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Biomethanated distillery spentwash and pressmud biocompost as sources of plant nutrients for groundnut (*Arachis hypogaea* L.)

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Abstract: A field experiment was conducted to study the impact of biomethanated distillery spentwash and pressmud biocompost in various proportions with inorganic fertilizers on yield attributes, yield, oil and protein content of groundnut at Research and Development Farm of M/s. Bhavani Distilleries and Chemicals Ltd., T.Pudur, Thimiri, Tamil Nadu. Results of the field experiment revealed that yield and yield attributes *viz.,* number of matured pods, 100 kernel weight and shelling percentage of groundnut were improved by the application of biomethanated distillery spentwash and pressmud biocompost compared to recommended NPK as chemical fertilizers. One-time pre-sown application of BDS @ 100 m^3 ha^{-1} along with recommended NP in groundnut registered higher pod, grain and haulm yield of 1774, 1272 and 4668 kg ha^{-1}, respectively and the increase was to the tune of 35.83, 43.57 and 46.01 per cent, respectively over control. Similar to yield, BDS application increased the protein and oil content of groundnut kernels significantly. The net returns and benefit cost ratio of sugarcane were also as high as Rs.19,612 ha^{-1} and 1.90 for the treatment that received pre-sown application of BDS @ 100 m^3 ha^{-1} along with recommended NP as compared to control of Rs.19,612 ha^{-1} and 1.38, respectively. This concludes that the biomethanated distillery spentwash can be conveniently used as source of plant nutrients for groundnut.

Keywords: Biomethanated distillery spentwash, Groundnut, Pressmud biocompost, Yield attributes

INTRODUCTION

India has witnessed a tremendous increase in food grain production after the post-green revolution phase. Now, large scale efforts are directed towards agro-based industrialization to utilize the agro-wastes. Sugar industries are the most important agro-based industries in India, which contribute substantially to the economic development of the country. 579 sugar industries in the country produce 19.0 million tonnes of white sugar with daily cane crushing capacities varying from 800-10,000 tonnes per day. Apart from the sugar, these sugar industries discharge a large amount of by-products and waste materials with tremendous pollution load. The annual byproduct production from these industries is in the form of 7 million tonnes of pressmud, 7.5 million tonnes of molasses and 45 million tonnes of bagasse. Molasses is utilized in the distillery for the production of alcohol (Murthy and Chaudhari, 2009).

Distilleries are the major agro-industries that generate large quantity of alcohol from molasses, a by-product of sugar industries. Alcohol bears immense significance as a raw material for rapidly advancing chemical industry and as a readily available source of energy. Therefore, in the present scenario as well as for the future, demand for alcohol will increase in the country and so as the number of distilleries (Sharma *et al.,* 2007). In India, this demand is projected to go up because of a law for mixing 5 per cent ethanol with petrol and further raising this amount to 10 per cent (The Gazette of India, 2002). In the year 1999, there were 285 distilleries in India producing 2.7×10^9 L of alcohol each year (Joshi, 1999) and this number has gone upto 319, producing 3.25×10^9 L of alcohol annually (Uppal, 2004). The distilleries are listed at the top in the "Red Category" industries having a high polluting potential by the Ministry of Environment and Forests (MoEF), Government of India (Tewari *et al.,* 2007). Effluent originating from distilleries known as spentwash leads to environmental pollution due to its large volume and with very high strength of chemical oxygen demand (COD) and biochemical oxygen demand (BOD). At present, there are 319 distilleries in India generating 40 billion litres of spentwash annually (Mohana *et al.,* 2009). The ever-increasing generation of distillery spentwash on the one hand and stringent legislative regulations of its disposal on the other has stimulated the need for developing new technologies to process this effluent efficiently and economically.

