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Effect of Biofuel Crop Residues as Organic Amendments on the Growth of *Zea mays* L.

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Abstract

A pot experiment was conducted in green house to study the effects of raw uncomposted and composted organic residues (leaf litter, fruit husk and oil cake) from two important biofuel tree species - *Milletia pinnata* (L.) Panigrahi and *Simarouba glauca* DC. on the growth of *Zea mays* L. The study's comparative results showed that, both the raw uncomposted and composted biofuel residues with an exception of simarouba fruit husk gave statistically significant higher growth attributes than recommended dosages of FYM and NPK fertilizers over the control. The application of these organic residues at the rate of 10 tons/ha is recommended for use as organic amendments for higher growth of maize in particular and agriculture in general.

Keywords : *Milletia pinnata*, *Simarouba glauca*, Raw uncomposted and composted organic residues

Application of organic fertilizers to agricultural lands has gained considerable importance in recent years. Continuous and over application of inorganic fertilizers has been proved to pose serious threat to sustainable agriculture via soil pollution, ground water contamination, burning crop residues, destruction of beneficial microbial ecosystems, biomagnifications, release of green house gas, etc. Despite the presence of large numbers of and easily available nutrients in inorganic fertilizers, growth promoting agents found in organic fertilizers makes them an important soil amendment. Moreover, since chemical fertilizers are often scarce and too costly beyond the reach of local farmers, low cost locally available organic amendments such as mulch, green manure, compost, FYM, animal manure, etc. provides better long term benefits. Organic amendments could be incorporated directly or as compost. Before deciding to incorporate organic wastes as fresh or composted organic fertilizers careful attention must be given to avoid or minimized underlying risks. Sometimes, they can be added without any risk but, some of them can cause toxicity or deleterious effects due to allelopathic effect in case of plant based organic residues (Zhang *et al*., 2015) or due to presence of toxic chemicals or pathogens in case of medical/industrial wastes, municipal solid waste, animal manure *etc*. or due to unfavourable enzymatic interactions in the soil and rhizosphere. This potential risk can be avoided through proper composting procedures which through controlled biological decomposition of organic material gets transformed and sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth and soil health.

Milletia pinnata and *Simarouba glauca* are two of the many tree borne oilseed species in India. The leaves and twigs of *M. pinnata* is known to be used as green manure which when ploughed into the soil is known to reduce nematode infestations. *M. pinnata* seed cake has proven to be effective against root knot nematodes (*Meloidogyne incognita*) and root wilt fungus *Fusarium oxysporum f. sp. Lycopersici* providing nutritional value (enriched with NPK and other constituents) which improved the general plant vigour as well (Manish Singh, 2015). Besides medicinal use, (Antony *et al*., 2016) the oil yielding *S. glauca*'s seed cake is also good manure (Dinesh Chand, 2017). These multipurpose biofuel tree species will certainly be grown as widespread plantations or/and agroforestry trees as the demand for biodiesel increases in the face of current global environmental concerns to reduce green house gas emissions and mitigate the adverse effect of climate change. As the biofuel industries rises, there will be considerable residues which will be required to be managed properly in order to avoid negative effect from dumpings and landfills. One possible solution will be the conversion of these biofuel residues and application as organic fertilizers for sustainable growth. The present study, was therefore taken up with focus on the development of an effective organic fertilizer from both raw and composted biofuel tree (*Milletia pinnata* and *Simarouba glauca*) residues *viz*., leaf litter, fruit husk and oil cake to see the effects on the growth of *Zea mays* L. - the third most important cereal crop in the world and an important biofuel crop.

Material and Methods

Composting and preparation of uncomposted biofuel crop organic residues

The raw materials *viz*., leaf litter, fruit husk and oil cake of the two biofuel tree species (*M. pinnata* and *S. glauca*) were collected and composted in plastic bins with cow dung slurry at the rate of 10 per cent as source of microbial innoculum. The decomposition was allowed to occur for three months. Regular turning was done at weekly interval for aeration and moisture was maintained at 60 per cent throughout the decomposing period.

