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RESEARCH ARTICLE

Performance of distillery industry by-products on nutrient aspects and enhanced yield of guinea grass

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SUMMARY : Distillery spentwash is a nutrient rich liquid organic waste obtained from molasses based distillery industries after biomethanation process and it is the carrier of huge amounts of nutrients and organic matter. A field investigation was carried out during 2009 to 2010, at Research and Development Farm M/s. Bannari Amman Sugars Distillery Division Ltd, Ealur, Sathyamangalam, Erode to assess the performance of guinea grass by utilizing distillery industry byproducts *viz.,* distillery spentwash, biocompost and spentwash ash. Treatments involved were distillery spentwash @ 37.5 and 50 kilo litre per ha at full and split dose, biocompost @ 5.0 tonnes per ha and spentwash ash @ 400 kg per ha with recommended dose of fertilizers and the parameters were assessed at 12th, 26th, 39th and 52nd weeks after planting. Results of the field experiment revealed that the application of spentwash @ 50 kilo litre per ha at full dose with recommend dose of nitrogen and phosphorus increased the quality and nutrient parameters and green fodder yield over recommended dose of fertilizer.

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Key Words **:**
BDS, Biocompost, Spentwash ash, Soluble protein, Nutrients, Green fodder yield.

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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 spentwash is produced. The raw spentwash is acidic in nature (pH < 4.0) and is generally characterized by high levels of biochemical oxygen demand and chemical oxygen demand. Alternatively, it is subjected to biomethanation treatment to decrease the content and the output is known as Biomethanated Distillery Spentwash (BDS). It contains nutrients, organic matter and plant growth promoters namely gibberellic acid and indole acetic acid. Biocompost is being prepared by using pressmud and distillery spentwash at the ratio of 1:2.5. It is being used a source of nutrients with a potential of increasing crop production on sustainable manner. The distillery spentwash contains about 1.2 per cent of potassium but this concentration is increased to the range between 10 and 18 per cent, when it is ignited into ash. Forage crops require high amount of N and K and are the better choice towards assessing the nutrient potential of spentwash since it is rich in K and N (Galavi *et al.*, 2009). Keeping this in view, the present study was made to assess the performance of distillery industry byproducts on growth and quality of guinea grass.

EXPERIMENTAL METHODOLOGY

Collection and characterization of distillery industry by-products :

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 procedures (APHA, 1998). 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 very low content of 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. Among the nutrients, the K content was highest (4.08 %), followed by Ca (3.72 %), Mg (2.46 %), P (2.06 %), Na (1.54 %) and N (1.24 %). The spentwash ash was alkaline nature (pH 8.96) with high EC (17.8 dS m^{-1}) and no organic carbon and N content. Among the nutrients, the K content was the highest (10.25 %), followed by Ca, Mg and Na (3.16, 2.54 and 0.65 %), respectively.

Field experimental details :

The field experiment was conducted during 2009 to 2010 at Ealur, Erode, Tamil Nadu. The location comes under the soil series of Irugur with the subgroup of *Typic Ustorthent* under the soil order Entisol. The soil texture of the experimental site was sandy loam, 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 high in K (248 kg ha^{-1}). Different doses of BDS, biocompost and spentwash ash along with inorganic fertilizers using cumbu guinea grass CO (GG) 3 as test crop has been tried. The experiment was laid out in Randomized Block Design with three replications; 40,000 rooted slips ha^{-1} were planted with the spacing of 50 x 50 cm. The treatment consisted of T_1 - Recommended dose of NPK (RD), 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 litre ha^{-1} at full dose + RD of NP, T_5 - BDS @ 37.5 kilo litre ha^{-1} at split dose (basal 40 % and 10 % after each harvest) + RD of NP, T_6 - BDS @ 50 kilo litre ha^{-1} at full dose + RD of NP, T_7 - BDS @ 50 kilo litre 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 nitrogen at 100 kg ha^{-1} as urea, phosphorus at 50 kg ha^{-1} as single super phosphate and potassium at 40 kg ha^{-1} as muriate of potash was applied as per the treatment. The first harvest was done on 90th days after planting, the crop was allowed for ratooning at 45 days intervals by supplementing N as top dress at the rate of 50 kg ha^{-1}.