Distilleries employ various forms of primary, secondary and tertiary treatments to reduce the pollution potential of spentwash. At present, the anaerobic digestion (biomethanation) of distillery effluents is widely applied as the primary treatment process to remove the organic

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load of the distillery spentwash (Pant and Adholeya, 2007). Anaerobic digestion can convert a significant portion (>80 %) of the COD to biogas, which may be used as an inplant fuel. The effluent discharged after biomethanation process is known as Biomethanated Distillery Spentwash (BDS). The BDS is effective organic liquid fertilizer derived from Sugar industry waste materials (Samuels, 1980). The BDS could be recycled in agriculture both as irrigation water and as a source of plant nutrients. It contains large amount of organic carbon, K, Ca, Mg, Cl and SO_4 and moderate amount of N and P and traces of Zn, Cu, Fe and Mn (Mahimairaja and Bolan, 2004).

Pressmud, a waste product from sugar mill is yet another source for nutrients which can be utilized by biocomposting it with BDS. Biocomposting of sugarcane pressmud with BDS is a common practice in sugar-distillery complexes and over hundred units have adopted this measure in India (Tewari *et al.*, 2007). The product is packaged and sold as an organic fertilizer. The pressmud biocompost contains appreciable amount of plant nutrients *viz.*, organic carbon, nitrogen, phosphorus, potassium, calcium and magnesium along with traces of micronutrients *viz.*, Zn, Fe, Cu and Mn (Banulekha, 2007). The beneficial effect of the organic matter for enhancing the soil fertility and thereby improving the crop productivity is well established (Laird *et al.*, 2001). Thus, the soil application of BDS and pressmud biocompost could offer the benefit of safe disposal of the wastes and also replenishes the soil nutrients and reduces the fertilizer cost. Therefore, the present investigation was carried out to study the effect of BDS and pressmud biocompost on yield attributes, yield and quality of groundnut.

MATERIALS AND METHODS

Experimental design: A field experiment was conducted to study the effect of BDS and pressmud biocompost on growth, yield and quality of Groundnut (*Arachis hypogaea* L.) var. TMV 7 at Research and Development Farm of M/s. Bhavani Distilleries and Chemicals Ltd., T.Pudur, Thimiri, Arcot taluk, Vellore district, Tamil Nadu. The soil of the experimental field was categorized as sandy clay loam with the series of Ethapur and the sub-order of Fine Loamy Hyperthermic Typic Rhodustalfs under the soil order of Alfisol. The soil was neutral in reaction with low in organic carbon, available N, available phosphorus and available potassium. Normal weather conditions prevailed during the crop growth period. The experiment was laid out in a randomized block design with ten treatments in three replications.

Treatment details

T_1: Recommended NPK (17: 34: 54 kg of N: P_2O_5: K_2O ha^{-1})

T_2: Application of biocompost @ 2.5 t ha^{-1} + Recommended NPK

T_3: Application of biocompost @ 5 t ha^{-1} + Recommended NPK

T_4 : Pre-sown application of BDS @ 100 m^3 ha^{-1} + Recommended NP alone

T_5 : Pre-sown application of BDS @ 10 m^3 ha^{-1} (=100 % RDF- N) + balance P through inorganic fertilizer

T_6 : Pre-sown application of BDS @ 20 m^3 ha^{-1} (=200 % RDF- N) + balance P through inorganic fertilizer

T_7 : Pre-sown application of BDS @ 30 m^3 ha^{-1} (=300 % RDF- N) + balance P through inorganic fertilizer

T_8 : Pre-sown application of BDS @ 40 m^3 ha^{-1} (=400 % RDF- N) + balance P through inorganic fertilizer

T_9 : Post-sown application of BDS @ 10 m^3 ha^{-1} (=100 % RDF- N) on 30 DAS + balance P through inorganic fertilizer

T_{10} : Post-sown application of BDS @ 20 m^3 ha^{-1} (=200 % RDF- N) on 30 DAS + balance P through inorganic fertilizer

