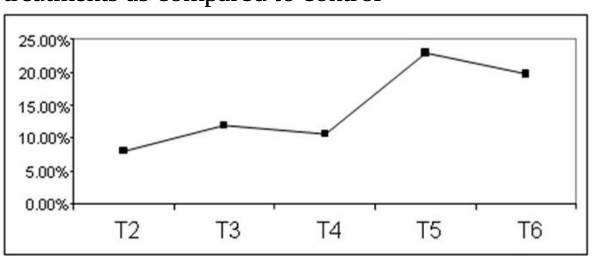


Fig. 4. Percentage change in Average Dry Weight per bulb for Garlic plants grown under various treatments as compared to control

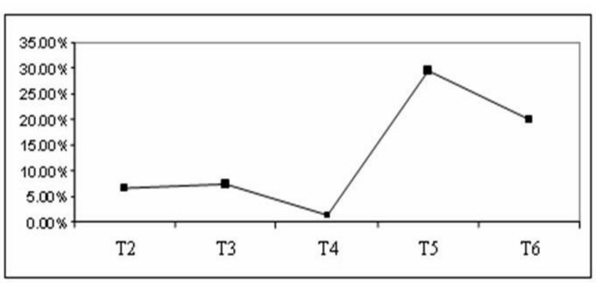


Fig. 5. Percentage change in Average Yield of Fresh Garlic plants grown under various treatments as compared to control

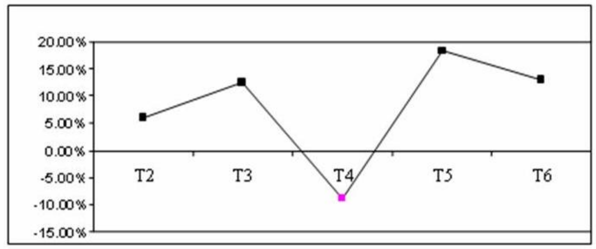
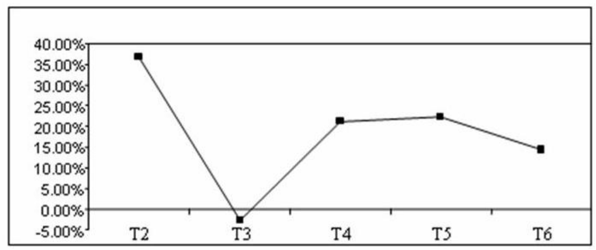


Fig. 6. Percentage change in Average Yield of Dry bulb for Garlic plants grown under various treatments as compared to control



The results related to average bulb weights revealed that for all the treatments (T2 to T6), the average fresh weight per bulb was significantly higher than control. However, treatment T5 recorded the highest increase of 22.88% over the control followed by T6 with 19.79%, T3 with 12%, T4 with 10.71% and T2 with 7.94%. This might be on account of synergistic effect of organic manure by supplying of nutrient elements to the plant and also by improving soil physical characteristics [12-14]. The favorable effect of early nitrogen fertilization on garlic yield has already been demonstrated through extensive field trials [15- 18]. This effect can be interpreted in terms of an increase in foliar growth which ensures a higher photosynthesis potential and then promotes the synthesis and accumulation of reserve carbohydrates in the garlic bulb.

The randomly selected samples of fresh bulbs were then dried and the dry weights were measured. The results revealed that T5 recorded highest percentage increase of 29.52% over the control. This increase was comparable with that recorded for garlic grown on chemical fertilizer which was 20%. Increase was also recorded for treatments T2, T3 & T4, however these were insignificant. The earlier researchers have indicated that yield advantages of the organic manures over inorganic fertilizer obtained in experiment were probably due to the effects of the organic manures in improving the physical characteristics of the soil [14] and to their supply of the macro and trace elements not contained in the inorganic fertilizer. Jaramillo [19] had showed the significant beneficial effects of the trace elements Fe, Zn and B on tomato fruit yield.

The average yields of dry and fresh bulb weight were recorded using the data recorded after harvesting the complete crop. Similar results were achieved for average yields of fresh garlic bulb with 18.3% increase corresponding to T5 as compared to the control. The highest increase for yield of dry bulb was, however, recorded for T2 (FYM treated soil) which was 36.84% followed by T5 with 22.37% and T4 with 21.05%. Agarwal et al., [20] observed the beneficial effect of nutrients like nitrogen and phosphorus on plant growth and yield of moong and bean. Similarly, Levizou and Manetas [21] also observed that a high nutrient level of NPK improves the growth in *Phlomis fruticosa*. Bogatirenke [22] recorded a yield of 91centners/ha by using 40 tonnes of FYM as compared to 79 centners from the untreated field. In Brazil, Pereira [23] however obtained highest yield (7067kg/ha) with 20 tonnes compost/ha which decreased to 6800kg/ha at 50tonnes compost/ha. The seed cake was found to be biodegradable when used as organic manure. Similarly, neem oil cake was found to have a high NPK content with NPK percentage reported as 5.2, 1.1-1.5 and 1.5-1.7 and has been recommended for use as a fertilizer for enhancing the soil productivity.

Tobacco waste addition to tomato crop has earlier shown to enhance the growth [9] and also significantly increase the N-content of wheat straw and wheat grain [24]. Application of tobacco waste to alkaline soils was found to improve both soil conditions and nutrient concentration of soil [25].

The above results indicate that treating the soil with 2 tonnes per hectare of composted *Jatropha* cake and tobacco waste in the ratio 2:1 has resulted in a significant increase in yield, weight of fresh bulb and dry bulbs. The increase is more significant in case of average dry weight per bulb. Furthermore, the increase in yield is comparable to that achieved through application of chemical fertilizers. Even though the past studies have demonstrated that bio-waste applications improve yields, however, tailored crop specific formulations have not yet being developed. The present study has, however, successfully demonstrated that application of crop specific organic fertilizer formulations to soil can result in yield enhancement comparable to chemical fertilizers. Since these organic fertilizers have been developed from wastes of the bio-diesel extraction process and tobacco industry, they thus offer a sustainable, commercially viable and cost effective alternative.

4. Conclusions

This study clearly demonstrated that the optimal use of composted *Jatropha* deoiled cake, Neem cake and Tobacco waste formulations leads to the desired increase in yields of the Garlic crop. Use of Bio-wastes in a composted form as organic fertilizer not only ensures sustainable development but also reduces the cost of farming. These tailored formulations developed for garlic crop can be commercially propagated and popularized as a viable alternative to chemical fertilizers.

Acknowledgements

The authors are highly grateful to National Botanical Research Institute, Lucknow and Indian Institute of technology Delhi for providing research facilities. The project is under the financial support of Department of Science and Technology (DST), New Delhi.

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