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Treatment of Biowaste (Generated in Biodiesel Process) - A New Strategy for Green Environment and Horticulture Crop

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***Abstract*—**Recent research on seeds of bio-diesel plants like *Jatropha curcas*, constituting 40-50% bio-crude oil indicates its potential as one of the most promising alternatives to conventional sources of energy. Also, limited studies on utilization of de-oiled cake have revealed that *Jatropha* bio-waste has good potential to be used as organic fertilizers produced via aerobic and anaerobic treatment. However, their commercial exploitation has not yet been possible. The present study aims at developing appropriate bio-processes and formulations utilizing *Jatropha* seed cake as organic fertilizer, for improving the growth of *Polianthes tuberose* L. (Tuberose). Pot experiments were carried out by growing tuberose plants on soil treated with composted formulations of *Jatropha* de-oiled cake, Farm Yard Manure (FYM) and inorganic fertilizers were also blended in soil. The treatment was carried out through soil amendment as well as foliar spray. The growth and morphological parameters were monitored for entire crop cycle.

The growth Length and number of leaves, spike length, rachis length, number of bulb per plant and earliness of sprouting of bulb and yield enhancement were comparable to that achieved under inorganic fertilizer. Furthermore, performance of inorganic fertilizer also showed an improvement when blended with composted bio-waste. These findings would open new avenues for *Jatropha* based bio-wastes to be composted and used as organic fertilizers for commercial floriculture.

***Keywords*—**Organic fertilizer, Jaropha cake, Tuberose (Polianthes tuberosa L.).

I. Introduction

Tuberose (*Polianthes tuberosa* L.) is an important flower crop native of Mexico. It is of commercial significance having an economical potential for the cut flower trade due to its beauty & fragrance [1].

The flower spikes are in great demand in global markets throughout the year. It is also a very good source for essential oil industry [5]. The total area under tuberose cultivation in India recorded during 1998-99 was 28.23 ton [4]. For the production of good quality tuberose spike at reasonable cost, it is necessary to have standard agro-technique based on latest technology. Yield and quality of tuberose could also be improved and enhanced by application of different organics and bio-fertilizers.

Various organic fertilizers have been tried to enhance productivity and flowering of the tuberose crop. Use of Azatobacter alone or in combination with others improved the growth and yield of tuberose [10]. Recently limited studies has also been reported on potential of *Jatropha* bio-wastes to be used as organic fertilizers [12]. 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 [8]. The cake is rich in nitrogen (3.2%) and phosphorus (1.4%) & potassium (1.3%) and can be used as manures [6], [9]. The application of mixture consisting of 20 kg well rotten cow dung, 200g *Jatropha* cake and 100g bone meal applied after pruning of the plants have demonstrated improved growth and flowering of roses [2].

However, their commercial exploitation has not been possible since its efficacy vis-a-vis inorganic fertilizers in terms of yield is yet not established. Further more, crop specific organic fertilizer formulation de-oiled seed cake has not been attempted to enhance the confidence of the farmer to get yield at par with inorganic fertilizers. Also, studies that demonstrates the impact of *Jatropha* based organic fertilizers on the growth and yield of the tuberose crop are lacking.

The present study aims at developing appropriate bio-processes and formulations utilizing *Jatropha* seed cake as organic fertilizer, for improving the growth of *Polianthes tuberose* L. Investigation was undertaken to study the effect of *Jatropha* cake on sprouting, growth, flowering and yield of tuberose plants.

II. Materials And Methods

The experiment was carried out during the year 2005-06 and 2006-2007 at Aurawan field station of National Botanical Research Institute (NBRI), Lucknow. The pot experiment was conducted under seven different treatments and with ten replicates each. The composted *Jatropha* cake, FYM and chemical fertilizers were mixed in soil to prepare 6 kg pots.

The treatments consists of control (T1), FYM at 1.5 kg pot $^{-1}$ (T_2), chemical fertilizer 18g pot $^{-1}$ (T_3), *Jatropha* cake 120g pot $^{-1}$ (T4), *Jatropha* cake 240g pot $^{-1}$ (T_5), 0.9 kg FYM + 100g *Jatropha* cake pot $^{-1}$ (T_6), 9g chemical fertilizer + 120g *Jatropha* cake pot $^{-1}$ (T_7).

