Potential of lignocellulolytic microbial consortia in achieving in-situ crop residue decomposition to abate residue burning

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INTRODUCTION

Open field burning of crop residue (CR) causes severe air pollution and green house gas emission contributing to global warming. Emission from the menace of CR burning has been reported to be equivalent to 379 Gg C. In India, rice –wheat cropping system of IGP and sugarcane based systems of Maharashtra have been found to be the major contributors of crop residue burning. In order to seek an alternative, the current study was executed to explore the prospective of ligno-cellulolytic microbes to expedite in situ decomposition of crop residues.

MATERIALS AND METHODS

Field trials on farmers' field were conducted in the state of Haryana and Maharashtra, to target the burning of rice and wheat residue and sugarcane trash, respectively. A comparative study among crop residue removal (CRR), crop residue burning (CRB) and in situ decomposition of crop residues (IND; Fig. 1 and 2) was conducted at the field (200 m²) of 16 farmers in Haryana and 12 farmers in Maharashtra. IND includes the application of novel lignocellulolytic microbial consortia (Table 1) to expedite the in field decomposition of left over crop residues. To determine the status of the in situ decomposition of crop residues, lignin and cellulose content as well as biodegradation ratio of cellulose (BRcellulose) and delignification were computed.

Microbes	GenBank Accession Number
Bacteria	
Bacillus licheniformis	KF479458
Bacillus pumilus	KF479459
Bacillus amyloliquefaciens	KF479460
Bacillus subtilis	KF479461
Actinomycetes	
Streptomyces tendae	MK680814
Streptomyces parvus	MK680815
Streptomyces badius	MK680817
Streptomyces thermocarboxydus	MK680818
Fungi	MTCC/ITCC Number
Rhizomucor pusillus	MTCC8806
Aspergillus flavus	ITCC9943.15

