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Biodegraded agroindustrial wastes as soil amendments for plant growth

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The biodegraded products of jutestick and sugarcane bagasse by organisms like *T. viride, C. globosum* and *P. saior-caju* were used as amendment to soil to study growth promoting effect on rice and pea seedlings. On both substrates significant promotion of growth was recorded more so with sugarcane bagasse. Of the three organisms, wastes degraded by *C. globosum* proved to be the best promoter of plant growth followed by *T. viride* and *P. sajor-caju*.

Key words : Biodegradation, Jute stick, Sugarcane bagasse, Soil, *Trichoderma viride*, *Chaetomium globosum*, *Pleurotus sajor-caju*, Rice & Pea seedlings

INTRODUCTION

Biodegraded agroindustrial wastes often improve soil fertility through promotion of growth and weight of biomass (Chattopadhyay, 1982). Sometimes, the degraded products may not favour crop growth. Under laboratory condition degradation represents a simple process as the organism faces only limited intraspecific competition. In the field condition, however, a strong interspecific competition may be expected because of presence of several organisms in the soil. The test organisms itself may be replaced by other organisms during degradation in soil. During degradation phytotoxic substances are often

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produced by soil inhabiting microorganisms (Sinha, 1975). Sometimes, these phytotoxic substances lose their activities by other organisms when it is left over for long (Kute *et al.*, 1967).

In the sterile soil, usually less complexity arises by the test organism(s) at the time of degradation than in natural soil because of absenee of organisms other than the inoculated ones, Such seminatural condition is helpful to understand the nature of degraded products and efficiency of the test organisms under limited competition in soil. The seminatural condition can be advantageously used to determine the effect of biodegradation by the test organisms and the subsequent effect of the products on crop growth. In natural soil, degradation seems to be complex because of higher microbial competition. Here a competition between the test organisms and the preexisting colonizers of the soil is always encountered. Therefore, an efficient degrading organism should possess not only more competitive character for substrate utilization but also should be more tolerant to antibiotics and microbe-static growth products of others in soil. Degradation of agroindustrial wastes in soil, which involves complex interactions, transformations and productions, plays an important role in determining soil productivity,

The present investigation reports the relative efficiencies of some degraders viz., *Trichoderma viride, Chaetomium globosum* and *Pleurotus sajor-caju* in determining growth of rice and pea plants when soil was amended with different agroindustrial wastes like jutestick and sugarcane bagasse under varying soil conditions.

MATERIALS AND METHODS

Effect of biodegraded jutestick and sugarcane bagasse as soil amendment in promoting crop growth was carried out using rice seedlings during June to July and pea seedlings during November to December.

Crop growth in sterile soil : Earthen pots (6″) containing 2.5 kg. of soil, sterilized by autoclaving at 20 lbs pressure p.s.i. for 1 h on two consecutive days were used. Ten days' old rice seedling ('Ratna' variety) and 7 days old pea seedlings ('Azad' variety) of more or less identical size were transplanted from seed bed to pots (5 seedlings/pot) and kept in net-house. Length of the plants and the number of the leaves were recorded after 20, 40 and 60 days. The plants were given equal amount of sterilized distilled water from time to time. Final biomass of each plant was measured on dry weight basis by uprooting the plants from soil with their entire root system, washing them thoroughly in running water and drying them to constant weight in an oven at 65°C.

Crop growth on soil amended with agroindustrial wastes : Soil (2.5 kg) mixed thoroughly with powdered jutestick or sugarcane bagasse (100 g) and taken in earthen pots (6″ diameter), were sterilized as before. Rice and pea seedlings were transplanted to the pots and were periodically watered as stated earlier. Length of plants and number of leaves were recorded and final biomass was determined as before.

Crop growth on soil supplemented with degraded wastes : Soil (2.5 kg) was taken in pots (6″ diameter) and the soil surface was covered by powdered jute-stick or sugarcane bagasse (100 g) and sterilized as before. Pots were first inculated separatetely with 50 ml of spore suspension ca. 4.4 x 10^7 spores/ml. In case of *Pleurotus sajor-caju*, mycelial suspension of almost same potency was inoculated. These were kept for 10 days to allow the organisms to estabiish in the pot-soil. After 10 days the degraded material was mixed thoroughly with the soil and left over for another 20 days. A set of control (without the fungi) and a set of blank (with only sterile soil) were also maintained. After 20 days, rice and pea seedlings of about equal length were transplanted and periodic moistening of soil was done as before. Growth of seedlings, number of leaves and the final biomass production was determined as earlier.