Application of BDS itself supplied the entire quantity of crop requirement of N and K_2O for the treatments T_5 to T_{10}. The entire dose of inorganic source of N and K_2O were applied basally for the Treatments T_1, T_2, T_3 and T_4 (N alone). The calculated quantity of BDS (Table 1) was uniformly applied in each plot as per the treatment details. Then, the soil was ploughed at 10 days interval for two times providing better soil aeration and consequent reduction of BOD level in the soil-water system. Biocompost (Table 2) was incorporated in the respective treatments at the time of last ploughing. On 30th day of BDS application, individual plots were formed with flat beds and the Groundnut seeds of TMV 7 were sown by adopting a seed rate of 125 kg ha^{-1} and a spacing of 30 cm x 10 cm during the last week of July, 2008. In post-sown application, BDS were applied along with irrigation on 30 days after sowing (DAS) of groundnut. All cultural practices including gap filling, thinning, weeding, plant protection measures and other cultural practices were done as per the recommendations of Tamil Nadu Agricultural University.

Yield attributes: The total number of matured pods per plant was counted from randomly selected plants in the net plot area of individual treatment at harvest. Pod weight, kernel weight and shelling percentage were recorded from randomly selected one hundreds pods of five batches in each plot.

Yield: The pods and haulm from the net plot were harvested and sun dried, and its mean yield was expressed in kg ha $^{-1}$ for individual treatment.

Oil content: The oil content in groundnut kernels was determined using Nuclear Magnetic Resonance Spectrometer (Sagare and Naphade, 1983).

Protein content: Total nitrogen content of kernel was estimated by micro Kjeldahl's method in the defatted material as followed by Humphries (1956). Total nitrogen content was multiplied by the factor 6.25 (Dubtez and Wells, 1968) to get crude protein content.

Statistical analysis: The experimental results were statistically scrutinized as suggested by Panse and Sukhatme (1985) to find out the influence of various treatments on yield, yield attributes and quality of groundnut. The critical difference was worked out at 5 per cent (0.05) probability.

RESULTS AND DISCUSSION

Effect on yield attributes of groundnut: In general, the yield attributes *viz.*, number of matured pods, 100 kernel weight and shelling percentage were significantly influenced by the application of BDS and biocompost. Application of different levels of BDS and biocompost markedly increased the number of matured pods which ranged from 16.4 to 25.2 (Table 3). Plants with the pre-sown application of BDS @100 $m^3 ha^{-1}$ along with recommended NP (T_4) had greater number of matured pods (25.2), whereas plants that didn't receive BDS had lesser number of matured pods (16.4). The 100 kernel weight of groundnut crop ranged from 34.4 to 36.2 g (Table 3). Application of BDS and biocompost did not significantly influence the 100 kernel weight. The different treatments significantly influenced the shelling percentage of groundnut which ranged from 67.43 to 71.69. The increase in yield attributes could be due to the favourable effect of BDS, which enhanced the fertility status of soil and improved the soil physical environment that might have promoted better germination, root proliferation, nutrient and water uptake by the crops (Hati *et al.*, 2007). The result substantiates the findings of many researchers, who reported the significant improvement in yield attributes of crops due to the application of spentwash (Rajukannu *et al.*, 1996, Devarajan *et al.* (1998) and Mallika, 2001). Kalaiselvi and Mahimairaja (2011) also found that application of BDS @ 120 m^3 ha^{-1} along with recommended NP recorded maximum yield attributes of the groundnut variety TMV 7 over control.

Effect on pod, kernel and haulm yield of groundnut: Application of BDS and biocompost significantly increased the pod, kernel and haulm yield in groundnut over the application of recommended fertilizer. Pre-sown application of BDS @ 100 m^3 ha^{-1} along with recommended NP (T_4) recorded the highest pod yield of 1774 kg ha^{-1}, kernel yield of 1272 kg ha^{-1} and haulm yield of 4668 kg ha^{-1} compared to recommended NPK which recorded the lowest

Table 1. Physico-chemical characteristics of biomethanated distillery spentwash.

