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RESEARCH ARTICLE

Effect of distillery industry by-products on soil biological properties

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SUMMARY : In today's era of ecofriendly operation, it is necessary to overcome the pollution problems. Recycling of industrial waste water in crop production is one of the ways of disposal of waste water alternatively helped in attaining the high crop productivity goals. The effect of distillery industry wastes *viz.*, spentwash, biocompost and spentwash ash on soil biological properties was examined through a field experiment using Cumbu Napier hybrid grass. The study revealed that spentwash at the rate of 50 kilo l ha^{-1} at full dose with recommended dose of nitrogen and phosphorus registered the highest microbial and enzyme activities. The spentwash, being loaded with organic compounds could bring remarkable changes on the biological properties of soils and thus influences the soil fertility.

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Recycling of industrial waste water in crop production is one of the ways of disposal of wastes alternatively helping in attaining the required crop productivity goals. Distilleries, one of the most important agro-based industries in India, produce alcohol from molasses. They generate large volume of foul smelling coloured wastewater known as spentwash. For production of each litre of alcohol, 12-15 litre of effluent is produced. Approximately 40 billion litres of wastewater is generated per annum from 319 distilleries in the country (Kanimozhi and Vasudevan, 2010). It is rich in nutrients and organic components with high Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Therefore, upon field application, it increases the soil organic matter content, the nutrient content and mineral content. Also the high concentration of soluble carbon added from the spentwash might be responsible for the enhanced microbial and enzyme activities. This condition may be favourable for number of microbes and enzymes in soils. Indiscriminate disposal of the effluent in water and on land leads to serious pollution and changes the nutrient and biological statues of the soil where they are disposed off. The present study was undertaken with a view to studying the effect of distillery effluent on the microbial population dynamics and enzyme activities of soil in field experiment.

EXPERIMENTAL METHODOLOGY

Collection and characterization of distillery industry byproducts:

The BDS was collected from the distillery unit of M/s. Bannari Amman Sugars Ltd., Periyapuliyur, Erode district, Tamil Nadu and analyzed for its physico-chemical properties by standard methods (APHA, 1989). Biocompost is being prepared and marketed by M/s. Bannari Amman Sugars Ltd., Ealur and analyzed for its physico - chemical properties. Spentwash ash is being produced by M/s. Bannari Amman Sugars Ltd., Distillery division, Alakangi, Nanjangud, Karnataka and analyzed for its physico - chemical properties. BDS was dark brown colour and a neutral pH (7.42) with high EC (32.5 dS m^{-1}), BOD (6,545 mg L^{-1}) and COD (34,476 mg L^{-1}). It contains highest K (8,376 mg L^{-1}) followed by N (2,116 mg L^{-1}), Ca (2,072 mg L^{-1}), Mg (1,284 mg L^{-1}) and low P (52.8 mg L^{-1}). The biocompost showed a neutral pH (7.26) and 1.74 dS m^{-1} EC with 15.42 per cent organic carbon content and high K (4.08 %). The spentwash ash was alkaline in nature (pH 8.96) with high EC (17.8 dS m^{-1}) and no organic carbon and N content and K was the highest (10.25 %).

Field experimental details:

The field experiment was conducted 2009 to 2010 using Cumbu Napier hybrid grass [$CO(CN)_4$] as test crop to examine of effect of spentwash, biocompost and spentwash ash on microbial and enzyme dynamics at Research and Development farm, M/s. Bannari Amman Sugars Ltd., Ealur. The initial soil was neutral pH (7.24), non-saline (0.28 dS m^{-1}) and rich in organic carbon (3.56 g kg^{-1}). With regard to nutrient status, the soil was low in N (118.5 kg ha^{-1}), medium in P (19.2 kg ha^{-1}) and K (248 kg ha^{-1}) status. Among the exchangeable cations, Ca was present in highest amounts and they were in the order of Ca>Mg>Na>K. Considerable population of micro-organisms (bacteria, fungi and actinomycetes) and enzyme (dehydrogenase, phosphatase and urease) activities were also assayed in the soil. The experiment was laid out in Randomized Block Design with three replications. The treatments consisted of T_1- Soil alone, T_2 – Biocompost @ 2.5 t ha^{-1} + RD of NP, T_3 - Spentwash ash @ 400 kg ha^{-1} + RD of NP, T_4 - BDS @ 37.5 kilo l ha^{-1} at full dose + RD of NP, T_5 - BDS @ 37.5 kilo l ha^{-1} at split dose (basal 40 % and 10 % after each cutting) + RD of NP, T_6 - BDS @ 50 kilo l ha^{-1} at full dose + RD of NP, T_7 - BDS @ 50 kilo l ha^{-1} at split dose + RD of NP.

Application of amendments:

Spentwash was applied as per the treatment and incorporated into the soil at 30 days before planting in order to reduce the BOD and COD. Biocompost and spentwash ash were applied as basal. Recommended dose of fertilizers (N, P and K @150, 50 k and @40 kg ha^{-1}) was applied as per the treatments.