Collection and analysis of plant samples :

The plant samples collected from the field at 12th, 26th, 39th and 52nd WAP coinciding 1st, 3rd, 5th and 7th cuttings were dried in hot air oven at 65^{0}C to determine the moisture percentage. The total chlorophyll and carotenoid content were estimated by adopting the procedure of Yoshida *et al*. (1971), reducing sugars content was determined by Somogyi method (Nelson and Sommers, 1982), soluble protein content was determined by the procedure described by Lowry *et al*. (1951). The oven dried samples were powdered in Wiley mill attached with stainless steel blades and analyzed for its nutrient content by adopting the standard methods. The four harvest values were cumulated and mean value was presented in Tables. Each harvesting was made at above the ground level in each plot and the total green biomass was weighed and expressed in t ha^{-1}. The data were analyzed statistically and the treatment means were compared using LSD technique at 5 per cent probability (Panse and Sukhatme, 1985).

EXPERIMENTAL FINDINGS AND DISCUSSION

BDS and biocompost applied plots showed that there was improvement in nutrient status of N, P, K, pH, EC, and OC compared to initial status of soil (Table 1).

Application of BDS and biocompost on guinea grass had significant influence on the physiological parameters *viz.*, total chlorophyll, carotenoid, reducing sugar and soluble protein compared to spentwash ash and RD (Table 2). Among the treatments, BDS @ 37.5 kilo litre ha^{-1} at full dose + RD of NP registered the highest total chlorophyll (3.01 mg g^{-1}), carotenoid (0.57 mg g^{-1}), reducing sugar (0.52 %) and soluble protein (28.2 mg g^{-1}) which was on par with BDS @ 50 kilo litre ha^{-1} at full doses + RD of NP and the lowest was recorded by RD (2.56 mg g^{-1}, 0.41 mg g^{-1}, 0.43% and 26.2 mg g^{-1}, respectively) which was at par with spentwash ash @ 400 kg ha^{-1} + RD of NP. The productivity of crop depends on photosynthesis and partitioning of assimilates to the economically important parts. An increased content of total chlorophyll and carotenoid was due to the application of BDS. This reflected the high manurial potential of the distillery effluents (Sivasankari, 2009). Plant cells might have retained higher water potential with the application of BDS which might have prevented protein degradation metabolism and enhanced the soluble protein synthesis by activating enzyme activity (Koach and Mengel, 1977).

Application of BDS and biocompost had significantly influenced the nutrient parameters of guinea grass compared to recommended dose of fertilizer and spentwash ash (Table 3). Among the treatments, BDS @ 37.5 kilo litre ha^{-1} at full dose + RD of NP registered the highest nutrient content *viz.*, 1.04, 2.68, 0.42, 0.65 and 0.41 per cent of N, K, Na, Ca and Mg, respectively and which was on par with BDS @ 50 kilo litre ha^{-1} at full dose + RD of NP. In the case of phosphorus, biocompost @ 2.5 t ha^{-1} + RD of NP recorded the highest content of 0.31 per cent which was at par with BDS @ 37.5 kilo

Table 1 : Effect of distillery industry byproducts on initial and after harvest of guinea grass

Initial soil nutrient status	pH	EC (dS m^{-1})	OC (g kg^{-1})	Available nutrient (kg ha^{-1})		
				N	P_2O_5	K_2O
Treatments	7.24	0.28	3.56	11.85	22.3	228
T_1 - Recommended dose of fertilizers	7.29	0.25	3.37	119	21.7	212
T_2 - Biocompost @ 2.5 t ha^{-1} + RD of NP	7.35	0.32	3.75	140	28.9	276
T_3 - Spentwash ash @ 400 kg ha^{-1} + RD of NP	7.30	0.27	3.41	121	22.1	231
T_4 - BDS @ 37.5 kilo l ha^{-1} at full dose + RD of NP	7.38	0.37	3.84	145	26.1	302
T_5 - BDS @ 37.5 kilo l ha^{-1} at split dose + RD of NP	7.24	0.32	3.58	125	24.3	331
T_6 - BDS @ 50 kilo l ha^{-1} at full dose + RD of NP	7.41	0.42	3.93	153	27.2	321
T_7 - BDS @ 50 kilo l ha^{-1} at split dose + RD of NP	7.28	0.37	3.70	129	25.1	359