Table 1. Composition of microbial consortia

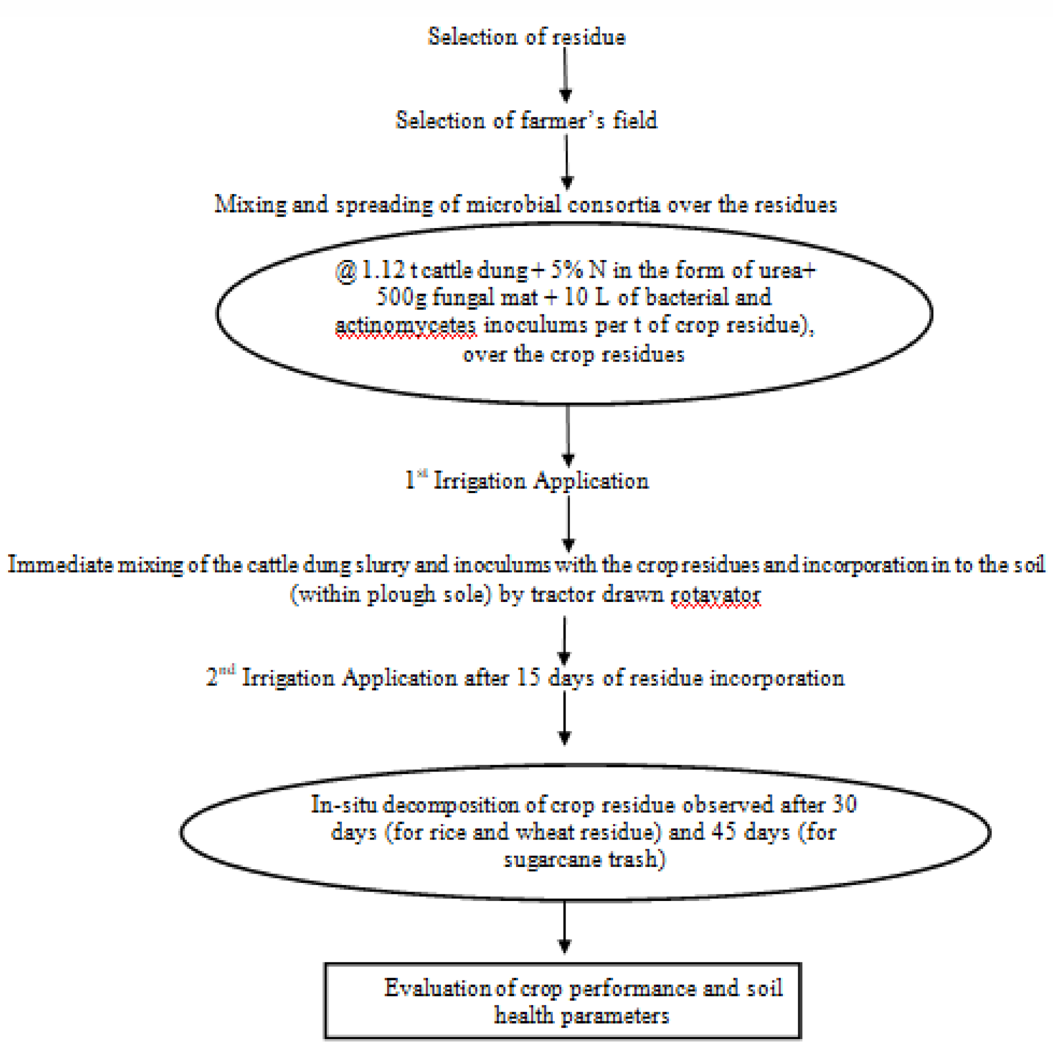


Fig.1 Flowchart of in situ decomposition technology for crop residue

Fig.2 Steps followed for in-situ decomposition technology

RESULTS

- Ligno-cellulolytic microbial consortia showed a promising effect by significantly reducing lignin and cellulose content of the incorporated crop residues, where the ratio of lignin to cellulose increased ($p<0.05$) from 0.23 to 0.25, 0.21 to 0.23 and 0.24 to 0.27 for rice, wheat residues and sugarcane trash, respectively.
- The in situ decomposition of rice and wheat residue was achieved after 30 days of incorporation, whereas it was 45 days fro sugarcane trash.
- No yield loss was noticed in IND for both rice-wheat system and sugarcane based system; rather IND showed relatively better crop yield as well as soil health parameters than CRB and CRR.
- Basal soil respiration, metabolic quotient and sodium adsorption ratio had been found to be the sensitive indicators for the experimental sites of Haryana whereas β-Glucosidase activity, WSC, BSR and pH were the sensitive indicators discriminating CRR, CRB and IND in the experimental sites of Maharashtra (Fig. 3).
- Environmental impact assessment of residue burning indicated a substantial loss of nutrients (28–31, 23–25 and 51–77 kg ha^{-1} of N+P2O5+K2O for rice, wheat and sugarcane residue; Table 4) as well as the emission of pollutants to the atmosphere (Fig . 4).