RESULTS

Effect of degraded agroindustrtal wastes on growth of rice plants (Table 1).

In sterilized soil (blank set) rice plants showed fair amount of root and shoot growth. Root growth increased steadily with time but shoot growth was low till 40 days of incubation and then increased after 60 days. Leaf number and biomass increased with time to 11 and 1.82 g respectively after 60 days.

When soil was mixed with undegraded powdegraded powdered jutestick (control set-1) growth of root and shoot of rice plant considerably increased over the blank-set and it was 8 cm and 26.5 cm respectively after 60 days. Root increased steadily with time while shoot, leaf number and biomass production increased only after 60 days.

Soil mixed with undegraded powdered sugarcane bagasse (control set-2) also showed increased growth over the blank set as well as that in soil with jutestick (control set-1). Root increased steadily with time. Shoot, leaf number and biomass increased to the maximum after 60 days.

When soil was amended with wastes degraded by *I. viride*, root growth more than doubled after 20 days and further increased to about three times of the control after 60 days wh)le shoot increased to about one and half times of the control set. Growth of root, shoot and leaf number was maximum after 60 days in conformity with the highest biomass produetion.

Soil amended with degraded jutestick by *C. globosum*, root growth was two and half times or more over control after only 20 days which further increased to more than three times after 60 days. In case of sugarcane bagasse where root growth was about four and half times over control after 40 days while shoot growth was one and half times even after 20 days oniy. Growth of root. shoot and leaf number reached maximum after 60 days as was also reflected in highest biomass production particularly on sugarcane bagasse.

When soil was amended with degraded wastes by *P. sajor-caju* root growth was more than double our control after only 20 days while shoot growth was one and half times or more than that of control set. Growth of root, shoot and leaf number was maximum after 60 days as was reflected in highest amount of biomass production.

Of the two substrates, growth promotion was higher on sugarcane bagasse than that on jutestick and highest by *C. globosum* followed by *T. viride* and *P. sajor-caju*.

Effect of degraded agroindustrial wastes on growth of pea plants (Table 2).

In sterilized soil (blank set) some root and shoot growth occurred in pea plants which reached maximum after 60 days of incubation. Leaf number and biomass increased with time and were 27 and 0.235 g respectively after 60 days.

When soil was mixed with undegraded wastes, root and shoot growth of pea plants increased over the blank, more so with sugarcane bagasse as amendment. Leaf number and biomass increased with time to the maximum after 60 days.

When soil was amended with degraded wastes, root and shoot growth and leaf number increased steadily with time and reached maximum after 60 days when highest amount of biomass was produced.

Of the two substrates, growth and biomass production was higher in sugarcane bagasse than in jutestick and among the three organisms, C. *globosum* showed highest growth followed by *T. viride* and *P. sajor-caju*.

DISCUSSION

Some root and shoot growth was recorded in blank soil as it acted as a direct substrate and served as reservoir of nutrients and water for the crops and also provided mechanieal anchorage and favourable tilth. The components of soils viz., minerals, organic matter, water and air, the proportions of which are known to vary together form a system for plant growth (Anon, 1987).

Increased crop growth was observed following addition of amendments to soil in the form of plant residues containing carbohydrates, nitrogen, lignin etc. This might be due to increased organic matter in soil which though normally forms a small part of mineral soil, played a vital role in productivity and conditioning of the soils. It served as a source of food for soil bacteria and fungi which were responsible for converting complex organic materials into simpler substances that were subsequently used by the plants. The intermediate products of decomposition of fresh organic matter helped to improve the physical condition of the soil. The addition of organic matter was also reported earlier to improve the working quality or friability of the soil (Anon, 1987). Thus, the plant residues provided a major source of energy and nutrients for the microorganisms in agroecosystems, and affected the biological, chemical and physical properties of the soil Growth of the microbial biomass on residues enhanced the turn over of soil organic matter through concurrent immobilization, mineralization and stabilization reactions. This fundamental processes maintained plant nutrient cycle and was known to be important for long term conservation of soil organic matter through production of precursors of humic substances (Voroney *et al.*, 1989). Chemically, humus represents a mixture of decomposed or altered products of carbohydrates, proteins, fats, resins etc. which are gradually decomposed by soil microorganisms into simple mineral salts, organic acids, water, carbon dioxide and free nitrogen depending upon the initial composition of the organic matter which the plants can readily utilize.