S.No	Parameters	BDS
	Physical properties	
1	Colour	Dark brown
2	Odour	Unpleasant
3	Total dissolved solids (mg L^{-1})	42300
4	Total suspended solids (mg L^{-1})	6100
5	Total solids (mg L^{-1})	48400
	Physico-chemical properties	
6	pH	7.57
7	EC (dSm^{-1})	33.45
8	BOD (mg L^{-1})	11400
9	COD (mg L^{-1})	42800
10	Organic carbon (mg L^{-1})	25200
11	Nitrogen (mg L^{-1})	1700
12	Phosphorus (mg L^{-1})	248
13	Potassium (mg L^{-1})	10680
14	Sodium (mg L^{-1})	480
15	Calcium (mg L^{-1})	2120
16	Magnesium (mg L^{-1})	1680
17	Chloride (mg L^{-1})	9050
18	Bicarbonate (mg L^{-1})	3470
19	Carbonate (mg L^{-1})	Absent
20	Sulphate (mg L^{-1})	2950
21	Copper (mg L^{-1})	3.9
22	Manganese (mg L^{-1})	7.2
23	Iron (mg L^{-1})	51.4
24	Zinc (mg L^{-1})	6.4
	Biological properties	
25	Bacteria (x 10^6 CFU ml^{-1})	21
26	Fungi (x 10^4 CFU ml^{-1})	11
27	Actinomycetes (x 10^2 CFU ml^{-1})	3

Table 2. Physico-chemical characteristics of pressmud biocompost.

S. No.	Parameters	Values
1	pH	7.50
2	EC (dSm^{-1})	8.80
3	Organic carbon (%)	24.80
4	Total nitrogen (%)	1.54
5	Total phosphorous (%)	1.08
6	Total potassium (%)	2.95
7	Total calcium (%)	3.20
8	Total magnesium (%)	2.00
9	Sodium (%)	1.05
10	C/N ratio	16.10
11	Copper (mg kg^{-1})	45
12	Zinc (mg kg^{-1})	105
13	Iron (mg kg^{-1})	2000
14	Manganese (mg kg^{-1})	190
	Biological properties	
15	Bacteria (x10^6 CFU g^{-1})	31
16	Fungi (x10^4 CFU g^{-1})	17
17	Actinomycetes (x10^3 CFU g^{-1})	11

Table 3. Effect of biomethanated distillery spentwash and pressmud biocompost on yield attributes and yields of groundnut.

Treatments	No. of pods plant^{-1}	100 kernel weight (g)	Shelling percentage	Pod yield (kg ha^{-1})	Kernel yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
T_1	16.4	34.4	67.80	1306	886	3197
T_2	18.8	34.8	70.10	1515	1062	3968
T_3	22.6	35.4	70.66	1673	1182	4208
T_4	25.2	36.2	71.69	1774	1272	4668
T_5	17.4	34.5	67.43	1448	977	3666
T_6	18.2	34.8	68.90	1502	1035	3918
T_7	18.6	34.9	69.01	1513	1044	4012
T_8	22.0	35.3	70.57	1633	1152	4299
T_9	17.2	34.5	67.56	1448	978	3730
T_{10}	18.3	34.8	68.72	1505	1034	3910
Mean	19.5	35.0	69.24	1532	1062	3958
SEd	1.73	0.90	1.26	79.26	50.01	101.28
CD (0.05)	3.64	NS	2.64	166.44	105.02	212.68

pod yield of 1306 kg ha^{-1}, kernel yield of 886 kg ha^{-1} and haulm yield of 3197 kg ha^{-1} (Table 3). The pronounced effect of BDS on pod, kernel and haulm yield of groundnut might be because of the presence of considerable quantities of primary and secondary nutrients and organic matter essential for plant nutrition. Increase in the availability of these nutrients might have favoured greater uptake of nutrients by groundnut which was reflected on better growth, development and yield of the crop obtained. The current result corroborates with the findings of Ramana *et al.* (2002) who reported that the distillery spentwash significantly increased the seed yield in groundnut over the control.

