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QUALITY INTENSIFICATION OF COMPOST PREPARED FROM AGRO-INDUSTRIAL WASTES BY PHOSPHATE SOLUBILIZING FUNGI

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Abstract: Compost, a soil amendment or a growth medium to plants is prepared by combining organic wastes in proper quotients. Efficient decomposing culture accelerates composting process. Present investigation was carried out to assess the composting power of consortium of five phosphate solubilizing fungi isolated from sugarcane and sugar beet rhizosphere including *Aspergillus niger* (NFCCI 1991), *Aspergillus awamori* (NFCCI 1992), *Penicillium oxalicum* (NFCCI 1997), *Penicillium rubrum* (NFCCI 1998) and *Trichoderma viridae* (NFCCI 1999), on availability of nutrients along with different kinds of agro- industrial wastes *viz.*, sugar cane trash, farm yard manure, spent wash, press mud cake, molasses and dairy waste. The highest values of available phosphorous and nitrogen were recorded in the fungal consortium inoculated treatments, showing rise by 72.49 to 89.71 per cent and 61.92 to 92.51 per cent, respectively as compared to uninoculated control. In fungal inoculated treatments available potassium, enzyme activities and CO_2 evolution rate were also found to be increased. Inoculation of fungal consortium developed mature compost within 60-65 days.

Keywords: Compost, phosphate solubilizing fungi, soil available nutrients, soil enzymes.

INTRODUCTION

Composting is a heat generating biological decomposition process that reduces a large volume of organic waste into a stable product under controlled conditions. The composting process involves the breakdown of many organic constituents such as sugars, waxes, acids, agro lingo-cellulosic compounds. Air, water, the right food and temperature combine to create a good composting environment. Soil microorganisms especially bacteria and fungi arbitrate soil processes such as nutrient mobilization and mineralization, storage and release of nutrients and water. Traditional method of composting is a slow process and takes more than 6 to 9 months.

Indian sugarcane crop cultivation plays an important part of the Indian agriculture economy. Adverse effects of agro industrial wastes viz., molasses, pressmud cake, cane trash, dairy waste, spent wash and others can be minimized by compost technology employing efficient microbial isolates or by direct addition to soil. Molasses [1], press mud [2, 3], spent wash [4, 5, 6] and dairy waste [7] are rich in many plant nutrients viz., nitrogen, phosphorus, potassium, sulphur, magnesium and others and also have properties to ameliorate degraded soils. The composted product consists of humic acid, stable nutrient components that support the micro- and macro flora and fauna normally found in soil and improve soil tilth and aeration, reduce raw manure odor and reliance on synthetic fertilizers. Composting is thus sustainable waste management practice.

Fungi carry out important functions related to disease suppression and nutrient cycling in soil. They have 40 to 55 per cent carbon use efficiency so they store and recycle more carbon compared to bacteria. Fungi are dominant in acid soils where they exhibit the monopoly for utilization of native substrates in soil. Especially they are potent lignin degraders. Fungi play important role similar to plant growth promoting rhizobacteria (PGPR) as they solubilize phosphate and produce plant growth promoting hormones, siderophores and antimicrobial agents [8].

Present investigation was carried out to assess the composting power of five phosphate solubilizing fungi isolated from sugarcane and sugar beet rhizosphere on availability of nutrients and microbial activities using different kinds of agro-industrial wastes viz., sugarcane trash, farm yard manure (FYM), molasses (M), pressmud cake (PMC), spent wash (SW) and dairy waste (DW) and biocompost (BIOC) derived from spent wash and pressmud cake.