Nitrogen plays a major role in growth and reproductive processes of plants. The relation of organic matter to nitrogen is of particular interest. Investigations have shown that the ratios among nitrogen, carbon and organic matter in the cultivated soils remaining fairly constant. The general level of carbon and nitrogen in most Indian soils is low and the C : N ratio fluctuates from 5 to 25 : 1 with an average value around 14 : 1. In our experimental sets also C : N ratio of soil was 9 : 1 and after amended with jutestick and sugarcane bagasse it became 13.68 : 1 and 13.16 : 1 respectively. In these low C : N ratio the test organisms degraded the materials very well resulting higher amout of plant growth.

Plant growth further increased when soil was amende , with the agrowastes partially degraded by the test organisms. As raw organic matter in the soil could not be directly used by the plants as nutrients, these needed to be broken down first into humus and then into simpler products before it could be so utilized. The decomposition of the organic matter primarily formed part of the feeding and growth process of the microscopic plants and animals present in soil. Sugars, starch and protein are broken down first, followed by cellulose and

Table 1. Effect of agroindustrial wastes, partially degraded by the test fungi, on growth of rice plants * after different periods

Type	Incubation period (days)	Increase in length (cm)** Root	Shoot	Leaf Number	Mean of biomass (g)
Soil (blank)	20	2.5	17	8	1.43
	40	4.8	19	9	1.60
	60	7.0	25	11	1.82
LSD (P = 0.05)		0.5	0.7	0.7	0.02
Soil + Jutestick (Control – 1)	20	3.50	18 8	10	1.65
	40	5.36	19 8	10	1.70
	60	8.00	26 5	12	2.00
LSD (P = 0 05)		0.7	0.2	0.8	0.02
Soil + Sugarcane bagasse (Control – 2)	20	4.0	18.0	10	1.72
	40	5.8	18.5	11	1.90
	60	9.0	28.0	14	2.23
LSD (P = 0.05)		0.5	0.3	1.0	0.03
Soil + Jutestick + *T. viride*	20	8.0	29.0	12	2.00
	40	12.8	30.0	16	2.50
	60	23.0	41 0	23	3.25
LSD (P = 0.05)		0.8	0.2	1.0	0.05
Soil + Sugarcane bagasse + *T. viride*	20	9.0	31.5	14	2.2
	40	14.8	32.5	18	2.8
	60	25.0	41.8	29	3.5
LSD (P = 0.05)		0.8	0.3	1.2	0.04
Soil + Jutestick + *C. globosum*	20	8.4	31.0	13	2.4
	40	13.8	32.5	18	2.8
	60	26.2	41.5	29	3.8
LSD (P = 0.05)		1.0	0.7	1.5	0.05
Soil + Sugarcane bagasse + *C. globosum*	20	9.5	32.0	18	2.75
	40	25.8	41 0	29	3.90
	60	28,5	45.0	33	4.36
LSD (P = 0.05)		1.5	0.8	1.0	0.05
Soil + Jutestick + *P. sajor-caju*	20	8 0	27.5	12	2.0
	40	13.0	29.5	16	2.4
	60	21.0	40.0	22	3.0
LSD (P = 0.05)		1.4	0.7	1.0	0.04
Soil + Sugarcane bagasse + *P. sajor-caju*	20	9.5	30.0	14	2.20
	40	14.8	32.0	18	2.70
	60	23.5	41.0	27	3.25
LSD (P = 0.05)		1.5	0.7	1.0	0.04

* Mean of 35 replicates

** Initial length Root 9 5 ± 0.1 cm
Shoot 8 0 ± 0.1 cm

Table 2. Effect of agroindustrial wastes, partially degraded by the test fungi, on growth of pea plants* after different periods