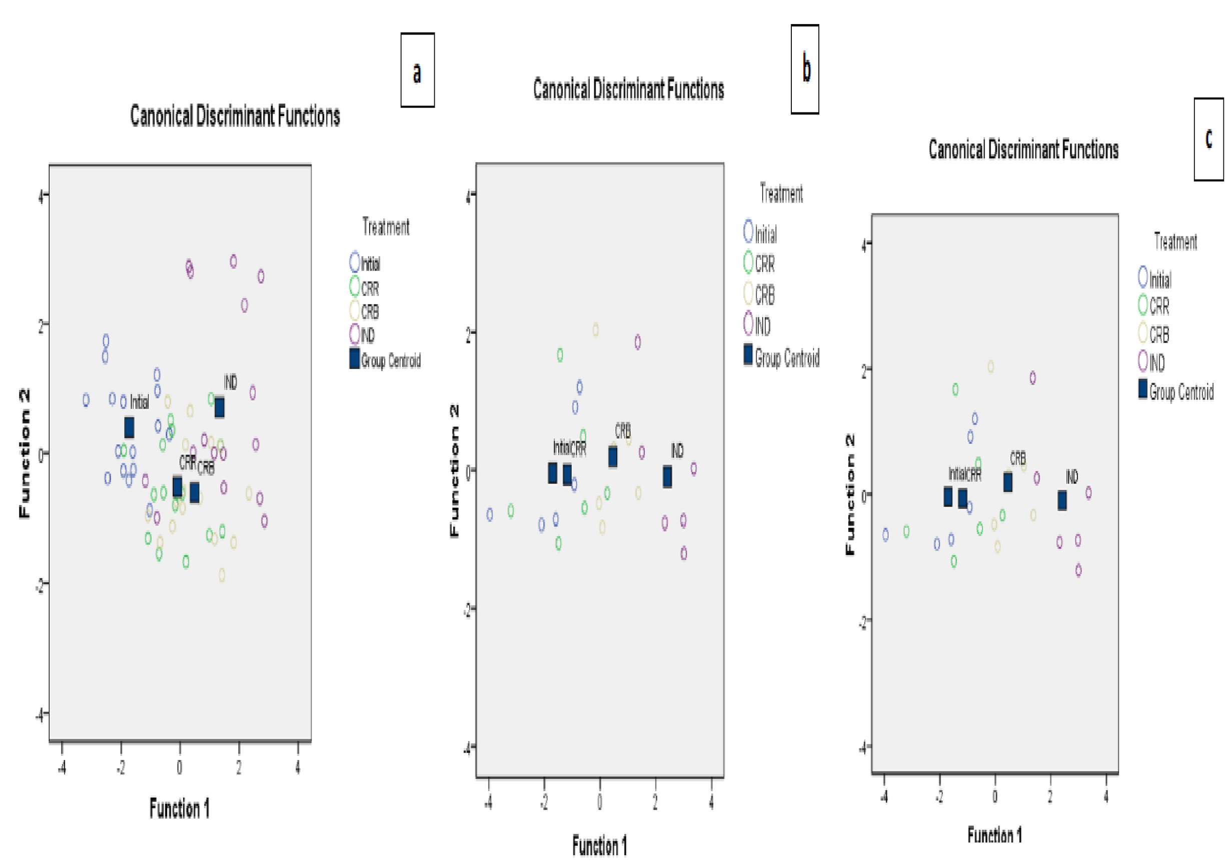
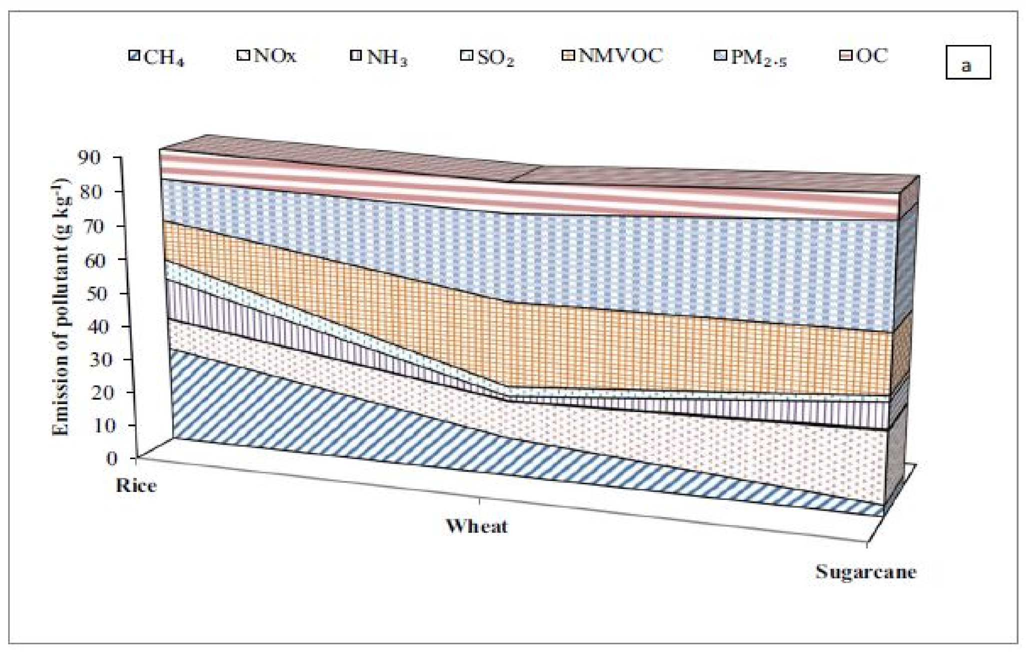