MATERIALS AND METHODS

Fungal culture:

Five phosphate solubilizing National Fungal Culture Collection of India (NFCCI) Pune, deposited fungal

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cultures, isolated by Mahamuni *et al.*,[9] from sugarcane and sugar beet rhizosphere, were used to prepare lignite based consortium- inoculant. Cultures employed under present investigation were *Aspergillus niger* (NFCCI 1991), *Aspergillus awamori* (NFCCI 1992), *Penicillium oxalicum* (NFCCI 1997), *Penicillium rubrum* (NFCCI 1998) and *Trichoderma viridae* (NFCCI 1999). Mahamuni *et al.*,[9] reported that per cent P solubilized from TCP and RP containing liquid medium by these fungal isolates ranged from 37.2 to 57.8 per cent and from 19.2 to 36.6 per cent, respectively. Fungal cultures were separately grown on Sabouraud's agar at room temperature for 6 to 7 days. After incubation each sporulated culture was mixed thoroughly with lignite powder adjusting 40 per cent moisture level. Fungal count was determined by using potato dextrose agar (PDA). Five individual lignite based fungal cultures having count more than 1×10^6 were mixed in equal proportions to prepare a fungal consortium (FC) for the present studies.

Plant growth promoting characterization:

Rather than phosphate solubilization ability, other plant growth promoting characteristics of fungal cultures were investigated as-

Cellulase test: The isolates were spot inoculated separately on cellulose agar and incubated at 30°C for 3 to 4 days. The isolates showing growth on cellulose agar were considered cellulase positive. After incubation, plates having colonies were repeatedly treated with 0.5 per cent Congo red with intermittent washing by 1 per cent NaCl solution. Cellulase producers develop clear zone around.

Amylase test: Isolates were spot inoculated on starch agar and incubated at 30°C for 3 to 4 days. After incubation, the plates were flooded with 1N iodine solution. A positive reaction was indicated by colourless zone around colonies against blue background.

Chitinase test: Isolates were spot inoculated on colloidal chitin agar and incubated at 30°C for 5 days. The Chitinase activity was examined as positive if there was zone of clearance around the colony.

Protease test: The isolates were spot inoculated on milk agar and incubated at 30°C for 48 hrs. The isolate with clear zone around the colony against opaque background was considered as positive.

Experimental set-up

Experiment was designed to investigate the impact of phosphate solubilizing fungal consortium (FC) inoculation on quality of compost using agro- industrial wastes using 3 replications and 12 treatments in factorial randomized block design (FRBD) pattern. Agro industrial wastes such as molasses, pressmud cake, spent wash and biocompost were obtained from the Malegaon Cooperative Sugar Factory, Malegaon Bk., Baramati, district Pune. The dairy waste was obtained from Schreiber Dynamix Dairy Industries Ltd., Baramati, district Pune. The treatment combinations used were as following.

1. T1: Molasses (M)
2. T2: Dairy waste (DW)
3. T3: Spent wash (SW)
4. T4: Press mud cake (PMC)
5. T5: Biocompost (BIOC)
6. T6: Molasses + FC
7. T7: Dairy waste + FC
8. T8: Spent wash + FC
9. T9: Press mud cake + FC
10. T10: Biocompost + FC
11. T11: FC alone
12. T12: Control uninoculated (CO)

Pits having size 2ft × 2ft × 2ft were dug at the field conditions. Agro industrial wastes and biocompost in 2.5kg level were added in pits as per the treatments along with common base of 5kg sugarcane trash + 10kg soil +1kg FYM. In each pit 50-60 per cent moisture was maintained. One gram lignite based fungal consortium was mixed in 1kg FYM having 50 per cent moisture level and incubated for five days to prepare working fungal consortium (FC) for the addition into particular treatment combinations. Such 5g working fungal consortium (FC) was added in the related treatments. Composting of pits containing materials were allowed by regular mixing and maintaining moisture level up to 65 days.

Analyses:

Physicochemical analysis:

Routine soil analysis [10] consisting of parameters *viz.*, pH, EC, available N (alkaline permanganate method -Subbiah and Asija), P (Olsen's method), K (using extraction with 1N ammonium acetate and flame photometer) and organic matter (Walkley and Black method) was carried out before the composting. Similar parameters were estimated for the developed compost on 60 days.