Table 2: Effect of BDS, biocompost and spentwash ash on physiological parameters of guinea grass

Treatments	Total chlorophyll (mg/g)	Carotenoid (mg/g)	Reducing sugar (%)	Soluble protein (mg/g)
T_1 - Recommended dose of fertilizers	2.56	0.41	0.43	26.2
T_2 - Biocompost @ 2.5 t ha^{-1} + RD of NP	2.86	0.53	0.49	27.5
T_3 - Spentwash ash @ 400 kg ha^{-1} + RD of NP	2.67	0.44	0.45	26.5
T_4 - BDS @ 37.5 kilo l ha^{-1} at full dose + RD of NP	3.01	0.57	0.52	28.2
T_5 - BDS @ 37.5 kilo l ha^{-1} at split dose + RD of NP	2.7	0.47	0.46	26.9
T_6 - BDS @ 50 kilo l ha^{-1} at full dose + RD of NP	2.94	0.55	0.5	27.8
T_7 - BDS @ 50 kilo l ha^{-1} at split dose + RD of NP	2.76	0.50	0.47	26.8
C.D. (P=0.05)	0.10	0.04	0.02	0.51

Table 3: Effect of BDS, biocompost and spentwash ash on macro and micro nutrient content (%) of guinea grass

Treatments	N	P	K	Na	Ca	Mg	Fe	Cu	Zn	Mn
T_1 - Recommended dose of fertilizers	0.99	0.25	2.37	0.32	0.53	0.31	255	10.8	20.5	14.0
T_2 - Biocompost @ 2.5 t ha^{-1} + RD of NP	1.02	0.32	2.57	0.39	0.61	0.38	265	12.2	24.7	16.7
T_3 - Spentwash ash @ 400 kg ha^{-1} + RD of NP	1.00	0.26	2.48	0.35	0.56	0.34	260	11.5	22.5	15.6
T_4 - BDS @ 37.5 kilo l ha^{-1} at full dose + RD of NP	1.04	0.31	2.68	0.42	0.65	0.41	270	12.9	25.9	17.7
T_5 - BDS @ 37.5 kilo l ha^{-1} at split dose + RD of NP	1.01	0.27	2.52	0.36	0.58	0.36	263	12.0	23.5	16.2
T_6 - BDS @ 50 kilo l ha^{-1} at full dose + RD of NP	1.03	0.29	2.61	0.40	0.63	0.39	267	12.5	25.2	17.3
T_7 - BDS @ 50 kilo l ha^{-1} at split dose + RD of NP	1.01	0.26	2.52	0.37	0.58	0.37	262	11.7	24.2	15.9
C.D. (P=0.05)	1.01	0.28	2.54	0.37	0.59	0.37	263	11.9	23.8	16.2

litre ha^{-1} at full dose + RD of NP and BDS @ 50 kilo litre ha^{-1} at full dose + RD of NP. The recommended dose of fertilizers recorded the lowest nutrient content *viz.*, 0.99, 0.25, 2.37, 0.32, 0.53 and 0.31 per cent of N, P, K, Na, Ca and Mg, respectively and it was on par with spentwash ash @ 400 kg ha^{-1} + RD of NP and BDS @ 37.5 kilo litre ha^{-1} at split dose + RD of NP and BDS @ 50 kilo litre ha^{-1} at split dose + RD of NP. This increased nutrients uptake due to more absorption of nutrients by the crop, supplied through nutrient rich BDS and biocompost. These results corroborate with the findings of Vijayakumar (2006) and Suganya (2008). Effluent has a rich source of organics, which may be beneficial to microflora besides acting as slow nutrient releaser. Significant improvement was observed in the cations of Ca, Mg, Na and K content by the crop in BDS and biocompost applied treatments. Such improvements were possibly due to the enhanced biomass of the crop thereby increased the uptake of cations (Hati *et al.*, 2007). Similar to macro nutrients, BDS and biocompost had significant influence on the micronutrients compared to recommended dose of fertilizer and spentwash ash (Table 3). Among the treatments, BDS @ 37.5 kilo litre ha^{-1} at full dose + RD of NP registered the highest Fe, Cu, Zn and Mn content of 270, 12.9, 25.9 and 17.7 mg kg^{-1}, respectively and the lowest micro nutrient content (Fe -255 mg kg^{-1}, Cu -10.8 mg kg^{-1}, Zn - 20.5 mg $kg^{-1}$and Mn -14.0 mg kg^{-1}) was recorded by recommended dose of fertilizer. This might be due to that high