Type	Incubation period (days)	Interest in length (cm)**		Leaf Number	Mean of biomass (g)
		Root	Shoot		
Soil (blank)	20	6.50	7.5	12	0.135
	40	7.52	8.8	15	0.165
	60	14.30	15.0	27	0.235
LSD (P = 0.05)		0.08	0.09	0.7	0.02
Soil + Jutestick (Control — 1)	20	7.0	8.5	14	0.164
	40	9.2	9.8	20	0.181
	60	15.2	16.0	30	0.250
LSD (P = 0.05)		0.6	1.0	0.8	0.02
Soil + Sugarcane bagasse (Control — 2)	20	7.7	9.2	20	0.186
	40	10.0	11.8	24	0.191
	60	15.3	16.5	31	0.254
LSD (P = 0.05)		0.6	0.8	1.1	0.03
Soil + Jutestick + *T. viride*	20	8.50	10.3	20	0.188
	40	13.20	13.9	26	0.220
	60	16.72	17.0	32	0.253
LSD (P = 0.05)		0.8	1.5	1.0	0.04
Soil + Sugarcane bagasse + *T. viride*	20	9.7	11.5	23	0.190
	40	14.0	13.7	27	0.234
	60	18.7	18.2	35	0.300
LSD (P = 0.05)		0.9	1.6	1.0	0.04
Soil + Jutestick + *C. globosum*	20	9.5	11.6	23	0.192
	40	13.9	14.0	27	0.228
	60	16.7	17.8	33	0.264
LSD (P = 0.05		1.0	1.5	1.0	0.03
Soil + Sugarcane bagasse + *C. globosum*	20	12.6	13.0	25	0.200
	40	14 5	14.2	26	0.239
	60	19.2	19.2	37	0.320
LSD (P = 0.05)		0.8	0.7	0 7	0.03
Soil + Jutestick + *P. sajor-caju*	20	8.0	10.0	19	0.183
	40	10 8	13.3	24	0·198
	60	16.8	16.8	33	0.245
LSD (P = 0.05)		0.5	0.6	0.6	0 04
Soil + Sugarcane bagasse + *P. sajor-caju*	20	9.5	11.4	22	0.190
	40	13.1	13.5	25	0.202
	60	18 0	18.0	36	0.288
LSD (P = 0.05)		0.7	0.5	0.8	0.04

* Mean of 35 replicates ** Initial length Root 8.5 ± 0.1 cm
Shoot 9.5 ± 0.1 cm

fatty substances or lipoids and lastly the lignin or woody substances (Anon, 1987). This evidently resulted release of various organic compounds that were formed during plant matter decomposition which increased the avsilability of insoluble forms of phosphate and some trace elements (cf. Whitehead, 1963). Sinha (1975) also reported higher ratio of humic acid and fulvic acid in the humus that could cause better growth of the plants by mobilizing the phosphates. Besides, the test organisms showed higher efficiency of degrading cellulose, lignin and nitrogenous compounds that were present in the jutestick and sugarcane bagasse (Mitra, 1992) resulting into an increase in soluble fractions of carbohydrates, nitrogenous matter etc. which the plants could readily utilize leading to growth promotion and increased biomass production. Chatterjee and Nandi (1981) reported that the biodegraded product of wheat stubble by soil microorganisms improved fertility of the soil thereby exhibiting significant promotion of growth of crops like maize and rice. The increase in plant growth when soil mixture was inoculated with *Trichoderma viride* was in conformity with Windham *et al.* (1985).

Of the two substrates, plant growth was more on sugarcane bagasse than that on jutestick because the organisms preferred the sugarcane bagasse as substrate probably for its higher contents of simple carbohydrate. Of the three organiems, *C. globosum* proved to be the best promoter of plant growth. This might be due to relatively higher rate of breakdown than the rate of utilization, thus resulting a higher net release of the soluble fractions in the soil that caused growth promotion.

An attempt was also made with unsterilized soil where furthet improvement of plant growth was recorded in cases where *T. viride* and *C. globosum* was amended. But similar increase in plant growth with *P. sajor-caju* was not observed. This was evidently due to the fact that while the former two fungal species were common soil inhabitants, survived well in the introduced soil in presence of the soil organisms already present there, probably through antibiosis as the species are known antibiotic producers. On the other hand, *P. sajor-caju* could find it difficult to survive in presence of other organisms in the soil.

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