Analysis of microbial activity:

Microbial activity in the compost was determined on 60 days of incubation by estimating compost-soil-enzymes such as dehydrogenase [11], acid and alkaline phosphatases [12, 13] and CO_2 evolution rate [14]. Total viable counts (TVC) of phosphate solubilizing bacteria (PSB) and phosphate solubilizing fungi (PSF) in the compost were taken using Pikovskaya's agar plates [15].

Statistical analysis:

The data obtained was subjected to statistical analysis by using standard methods [16] and SAS software available at Agricultural Research Information System (ARIS), Mahatma Phule Krishi Vidyapeeth, Rahuri. The standard error (SE) for the treatments and the critical differences (CD) at 5 and 1 per cent level of significance were worked out and used for comparison between treatments.

RESULTS AND DISCUSSION

Fungal cultures employed in the present study were amylase, cellulase, protease and chitinase positive. The soil used for compost recipe as the common base was medium black in colour having pH 8.5, E.C 0.17 dSm^{-1}, organic carbon 0.65 per cent, available nitrogen (N) 168 kg ha^{-1}, available phosphorus (P) 8.9 kg ha^{-1} and available potassium (K) 197 kg ha^{-1}. Chemical analysis of compost recipe components obtained from agro industries is presented in table 1. Fertility indices recorded for developed compost on 60 days such as enzyme activities, CO_2 evolution rate and routine compost analysis including available N, P, and K are presented in table 2 and table 3, respectively. Figure 1 furnishes analysis of compost from different treatments regarding pH, EC, organic carbon per cent, count of native phosphate solubilizing bacteria and fungi. Slight decrease in pH was recorded in treatments containing fungal consortium (FC) as compared to respective uninoculated control treatments. This might be due to microbial production of organic acids which resulted in increased levels of available P as furnished in table 3. Significant EC values were also recorded with various treatments.

Table.1: Analysis of compost recipe components

Components of compost recipe	pH	N %	P_2O_5 %	K_2O %	Organic C %
1. Molasses	5.39	0.78	0.03	3.56	49.30
2. Pressmud cake	6.74	1.26	2.76	0.49	40.13
3. Spent wash	7.54	1.63	0.21	5.44	33.21
4. Dairy waste	7.55	2.1	2.52	0.89	38.45
5. Biocompost	7.33	1.30	1.71	2.32	36.24
6. Sugarcane trash	-	0.41	0.16	0.53	37.80

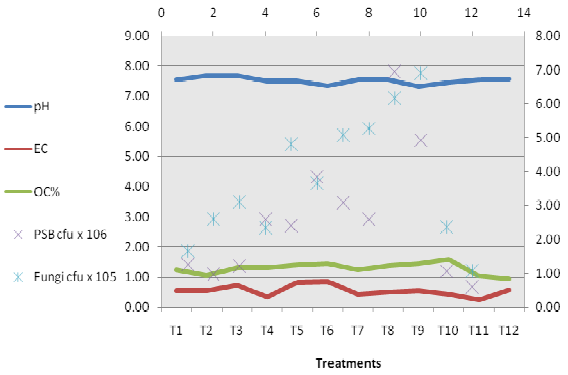

Figure.1: Physicochemical and microbial analysis of compost on 60 days

Agro- industrial wastes added organic carbon in the compost recipe. Depending upon the redox conditions, microbial decomposition of organic materials leaded to the production of CO_2. CO_2 is one of the products of aerobic respiration. Most of the researchers accept the amount of CO_2 secreted from the soil as the most general measure of microbial activity [17]. Beary, *et al.*,[18] reported that fungal bacterial consortium accelerated the decomposition of post-harvest sugarcane residue when it was mixed with soil and highlighted the role of agro industrial wastes as the source of carbon, nitrogen and vitamins which allowed rapid increase in microbial count. Mahamuni and Patil [19] prepared good quality composts by windrow and pit methods from PMC and spent wash using effective consortium of phosphate solubilizing four bacterial and six fungal cultures within 45 days having C:N ratio from 10.19:1 to 13.88:1 and 14.32:1 to 22.34:1, respectively.