Table 4: Influence of BDS, biocompost and spentwash ash on economics of guinea grass

Treatments	Total cost (Rs.)	Total return (Rs.)	Net return (Rs.)	BC ratio
T_1 - Recommended dose of fertilizers	75808	259700	183892	3.43
T_2 - Biocompost @ 2.5 t ha^{-1} + RD of NP	103774	282800	179026	2.73
T_3 - Spentwash ash @ 400 kg ha^{-1} + RD of NP	78574	268100	189526	3.41
T_4 - BDS @ 37.5 kilo l ha^{-1} at full dose + RD of NP	75474	291200	215726	3.86
T_5 - BDS @ 37.5 kilo l ha^{-1} at split dose + RD of NP	75474	273000	197526	3.62
T_6 - BDS @ 50 kilo l ha^{-1} at full dose + RD of NP	75474	288400	212926	3.82
T_7 - BDS @ 50 kilo l ha^{-1} at split dose + RD of NP	75474	273000	197526	3.62

micronutrient content with effluent application. This is in line with findings of Bhalerao *et al.* (2006) and Madhumitadas *et al.* (2010).

The application of BDS had significant influence in increasing the total green fodder yield when compared to RD and spentwash ash (Fig. 1). Application of BDS @ 37.5 kilo litre ha^{-1} at full dose + RD of NP (416 t ha^{-1}) recorded the highest green fodder yield which was on par with BDS @ 50 kilo litre ha^{-1} at full dose + RD of NP (412 t ha^{-1}). Irrespective of the harvests, recommended dose of fertilizers showed the lowest total green fodder yield (371 t ha^{-1}). The reason might be due to the favourable effect of organic matter and nutrients in distillery wastes which improved the physical environment and might have promoted better germination, root proliferation, nutrient and water uptake by the crops (Hati *et al*. 2007; Banulekha, 2007). Similar results were also obtained from the present study.

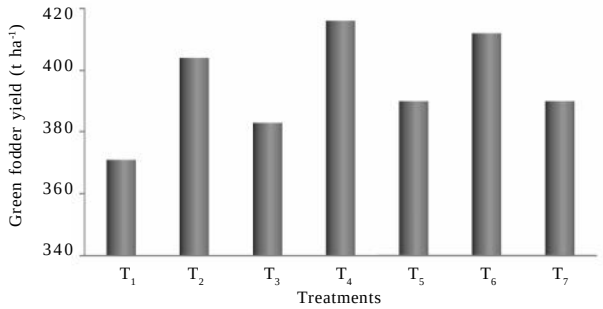

Fig. 1: Effect of BDS, biocompost and spentwash ash on total green fodder yield (t ha^{-1}) of guinea grass (COGG)

The treatment, BDS @ 37.5 kilo litre ha^{-1} at full dose + RD of NP recorded the highest benefit cost ratio and net profit followed by BDS @ 50 kilo litre ha^{-1} at full dose + RD of NP respectively compared to recommended dose of fertilizer (Table 4). The results revealed that the farmers could get a promising economic return in the distillery spentwash wastewater compared recommended dose of fertilizer, where the application of distillery spentwash is free of cost for neighbouring farmers on demand. Hence, basal application of BDS method could be adopted for better returns.

Conclusion :

From the present investigation, it could be concluded that the application of BDS @ 37.5 kilo litre ha^{-1} at full dose + RD of NP increased the nutrient parameters and these are highly correlated with green fodder yield of guinea grass. Distillery spentwash from sugar mills hither to considered as factory waste could be used as a source of nutrients to guinea grass. However, the level of application should be within the prescribed limit to avoid the development of soil salinity in the long run and it did not affect the ground water quality.

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