For studying the effect of raw materials (uncomposted), the collected raw materials *viz*., leaf litters, fruit husks and oil cakes of the two biofuel tree species (*M. pinnata* and *S. glauca*) were chopped into small pieces and dried.

Pot experiment

A pot experiment was conducted in green house to determine the effect of raw uncomposted and composted organic amendments on the growth attributes of maize. The treatments are listed in Table 1. The experiment was completely randomized design (CRD) with three replications. The dosages were designed as fresh material and compost at the rate of 10 tons per hectare, FYM (farm yard manure) at the rate of 7.5 tons per hectare and NPK at the rate of 150:75:37.5 kg per hectare as per the recommended package of practice. Pioneer hybrid corn 30B07 seeds as test crop were sown in pots of 5 kg soil for the study.

Table 1

List of treatments

No.	Treatments	Rate (g/5 kg soil pot)
T1	Control (only soil)	
T2	FYM	51.13
T3	Recommended NPK (Urea:DAP:MOP)	.22:1.11:0.43
T4	Pongamia leaf litter raw (PLLR)	68.18
T5	Pongamia fruit husk raw (PFHR)	68.18
T6	Pongamia oil cake raw (POCR)	68.18
T7	Simarouba leaf litter raw (SLLR)	68.18
T8	Simarouba fruit husk raw (SFHR)	68.18
T9	Simarouba oil cake raw (SOCR)	68.18
T10	Pongamia leaf litter compost (PLLC)	68.18
T11	Pongamia fruit husk compost (PFHC)	68.18
T12	Pongamia oil cake compost (POCC)	68.18
T13	Simarouba leaf litter compost (SLLC)	68.18
T14	Simarouba fruit husk compost (SFHC)	68.18
T15	Simarouba oil cake compost (SOCC)	68.18

Growth attributes measurement

Data on plant height, number of leaves, leaf area and stem diameter were taken at 30, 60 and 90 days after sowing (DAS) to assess the plant growth. Height was measured from soil surface to the highest point of the arch of the uppermost leaf whose tip is pointing down using meter rule (cm). Girth of stem was measured at the plant soil base level using measuring tape and converted into diameter (mm). Number of leaves were counted by leaf over method. Leaf area of individual leaf was calculated as the product of leaf length and breadth and was multiplied by a factor 0.75.

The average leaf area per plant was expressed in cm^2. Shoot and root dry weight were recorded at 90 DAS after carefully harvesting the plants and washed off to remove soil in the roots. Roots and shoots were separated with a knife and each replicate was replaced in separate paper bags, and oven dried at temperature of 75°C for 48 hrs to determine the dry weight.

Statistical analysis

The data was analyzed by using *One-way* ANOVA followed by DMRT (Duncan's Multiple Range Test) at the significance level of 5%. The statistical software SPSS version 25 was used for the analysis.

Results and Discussion

Leaves

The number of leaves per plant was least in T1 (control) and T8 (SFHR) at both 30 (6.00) and 60 (7.33) DAS and in T8 (SFHR) at 90 DAS (10.33) (Table 2). The highest was recorded in T12 (POCC) and T9 (SOCR) at 30 (7.33) and 90 (13.00) DAS and 9.33 in T6 (POCR) and T4 (PLLR) at 60 DAS. The leaf area was least in T8 (SFHR) (29.75 cm^2), T3 (NPK) (44.28 cm^2) and T14 (SFHC) (95.61 cm^2) at 30, 60 and 90 DAS, respectively. The maximum was recorded in T12 (POCC) at both 30 (54.61 cm^2) and 60 (84.85 cm^2) DAS and T6 (POCR) at 90 DAS (182.12 cm^2), (Table 2). This result indicated that pongamia oil cake both in raw uncomposted and composted form produced profuse number of leaves and leaf area over control whereas, simarouba fruit husk in raw form was not able to produce better results over the control (T1). This is in line with the results of Adebayo (2014) who

Table 2

Effects of raw uncomposted and composted biofuel crop residues on number of leaves and leaf area measured at 30, 60 and 90 DAS