Table.2: Enzymatic analysis of compost on 60 days

Treatments	Acid Phosphatase µg PNP $g^{-1}h^{-1}$	Alkaline Phosphatase µg PNP $g^{-1}h^{-1}$	Dehydrogenase µg TPF $g^{-1}h^{-1}$
T1: M	58.61	65.08	1.19
T2: DW	47.25	58.69	1.37
T3: SW	58.28	69.44	1.32
T4: PMC	59.14	71.66	1.22
T5: BIOC	66.74	83.45	1.17
T6: M+ FC	87.68	94.53	3.77
T7: DW+ FC	65.17	90.51	4.52
T8: SW+ FC	72.66	118.90	4.05
T9: PMC+ FC	99.39	142.12	3.78
T10: BIOC+ FC	112.11	214.55	4.45
T11: FC Alone	56.31	67.27	0.92
T12: Co (Control)	40.01	50.57	0.57
Treatments SE	1.28	1.76	0.12
CD at 5%	3.81	5.22	0.36
Without FC SE	0.91	1.24	0.09
CD at 5%	2.69	3.69	0.26
With FC SE	0.57	0.79	0.05
CD at 5%	1.70	2.33	0.16
CV%	3.24	3.24	8.93
ANOVA			
Source **DF**	**Mean sum of squares (MSS)**		
Replication 2	13.0	2.1	0.02
Treatments 11	**1351.9	**6375.6	**7.5
A (Without FC) 4	**970.9	**5297.2	**0.2
B (With FC) 1	**6481.2	**29255.6	**61.4
A× B 4	**273.8	**2614.8	**0.2
All Vs Co 1	**2677.7	**6144.6	**10.5
FC Vs Co 1	**44.3	*46.5	NS 0.02
Error 22	4.9	9.3	0.04

Note: * and ** denote significance at 5% and 1% level of significance, respectively.

NS = Non significant
PNP = p-nitro phenyl phosphate (PNP) released
TPF = tri phenyl formazan formed

The composting process involves microbial degradation of sugars, organic acids, proteins and lingo-cellulose. This may be the reason behind increased number of native phosphate solubilizing bacteria (PSB) and fungi. Increased contact between soil and residue allowed mass transfer from crop residue like sugarcane trash to microbial cells [18]. Sangodoyin and Amori [20] found significant correlation between total organic carbon (TOC) and total N, P, K during their experiment on supplements such as cow dung, sewage sludge and poultry manure in the compost making. Due to different treatment effects parameters such as enzyme activities, CO_2 evolution rate, and available N, P, K were found to be significant. N, P, K contents of mature compost prepared with inoculation of FC and agro industrial wastes was found to be increased in the present investigation. Increased dehydrogenase activity and CO_2 evolution rate were recorded by the treatments containing agro industrial waste and FC.

In the present investigation agro industrial wastes without FC increased available P from 53.68 to 61.87 per cent while with FC increased available P from 72.49 to 89.71 per cent, respectively as compared to uninoculated control. Available P was recorded maximum by the treatment of PMC + FC. Along with FC, agro industrial wastes also increased acid and alkaline phosphatase activities from 62.89 to 180.23 per cent and from 79.00 to 324.29 per cent, respectively as compared to absolute or uninoculated control.