Fig.3 Bi-plot of canonical discriminant functions separating different treatments: a Haryana, b Pune-Satara, c Sangli-Kolhapur

Crop	Nutrient Loss in CRB (kg ha^{-1})			
	N	P_2O_5	K_2O	Total
Rice	17-19	1.5-1.7	9-10	28-31
Wheat	13-15	1.3-1.5	8-9	23-25
Sugarcane	27-41	3.6-5.4	20-31	51-77

Table 4. Nutrient loss (kg ha^{-1}) due to crop residue burning in the field



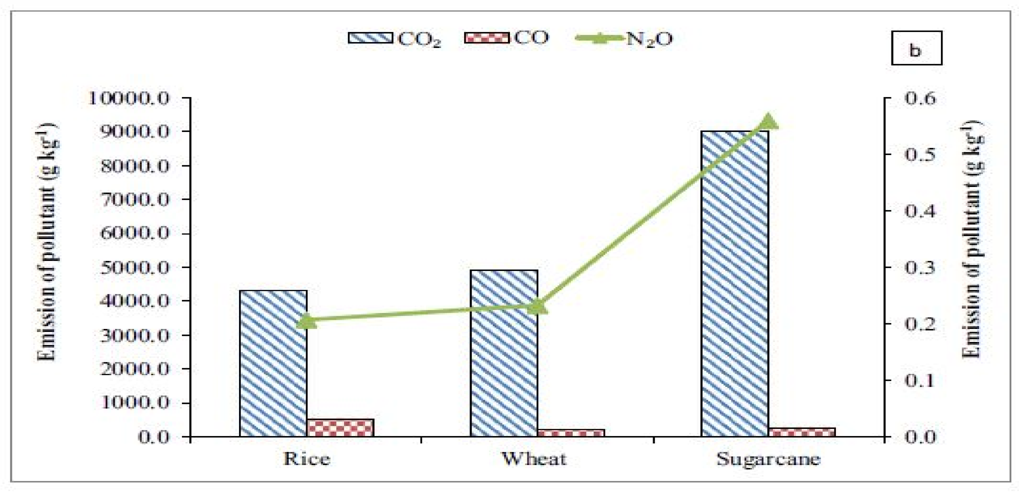


Fig.4 a, b Emission of pollutants due to crop residue burning (g kg^{-1}). # CH_4, methane; NOx, nitrogen oxides; NH_3, ammonia; SO_2, sulphur di-oxide; NMVOC, non-methane volatile organic compounds; PM2.5, atmospheric particulate matter having diameter <2.5 μm; OC, organic carbon; CO_2, carbon di-oxide; CO, carbon monoxide; N_2O, nitrous oxide

CONCLUSION

In situ decomposition of crop residue by efficient lignocellulolytic microbial consortia is a viable and eco-friendly alternative to the crop residue burning. It holds the potential to abate residue burning by the rapid decomposition of crop residue in the field. Besides, the technique did not have any adverse effect on crop yield and soil health. Nevertheless, the technology needs refinement as well as more field trials to validate and establish the positive potential of in situ decomposition of crop residue to make it a successful solution against the nuisance of crop residue burning.

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