Treatments		Number of leaves			Leaf area (cm^2)		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T1	Control	6.00 a	7.33 a	10.67 ab	47.70 cde	59.57 cd	104.15 ab
T2	FYM	7.00 b	8.67 ab	10.67 ab	34.70 bc	48.44 ab	105.54 b
T3	NPK	6.67 ab	8.33 ab	11 .00 abc	42.96 bcd	44.28 a	109.13 bc
T4	PLLR	7.00 b	9.33 b	12.33 cd	45.32 cde	58.57 cd	120.67 def
T5	PFHR	6.67 ab	9.00 b	11.67 abc	49.23 cde	67.20 de	106.32 b
T6	POCR	6.67 ab	9.33 b	12.00 bcd	51.85 cde	64.23 cde	182.12 i
T7	SLLR	7.00 b	8.67 ab	12.00 bcd	48.00 cde	55.68 bc	112.07 bcd
T8	SFHR	6.00 a	8.00 ab	10.33 a	29.75 a	58.79 cd	155.54 h
T9	SOCR	7.33 b	9.00 b	11.33 abc	41.85 bc	60.83 cde	126.41 f
T10	PLLC	6.67 ab	9.00 b	10. 67 ab	51.73 cde	82.95 f	143.22 g
T11	PFHC	6.67 ab	9.00 b	10.67 ab	42.54 bcd	66.75 de	177.83 i
T12	POCC	7.33 b	9.00 b	13.00 d	54.61 e	84.85 f	147.80 gh
T13	SLLC	7.00 b	8.33 ab	11.33 abc	47.88 cde	81.24 f	123.39 ef
T14	SFHC	7.00 b	8.33 ab	11.33 abc	51.55 cde	66.19 de	95.61 a
T15	SOCC	7.00 b	8.33 ab	10.67 ab	52.73 de	69.57 d	116.11 cd e
		*	NS	*	*	*	*
SEm ±		0.22	0.6	0.51	30	27.56	26.92
CD at 5%		0.79	1.29	1.19	9.13	8.75	8.65

Means followed by the same letter within the same column are not significantly different at 5% probability level according to Duncan's Multiple Range Test. *=significant and NS= non-significant at 5% level of significance had reported that jatropha seed cake at the rate of 2.5 tons/ha produced more profused leaves in *Amaranthus caudatus*.

Plant height and stem diameter

As per the result of the study, the plant height at 30 DAS varied from 12.00 cm (T8 SFHR) to 20.33 cm (T12 POCC), 19.53 cm (T1 control) to 33.40 cm (T9 SOCF) at 60 DAS and 35.66 cm (T8 SFHR) to 69.03 cm (T15 SOCC) at 90 DAS, (Table 3). At 30 DAS, raw treatment T8 (SFHR) recorded the minimum stem diameter (4.48 mm) (Table 3) and the application of treatment T12 (POCC) recorded maximum stem diameter of 6.27 mm and 10.71 mm at 30 and 60 DAS, respectively while T6 (POCR) produced largest stem diameter of 11.65 mm at 90 DAS. The positive effects of oil cakes of both the species in producing more plant height and bigger stem diameter can be compared with the findings of other authors (Adebayo, 2014; Mbewe, 2015; Emmanuel *et al*., 2011 and Chaturvedi *et al*., 2009).

Dry matter yield

In terms of dry matter yield, the shoot dry weight was found to be highest (13.50 g) in raw uncomposted pongamia oil Cake (T6) treated plants (Table 4). In the study, the lowest shoot dry weight (5.79 g) was recorded in plants treated with recommended dosage

TABLE 3

Effects of raw uncomposted and composted biofuel crop residues on plant height and stem diameter measured at 30, 60 and 90 DAS