Table.3: NPK and CO_2 analysis of compost on 60 days

Treatments	P kg ha^{-1}	K kg ha^{-1}	N kg ha^{-1}	CO_2 µg g^{-1}h^{-1}
T1: M	17.07	162.21	322.41	1.14
T2: DW	17.98	124.49	262.31	1.26
T3: SW	17.07	254.00	317.32	1.17
T4: PMC	17.90	164.08	325.47	1.16
T5: BIOC	17.38	290.15	334.24	1.37
T6: M+ FC	20.07	186.39	359.14	2.23
T7: DW+ FC	19.16	198.67	345.14	2.62
T8: SW+ FC	19.19	288.61	403.00	2.75
T9: PMC+ FC	21.08	174.95	410.34	2.66
T10: BIOC+ FC	20.11	319.10	386.79	2.81
T11: FC Alone	14.81	156.40	250.29	1.19
T12: Co (Control)	11.11	119.89	213.15	0.75
Treatments SE	0.32	5.41	3.81	0.04
CD at 5%	0.96	16.06	11.30	0.12
Without FC SE	0.23	3.82	2.69	0.03
CD at 5%	0.68	11.36	7.99	0.08
With FC SE	0.14	2.42	1.70	0.02
CD at 5%	0.43	7.18	5.05	0.05
CV%	3.15	4.61	2.01	3.91
ANOVA				
Source DF	**Mean sum of squares (MSS)**			
Replication 2	0.1	22.2	109.3	0.01
Treatments 11	**21.8	**13774.7	**11142.6	**1.8
A (Without FC) 4	**1.5	**26661.5	**4055.1	**0.1
B (With FC) 1	**44.6	**8957.6	**35223.4	**14.6
A × B 4	**1.0	**851.3	**762.1	**0.1
All Vs. Co 1	**144.1	**22740.3	**42767.7	**3.4
FC Vs. Co 1	**2.3	^{NS} 222.2	*229.8	**0.03
Error 22	0.3	87.7	43.5	0.01

Note: * and ** denote significance at 5% and 1% level of significance, respectively.
NS = Non significant

Barea *et al.,* [21] correlated the soil enzyme activities and soil respiration with microbial flora and soil fertility. Frankenberger Jr. and Dick [22] found significant correlation between microbial biomass and respiration. In the present experiment each microbial activity and available P of the soil amended with fungal consortium was significantly higher than that of non-added treatments. This may be due to proper moisture content, organic carbon in compost recipe which supported the growth of native PSB and inoculated PSF. The addition of organic fertilizers increases mobilization of P and microbial activities in soil. Microbial activities increase with increasing microbial populations following amendments of soils with nutrients [4, 23]. Similarly in the present study available P, CO_2 evolution rate and enzyme activities such as dehydrogenase, acid and alkaline phosphatase were found to be increased in FC inoculated treatments.

Along with FC, agro industrial wastes also increased available N and K from 61.92 to 92.51 per cent and from 45.93 to 166.17 per cent, respectively as compared to uninoculated control. Fungal count was recorded maximum as 6.9×10^5 by the treatment of BIOC + FC. Highest levels of phosphatase activity, available K and CO_2 evolution rate were also recorded by the treatment of BIOC + FC. Highest levels of available P and N were recorded by the treatment of PMC + FC. Due to utilization of certain fraction of organic content available N and K was found to be increased in FC inoculated treatments as compared to uninoculated controls. Microbial count was recorded maximum in FC treated combinations. These results were in accordance with the work of Naidu *et al.,*[24] and Kanwar *et al.,*[25].

CONCLUSION

Quality of compost prepared from agro industrial wastes such as PMC, molasses, dairy waste, spent wash and biocompost can be increased by the inoculation of consortium of phosphate solubilizing fungi including *Aspergillus niger* (NFCCI 1991), *Aspergillus awamori* (NFCCI 1992), *Penicillium oxalicum* (NFCCI 1997), *Penicillium rubrum* (NFCCI 1998) and *Trichoderma viridae* (NFCCI 1999). Good quality compost can be prepared within 60 to 65 days if these cultures are used for acceleration of composting process. Compost or soil fertility indices such as activities of dehydrogenase, acid and alkaline phosphatase, and CO_2 evolution rate were increased significantly by the inoculation of fungal consortium (FC) along with agro industrial wastes. Fungal consortium also significantly increased available N, P, and K. Cellulose degradation occurs through complex microbial communities that include

many non-cellulolytic organisms. In the present study fungal and developed native bacterial load including PSB helped to degrade sugarcane trash. Organic carbon added through agro industrial wastes also helped to increase microbial load which further played important role in intensification of compost quality. Composting is thus a process based on the management of microorganisms naturally present and / or inoculated in waste materials. Future field studies should be conducted using FC made compost and direct FC inoculant to check their impact on crop productivity and soil fertility.

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