Healthy bulbs of uniform size having approximate diameter of 1-2.0 cm. weighing 25-28g were selected for planting. Planting of bulbs was done in mid march directly into pots with treated soil. Weeding, hoeing, irrigation was done whenever necessary throughout the course of

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investigation. The data on growth, flowering parameters (length of spike, number of floret per spike and rachis length) and yield were recorded and analyzed.

TABLE I
NITROGEN PROVIDED TO SOIL UNDER VARIOUS TREATMENTS

Treatment		Description	Nitrogen provided/pot
T1	Control	Normal Garden Soil	Nil
T2	FYM 25%	25 % (or 1.5 Kg/pot)	7.5 g, @ 0.5 %
T3	Chem. fert. 0.2% + 0.1% Top dressing	Urea 18 g/pot, two phases	8.1 g, @45 %
T4	Jatropha cake 2%	Composted cake 120 g/pot	3.6 g, @ 3%
T5	Jatropha cake 4%	Composted cake 240 g/pot	7.2 g
T6	FYM 15% + Jat 1.6%	FYM 0.9 Kg + 100 g/pot composted cake	8.1 g (4.5 + 3.6)g
T7	Chem. fert. 0.15% + Jat 1.6%	Urea 9 g + 120 g/pot composted cake	7.6 g (4 + 3.6)g

Note: Percentages are given by weight; one pot consists of 6 Kg treated soil

The details of various combinations of organic & inorganic fertilizer applied under various treatments are given in Table I. The table also gives the amount of nitrogen provided per plot under various treatments. It is evident from the table that while preparing the treatments, it was ensured that the nitrogen being provided under various treatments is same so that a comparative assessment can be done.

III. RESULTS & DISCUSSION

A. Crop Performance: Growth parameters

The results of growth parameters like maximum leaf length and number of leaves per plant under various treatments are given in Table II. The percentage increase has been shown in Fig. 1. The results reveal that there has been a significant increase in maximum leaf length for the treatments T4, T5 and T6 and insignificant variation was recorded for other treatments. The enhancement recorded for T5 was about 16% followed by T6 (14%) & T4 (10%) as compared to control. This result indicates that application of composted de-oiled Jatropha cake has lead to very significant improvements in the leaf length and its application together with FYM has also yielded positive results.

Interestingly, the growth recorded for the above mentioned treatments was also higher as compared to chemical fertilizer treatment.

Similarly, the data regarding the number of leaves per plant, shown in Table I and Fig. 1 also reveal that there has been a significantly increase in case of treatment T4, T5 & T6. The increase recorded is as high as 100% for T5, followed by 61% for T4 and 30% for T6. The number of leaves per plant for T4, T5 & T6 was significantly higher than those recorded for chemical fertilizer (T3 & T7).

The results of one way ANOVA test for various parameters have been displayed in Table III. The results reveal that F calculated for the variables maximum leaf length and number of leaves per plant corresponding to the treatment was higher Than F value corresponding to 5% significance (obtained from the F Table). This leads us to reject the hypothesis that application of various organic fertilizer treatments on tuberose plant has no impact on plant growth parameters.

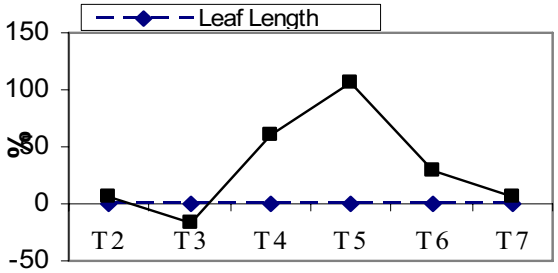

Fig. 1 Percentage increase in growth parameters under various treatments

Significantly higher number of leaves and plant height or leaf length may be due to high nitrogen and phosphorus content in *Jatropha* cake which might have helped to produce biological active substances, which favor the photosynthesis effectively and enhanced the growth and development of plants. Above results are in agreement with Deshmukh [3] in case of Gillardia.

B. Flowering Parameters

The impact of various treatments on parameter related to flowering like spike length, number of floret per spike, length of rachis & duration of flowering is also displayed in Table II. The percentage enhancements compared to control are shown in Fig. 2.