Treatments		Plant height (cm)			Stem diameter (mm)		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T1	Control	16.43 bcde	19.53 a	41.66 abc	5.55 bc	8.05 a	9.65 a
T2	FYM	15.43 abc	24.53 abcd	48.03 cde	5.38 abc	9.62 bcd	9.75 a
T3	NPK	16.13 bcd	22.16 bc	43.33 bc	5.12 ab	8.16 ab	10.07 ab
T4	PLLR	17.53 bcde	27.03 bcde	37.33 ab	5.59 bc	10.07 cd	10.38 abc
T5	PFHR	17.33 bcde	25.46 bcde	48.20 cde	5.40 abc	9.43 abcd	10.47 abc
T6	POCR	17.93 bcde	26.50 bcde	51.66 ef	5.82 bc	9.65 bcd	11.65 c
T7	SLLR	18.66 cde	25.66 bcde	60.33 g	5.62 bc	9.22 abcd	10.28 abc
T8	SFHR	12.00 a	21.76 bc	35.66 a	4.48 a	8.58 abc	10.81 abc
T9	SOCR	14.30 ab	33.40 f	57.33 fg	5.43 bc	9.54 abcd	11.35 bc
T10	PLLC	15.76 abcd	28.63 cdef	59.00 g	5.77 bc	9.86 cd	10.49 abc
T11	PFHC	14.83 abc	23.60 abc	44.00 bcd	5.34 abc	8.90 abc	11.13 abc
T12	POCC	20.33 e	29.93 def	51.86 ef	6.27 c	10.71 d	11.45 bc
T13	SLLC	18.83 cde	31.05 ef	51.00 def	5.71 bc	10.71 d	11.03 abc
T14	SFHC	16.43 bcde	24.80 abcd	42.33 abc	5.73 bc	8.80 abc	10.07 ab
T15	SOCC	19.66 de	25.06 abcd	69.03 h	5.09 ab	9.42 abcd	10.60 abc
		*	*	*	NS	*	NS
SEm ±		4.51	8.68	15.76	0.25	0.61	0.61
CD at 5%		3.54	4.91	6.62	0.83	1.30	1.31

Means followed by the same letter within the same column are not significantly different at 5% probability level according to Duncan's Multiple Range Test. *=significant and NS= non-significant at 5% level of significance

TABLE 4

Effects of raw uncomposted and composted biofuel crop residues on shoot dry weight, root dry weight and total dry weight

Treatments		Shoot dry weight (g)	Root dry weight (g)	Total dry weight (g)
T1	Control	6.12 ab	1.97 a	8.11 a
T2	FYM	6.51 ab	2.42 abc	8.94 abc
T3	NPK	5.79 a	2.23 ab	8.28 a
T4	PLLR	7.63 c	2.55 abc	10.19 c
T5	PFHR	7.95 c	2.24 ab	10.20 c
T6	POCR	13.50 f	2.46 abc	15.97 e
T7	SLLR	7.14 bc	1.86 a	9.01 abc
T8	SFHR	7.07 bc	1.67 a	8.75 ab
T9	SOCR	9.34 d	3.14 c	12.49 d
T10	PLLC	6.97 bc	2.22 ab	9.19 abc
T11	PFHC	6.16 ab	1.96 a	8.14 a
T12	POCC	11.18 e	3.97 d	15.16 e
T13	SLLC	7.75 c	2.10 a	9.85 bc
T14	SFHC	6.27 ab	2.50 abc	8.78 ab
T15	SOCC	9.35 d	3.04 bc	12.40 d
		*	*	*
SEm±		0.37	0.22	0.46
CD at 5%		1.01	0.78	1.13

Means followed by the same letter within the same column are not significantly different at 5% probability level according to Duncan's Multiple Range Test. *=significant and NS= non-significant at 5% level of significance

of NPK (T3). This result is in confirmation with Kibria *et al*. (2013) who reported that NPK fertilizer did not increase the shoot dry weight of ladies finger over the control. The highest root dry weight was recorded in plants treated with composted pongamia oil cake (T12) (3.97 g) and least with raw uncomposted simarouba fruit husk (T8) (1.67 g) (Table 4). The total biomass of plants harvested at 90 days varied from 8.11 g (T1 control) to 15.97 g (T6 POCR) (Table 4). The desirable effect of pongamia oil cake on dry matter yield had also been reported by Osman *et al*. (2009).