In pre-sown application of BDS @ 100 m^3 ha^{-1} along with recommended NP (T_4), combined use of organic matter along with inorganic fertilizers enhanced the inherent nutrient supplying capacity of the soil with respect to both macro and micronutrients as reported by Kachot *et al.* (2001) and Hao and Chang (2002), and also improved physical properties of the soil, which promoted better rooting, higher nutrient uptake by the crop, increased dry matter produc-tion and increased yield of groundnut. The result substantiates the findings of many researchers, who reported that the improvement in fertility and quality of soil, especially under low input agricultural systems, requires organic materials as the major input (Palm *et al.*,

Table 4. Effect of biomethanated distillery spentwash and pressmud biocompost on net returns and benefit cost ratio for groundnut.

Treatments	Total cost of cultivation (Rs.)	Return from dried pods (Rs.)	Return from haulm (Rs.)	Total returns (Rs.)	Net returns (Rs.)	Additional net returns over recommended NPK (Rs. ha^{-1})	Benefit/ Cost ratio
T_1	22040	28737	1599	30336	8296	-	1.38
T_2	22950	33323	1984	35307	12357	4062	1.54
T_3	24150	36809	2104	38913	14763	6467	1.61
T_4	21740	39018	2334	41352	19612	11317	1.90
T_5	21320	31862	1833	33695	12375	4080	1.58
T_6	21170	33042	1959	35001	13831	5535	1.65
T_7	21020	33290	2006	35296	14276	5980	1.68
T_8	20870	35920	2150	38070	17200	8904	1.82
T_9	21320	31849	1865	33714	12394	4099	1.58
T_{10}	21170	33119	1955	35074	13904	5608	1.66

Note: Cost of fertilizers: Urea = Rs. 4.8 kg^{-1}; Super phosphate = Rs. 9.4 kg^{-1}; Muriate of potash = Rs. 4.5 kg^{-1}; Cost of pressmud biocompost = Rs. 400 t^{-1}; Cost of dried pod = Rs. 22 kg^{-1}; Cost of haulm = Rs. 500 t^{-1}. (1 US $ = Rs. 44)