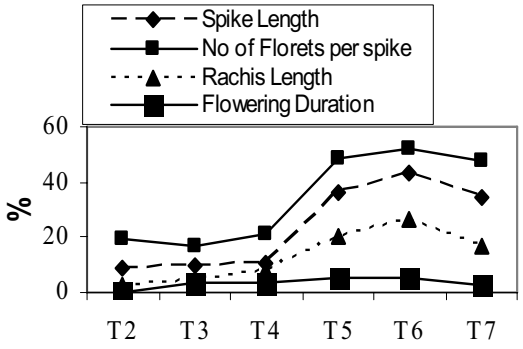

Fig. 2 Percentage increase in flowering parameters under various treatments

The results revealed that the application of all the treatments have resulted in significant increase in spike length as compared to control. However, most encouraging results were noted for the treatments T5 (36%), T6 (43%) and T7 (34%). Interestingly, while the application of *Jatropha* based organic fertilizer formulations had shown a positive impact on plant growth which was significantly higher than that corresponding to chemical fertilizer, the increase recorded for spike length is significant as compared to both FYM and chemical fertilizer.

TABLE II
EFFECT OF VARIOUS ORGANIC FERTILIZER FORMULATIONS ON KEY PARAMETERS OF TUBEROSE PLANT

Treatments	Max. Leaf Length (cm)	Leaf No./ plant	Spike Length (cm)	No. of Florets/spike	Rachis Length (cm)	Flowering Duration (days)	No. of bulbs/ plant
Control	32.36	10.00	47.99	21.29	11.39	11.00	13.57
FYM 25%	30.57	10.71	52.29	25.43	11.73	11.00	13.14
Chem. fert. 0.2% + 0.1% Top dressing	32.00	8.43	52.67	24.86	11.89	11.43	13.29
Jatropha cake 2%	35.57	16.14	53.20	25.71	12.29	11.43	13.43
Jatropha cake 4%	37.43	20.57	65.37	31.57	13.74	11.57	14.57
FYM 15%+Jat 1.6%	36.86	13.00	68.54	32.29	14.37	11.57	14.71
Chem. fert. 0.15% + Jat 1.6%	32.43	10.57	64.41	31.43	13.29	11.29	14.00
Sem	1.22	2.08	0.88	0.23	0.04	0.24	0.26
Sed	1.72	2.95	1.25	0.33	0.06	0.34	0.37
LSD	2.91	4.98	2.10	0.55	0.11	0.57	0.62

Note: The calculations are at 5 % significance; Values are average of 10 replicates

The data related to number of floret per spike also reveals the similar trends where all the treatments have shown significant enhancements as compared to control with best results achieved for T5 (48%), T6 (52%) & T7 (48%).

The results related to length of rachis reveal that there have been significant enhancements recorded for all treatments as compared to control. The highest improvement recorded is corresponding to T6 (26%) followed, by T5 (21%) and T7 (17%). This indicates that the data recorded for organic fertilizer (T5), combination of organic fertilizer with FYM (T6) and combination of chemical fertilizer with organic fertilizer (T7) all have shown significant enhancement as compared to control. Furthermore, the increase recorded in case of T5 & T6 has been significantly higher than that recorded for T3 (chemical fertilizer) as well as T7 (chemical fertilizer with organic fertilizer) indicating the higher efficacy of the organic fertilizer formulations. Similar results were observed by Kukde [7] in Tuberose with organic manure and bio-fertilizer.

The data related to the duration of flowering indicates that there has been insignificant effect of certain treatments (T2, T3, T4 & T7) on the flowering duration. However, T5 & T6 treatments enhanced the flowering duration by about 5%. This indicates that application of *Jatropha* based organic fertilizer on stand alone basis as well as in combination with FYM has lead to extended duration of flowering also. Similar trends have also reported by Yadav [11] in tuberose.

The results of ANOVA tests carried out on flowering parameters are shown in Table III. These indicate that for length of spike, number of florets per spike & length of Rachis, the calculated F value corresponding to treatment is higher than reference F value corresponding to 5% significance. This leads us to reject the null hypothesis that the application of various organic fertilizer treatments lead to insignificant impact on these parameters.

However for the duration of flowering, the F calculated is less than the F reference, indicating the insignificant impact of treatment on this parameter.

C. Yield Parameters

The data related to number of bulbs per plant (refer to Table II and Fig. 3) reveals that there has been significant increase recorded for treatments T5 & T6 as compared to control. There has been insignificant impact recorded for T2, T3, T4 & T7. The increase recorded has been 8% for T6, 7% for T5. Interestingly the yield recorded under treatments T5 & T6 is significantly higher than that recorded in case of chemical fertilizer treatment (T3 and T7). Similar results were recorded by [10] by application of bio-fertilizers and nitrogen fertilizer.