Comparative effects of raw uncomposted and composted amendments

The results of the present study indicated that incorporation of both raw uncomposted and composted biofuel residues with the exception of T8 and T14 as organic soil amendments produced significantly higher growth attributes in maize than the application of recommended dosage of FYM and NPK fertilizers over control under green house condition. Leaf litters of the two biofuel crops and fruit husk of pongamia both in raw uncomposted and composted form (T4, T5, T7, T10, T11 and T13) (Fig. 1-5) performed fairly well with statistically similar results when compared to oil cake treatments and showed better growth attributes in maize than those of FYM and NPK

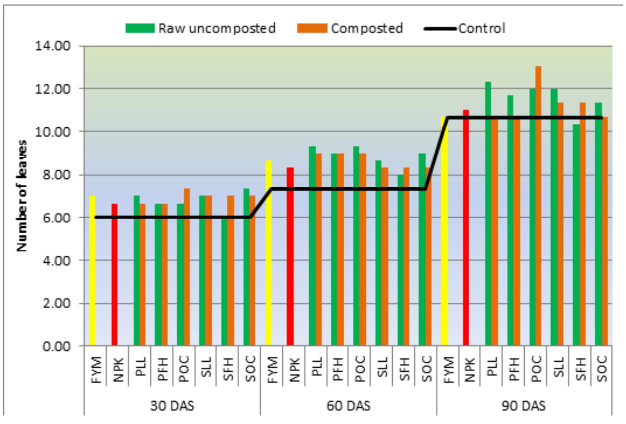

Fig. 1: Effects of raw uncomposted and composted organic materials, FYM and NPK fertilizers on number of leaves as compared to control.

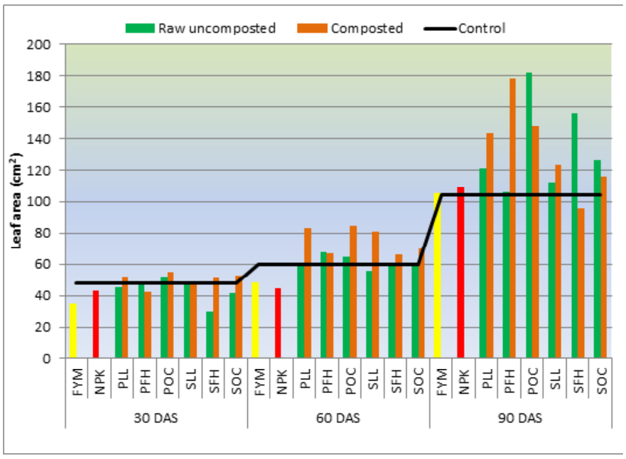

Fig. 2: Effects of raw uncomposted and composted organic materials, FYM and NPK fertilizers on leaf area as compared to control.

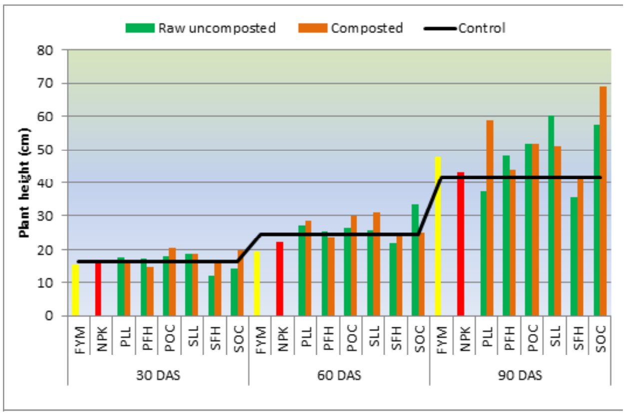

Fig. 3: Effects of raw uncomposted and composted organic materials, FYM and NPK fertilizers on plant height as compared to control.