Collection and analysis of soil samples:

Soil samples were drawn at 12th, 26th, 39th and 52nd weeks after planting (WAP) coinciding 1st, 3rd, 5th and 7th cuttings and collected soil samples were dried under shade, powdered with wooden mallet and sieved through 2 mm sieve and the number of bacteria, fungi and actinomycetes colonies were assessed by plating dilution technique by adopting the analytical methods outlined by Waksman and Fred (1922). Dehydrogenase activity was determined by triphenly farmazane method (Casida *et al.,* 1965), phosphatase activity was determined by adopting p-nitrophenyl phosphate (PNPP) method outlined by Tabatabai and Bremner (1969), Urease activity was determined by NH_4-N Distillation method (Bremner and Keeney, 1966). The data were analyzed statistically and the treatment means were compared using LSD at 5 per cent probability (Panse and Sukhatme, 1985).

EXPERIMENTAL FINDINGS AND DISCUSSION

Table 1 explains about the effect of distillery industry byproducts on soil microbial population. Among the treatments, BDS@ 50 kilo l ha^{-1} at full dose + RD of NP significantly recorded the highest soil bacterial population (30.5 x 10^6 CFU g^{-1} of soil), fungal population (16.0 x 10^4 CFU g^{-1} of soil) and actinomycetes population (6.6 x 10^2 CFU g^{-1} of soil) followed by BDS @ 37.5 kilo l ha^{-1} at full dose + RD of NP. The lowest bacterial, fungal and actinomycetes population count was recorded by RD which was on par with spentwash

Table 1: Effect of distillery industry wastes on soil microbial population at various cuttings of CN hybrid grass

Treatments /cuttings	Bacterial population (x 10^6 CFU g)				Fungal population (x 10^4 CFU g^{-1} of soil)				Actinomycetes population (x 10^2 CFU g)			
	12th WAP	26th WAP	39th WAP	52nd WAP	12th WAP	26th WAP	39th WAP	52nd WAP	12th WAP	26th WAP	39th WAP	52nd WAP
T_1- RD	21.9	20.7	19.4	18.7	9.60	9.10	8.5	7.40	4.7	4.4	4.1	3.9
T_2 - BC @ 2.5 t ha^{-1} + NP	28.6	27.6	26.1	24.3	14.8	13.6	12.2	10.7	6.8	5.8	5.4	5.1
T_3 - SWA @ 400 kg ha^{-1} + NP	22.8	21.1	20.1	19.4	9.80	9.30	9.10	7.80	4.9	4.6	4.3	4.1
T_4 - BDS @ 37.5 KL ha^{-1} at basal + NP	32.1	29.7	28.8	27.1	16.5	15.2	14.3	13.8	7.2	6.1	5.8	5.4
T_5 - BDS @ 37.5 KL ha^{-1} in split doses + NP	23.8	22.8	20.1	19.8	11.8	11.4	10.3	9.2	5.7	5.2	4.8	4.7
T_6 - BDS @ 50 KL ha^{-1} at basal + NP	33.4	30.4	29.6	28.7	17.9	16.3	15.7	14.2	7.9	6.4	6.1	5.9
T_7 - BDS @ 50 KL ha^{-1} in split doses + NP	24.4	23.4	22.5	21.3	12.3	11.8	10.6	9.6	6.3	5.5	5.2	4.9
	C.D. (0.05)				C.D. (0.05)				C.D. (0.05)			
T	0.76				0.37				0.17			
C	0.58				0.28				0.13			
T × C	NS				0.74				0.33			

RD - Recommended Dose of NPK; BC – Bio-compost; SWA - Spentwash ash; BDS - Biomethanated Distillery Spentwash; WAP- Weeks After Planting ash @ 400 kg ha^{-1} + RD of NP. The microbial population decreased significantly as the cuttings advanced. The interaction effects of treatments with various stages of cuttings were found to be non significant for bacterial population but it was significant for fungal and actinomycetes population count. Being rich in nutrients and organic matter, particularly easily oxidizable and soluble organic carbon, the spentwash might have favoured the proliferation of microbial population in soil. This supports the earlier findings of Murugaragavan (2002). Split dose of spentwash application recorded the lowest population and the reason for such reduction of microbial population might be due to faster depletion of oxygen in the soil because of high BOD of effluent and the resulting anaerobic soil environment prevailed immediately after its application (Saliha *et al*., 2005). The reduction in the microbial activities during the advancement of the crop growth, particularly at end of the crop growth was probably due to the exhaustation of nutrients and organic matter as a result of intense microbial activity and crop uptake of nutrients during the crop growth (Goyal *et al*., 1995).