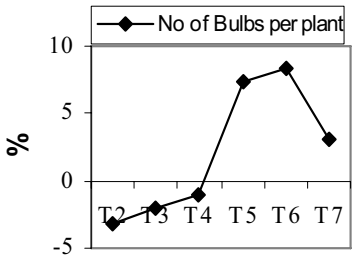

Fig. 3 Percentage increase in yield under various treatments

The results of ANOVA tests (Table III) reveal that F calculated for the variables yield per plant corresponding to the treatment was higher than F reference value corresponding to 5% significance. This leads us to reject the hypothesis that application of various organic fertilizer treatments on tuberose plant has no impact on plant yield.

Interestingly, for all the seven variables, F calculated corresponding to replicates is less than reference F value (obtained from the F table) indicating the insignificant impact of replication. This is an evidence of robustness of the experiment.

D. Sprouting

The impact of various treatments on sprouting of tuberose plant is displayed in Table IV. This table shows the percent of sprouting from the bulb after 30/ 40/ 90 days of sowing of bulbs in treated pots. The results reveal that earliest sprouting occurred in treatment T5 where in 57% seedling emerged after 30 days & 100% after 45 days. This was closely followed by control and T7 which achieved 28% sprouting in 30 days & 45% in 40 days. The most delayed sprouting was for T3 followed by T2 & T6, wherein the sprouting was 43, 57 & 57 % even after 45 days. This data leads us to conclude that chemical fertilizer delay in emergence of seedlings as compared to FYM. Surprisingly early sprouting is achieved by application of composted *Jatropha* cake in soil. The positive impact of the de-oiled composted cake on sprouting is displayed for its stand alone (T4 & T5) application as well as when applied with FYM and chemical fertilizer (T6 & T7).

TABLE III
RESULTS OF ONE WAY ANOVA CARRIED OUT ON DATA CORRESPONDING TO VARIOUS PARAMETERS OF TUBEROSE RECORDED UNDER VARIOUS TREATMENTS

F Values	Max. Leaf Length (cm)	Leaf No./ plant	Spike Length (cm)	No. of Florets/spike	Rachis Length (cm)	Flowering Duration (days)	No. of bulbs/ plant
F Calculated for Treatment	4.87	4.14	83.94	336.75	643	1.04	5.84
F reference value for treatment at 5 % significance	2.38	2.38	2.38	2.38	2.38	2.38	2.38
F calculated for replicates	1.34	0.45	1.03	2.15	0.66	0.80	0.68
F reference value for replicates at 5 % significance	2.38	2.38	2.38	2.38	2.38	2.81	2.38

Note: Degrees of freedom for treatments and replicates were 6.

TABLE IV
IMPACT OF VARIOUS TREATMENTS ON SPROUTING OF TUBEROSE

Treatments	Seedlings emerged or sprouting as a percentage of total plants after 30 days	45 days	90 days
Control	28.57	100	100
FYM 25%	28.57	57.14	100
Chem. fert. .2% + 0.1% Top dressing	0	42.86	100
Jatropha cake 2%	42.86	85.71	100
Jatropha cake 4%	57.14	100	100
FYM 15%+Jat 1.6%	28.57	57.14	100
Chem. fert.0.15%+Jat 1.6%	28.57	100	100

Successful commercial application of composted *Jatropha* de-oiled seed cake as organic fertilizer would enable these wastes to be used in a judicious and eco-friendly way as a viable alternative to the energy intensive chemical fertilizers. This would lead to energy conservation and would also help in mitigating the global climate change.

IV. CONCLUSION

Overall it is revealed that application of appropriate amount of organic formulations based on de-oiled Jatropha cake as soil amendment will lead to significant improvement in the growth parameters, flowering parameter as well as the yield of tuberose. Blending of FYM with composted Jatropha cake further enhances the yield which is comparable or even higher to chemical fertilizer treatment. In fact early emergence of seedlings by using such organic formulation as compare to chemical fertilizer is an important aspect for commercial floriculture. A systematic scientific investigation on different types of aerobic composting(example vermin composting, bio-dynamic system, NADEP technique) as well as anaerobic treatment of jatropha waste prior to its commercial application through rural entrepreneurship is warranted. It is hoped that these research findings would give a new dimensions to not only safe disposal of the io-waste of the bio-diesel extraction process but also its utilization as organic fertilizers for commercial floriculture. In addition, it would also provide an opportunity for energy savings and reduction of CO_2 emissions which will ultimately mitigate global warming. This gainful utilization also provides a solution for the problem associated with the safe disposal of de-oiled cake waste.

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