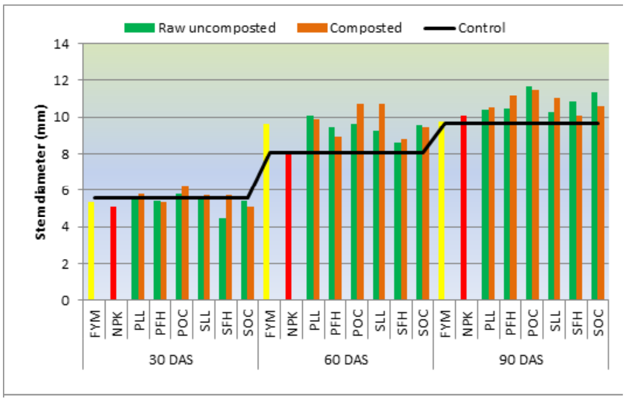

Fig. 4: Effects of raw uncomposted and composted organic materials, FYM and NPK fertilizers on stem diameter as compared to control.

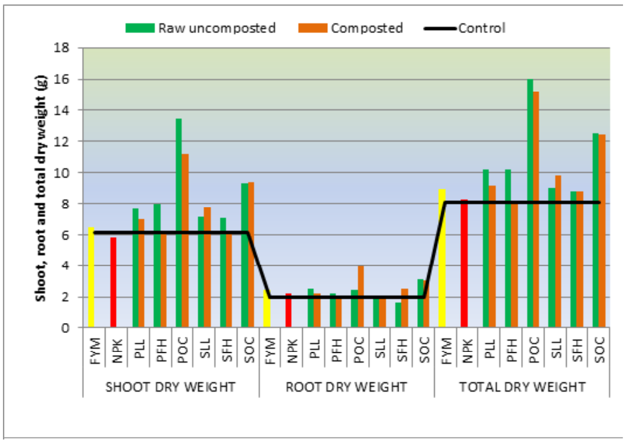

Fig. 5 : Effects of raw uncomposted and composted organic materials, FYM and NPK fertilizers on shoot, root and total dry weight as compared to control.

fertilizers. These results could mean that leaf litters of the two species are free from any toxicity or allelopathic effect that poses threat to the growth and establishment of crops in agroforestry systems diverging from the findings of Aiyelari *et al.* (2011) and Zhang *et al.* (2015), who showed that *Terminalia catappa* leaves applied as compost or mulch at 5 and 10 t/ha, respectively did not produce statistically significant ($p<0.005$) differences in terms of morphological parameters, dry matter and pod yield of okra and extracts from decomposed litter of *Eucommia ulmoides*, *Populus canadensis*, and *Malus pumila* inhibited the germination and seedling growth. Oil cakes of both *M. pinnata* and *S. glauca* either as raw uncomposted or composted (T6, T9, T12 and T15) (Fig. 1-5) applied at the rate of 10 tons per hectare performed equally and produced the maximum number of leaves, leaf area, stem diameter, plant height, shoot dry weight, root dry weight and total dry weight. This could be due tothe improved mineral content of soil by seed cake which in turn increased the yield of maize crop (Emmanuel *et al.*, 2011). Chaturvedi *et al.* (2009) suggested that such positive effects could not be attributed solely to the chemical and physical properties of composted de-oiled cake. However, they opined that the synergistic effect of karanjin could not be ruled out.

The results of this comparative study dismissed the findings by Badar *et al.* (2015) and Vijayakumari and Hiranmai (2012) who had found that composted organic materials enhanced more growth as compared to uncomposted material. Memon *et al.* (2012) also presented their work in favour of composted organic waste. Their results of pot experiment due to application of un-decomposed farmyard manure, un-decomposed banana waste and undecomposed pressmud generally depressed plant growth and dry matter yields as compared to control treatment in maize.

To maintain or restore soil fertility and produce sustainable agriculture yields while minimizing any harmful environmental effects and reduce the burden of biofuel by-products disposal and handling problems, the biofuel residues can be used beneficially as organic soil amendment. The results from the present study indicated that application of the biofuel tree species

(*M. pinnata* and *S. glauca*) residues *viz*, leaf litters, fruit husk (of *M. pinnata*) and oil cake either as raw uncomposted or composted form at the rate of 10 tons/ ha can be successfully adopted as organic amendments in agriculture.

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