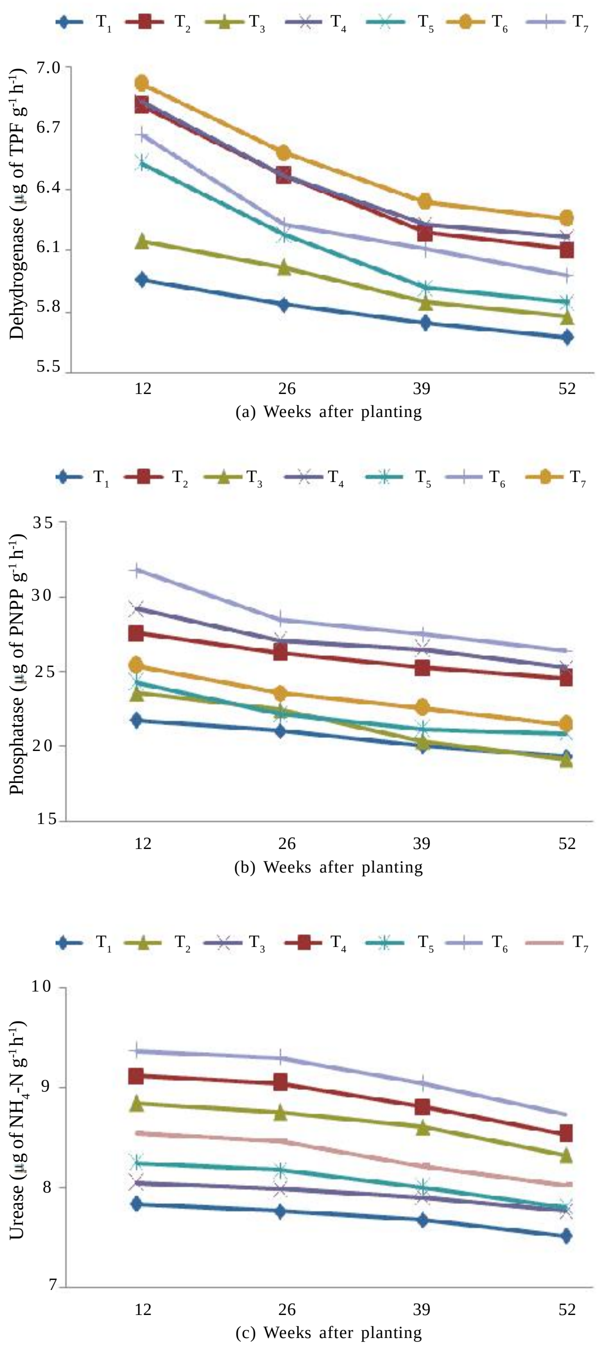

Fig. 1: Impact of distillery industry byproducts with inorganic fertilizers on changes in dehydrogenase (A), phosphatase (B) and urease activity (C) of soil grown with CN hybrid grass (T_1 - T_7 treatments as detailed in materials and methods)

Fig. 1 explains about the distillery industry by-products effect on soil enzyme activity The mean dehydrogenase, phosphatase and urease activity for the treatments ranged from 5.81 to 6.53 µg of TPF g^{-1} of soil h^{-1}, 20.6 to 28.6 µg of PNPP g^{-1} of soil h^{-1} and 7.70 to 9.11mg NH_4-N g^{-1} of soil h^{-1} respectively. Among the treatments, BDS @ 50 kilo l ha^{-1} at full dose + RD of NP recorded the highest dehydrogenase (6.53 µg of TPF g^{-1} of soil), phosphatase (28.6 µg of PNPP g^{-1} of soil) and urease activity (9.11mg NH_4-N g^{-1} of soil h^{-1}) which was at par with BDS @ 37.5 kilo l ha^{-1} at full dose + RD of NP and biocompost @ 2.5 t ha^{-1} + RD of NP. The lowest enzyme activity was recorded in RD which was on par with spentwash ash @ 400 kg ha^{-1} + RD of NP. The enzyme activity decreased significantly as the cuttings advanced. The interaction effects of treatments with various stages of cuttings were found to be non-significant for all the three enzymes. There was an increase in the activities of urease, phosphatase and dehydrogenase due to spentwash application which supplemented the organic matter and nutrients to the soil which in turn subsequently enhanced the microbial biomass. It is implied that organic and inorganic nutrients provided a nutrient rich environment, which is essential for the synthesis of enzymes. This is in accordance with the findings of Ramana *et al*. (2002). Organic manure addition was found to enhance the microbial activities which in turn favour the synthesis of various enzymes in soil which plays a significant role in the bio-transformation of nutrients in soil and thus influences the nutrients availability in soil and uptake by crops (Dinesh *et al.*, 2000).

Conclusion:

Thus, application of spentwash to the agricultural field, as an amendment, might be a viable option for the safe disposal of this industrial waste with concomitant enhancement of soil biological properties. However, the level of application should be within the prescribed limit to avoid development of soil salinity in the long run and not to affect the ground water quality.

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