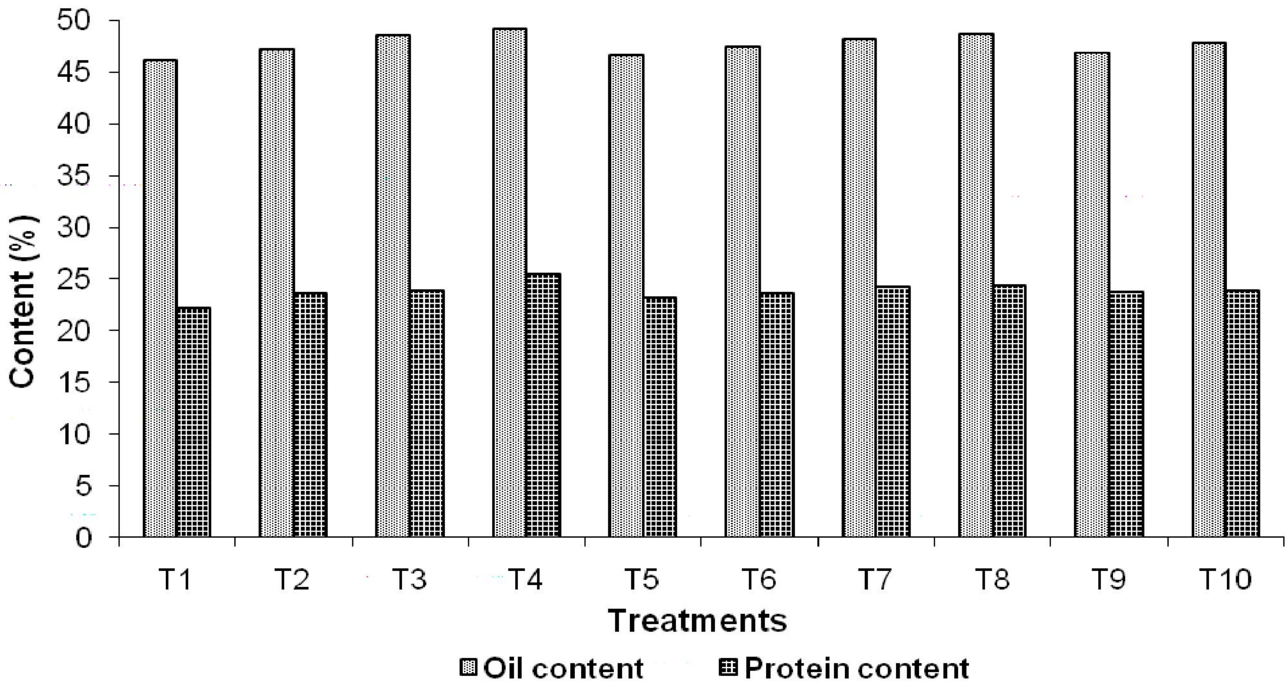

Fig. 1. *Effect of biomethanated distillery spentwash and pressmud biocompost on oil and protein content of groundnut.*

2001; Ouedraogo *et al.,* 2001; Bhadoria *et al.,* 2003; Soumare *et al.,* 2003; Hati *et al.,* 2006), which hold great promise due to their local availability as a source of multiple nutrients and abil-ity to improve soil characteristics. This corroborates the results of Haroon and Bose (2004) and Patil *et al.* (2007) who reported a significant improvement in yield of crops due to the application of BDS.

Effect on oil and protein content of groundnut kernel: The oil and protein content of groundnut kernels were improved significantly due to the application of BDS and biocompost. Pre-sown application of BDS @ 100 m^3 ha^{-1} with recommended NP (T_4) recorded the highest oil content of 49.2 per cent over recommended NPK, which recorded lower oil content of 46.1 per cent (Fig. 1). The increment in the oil content of kernels might be attributed to the increased concentration and uptake of P, Cu and Zn. Being rich in Zn (6.4 mg L^{-1}), application of BDS enriched the soil with Zn which might have led to higher concentration and uptake of Zn by kernels. This element plays a vital role in the activity of $NADH^+$, which is associated with fat synthesis. Hence, enhancement in Zn uptake resulted in increased oil content in the kernels. Singh *et al.* (2003) reported that the contents of methionine and cystine in seeds were higher due to application of BDS. The reason for higher methionine and cystine content might be due to high S content of the spentwash. Generally, sulphur addition is being recommended for groundnut crop to improve the oil content of kernal. Copper is also related with lipid synthesis (Karmakar *et al.,* 2001).

The protein content of kernel markedly increased with increase in the levels of BDS and biocompost application, and pre-sown application of BDS @ 100 m^3 ha^{-1} with RDF-NP fertilizers resulted in the highest protein content (25.5%) in kernels. With the application of recommended fertilizer (T_1) the kernel protein content of the kernel was only 22.2 per cent (Fig. 1). Due to BDS application, it was improved upto 25.5 per cent. Since N is an integral part of protein and P is structural element of certain co-enzymes involved in protein synthesis, higher concentration of N and P in kernels under integrated application of BDS along with RDF- NP fertilizer treated plots resulted in higher protein content. This corroborates the results of Devarajan *et al.* (1998) who observed an improvement in seed protein, and oil content in groundnut (var. TMV 7), due to application of 40 and 50 times diluted distillery spentwash.

Cost analysis: In general, net returns and benefit cost ratio were significantly higher in different levels of BDS and biocompost applied treatments compared to recommended NPK treatment. Among the treatments, split application of BDS @ 100 m^3 ha^{-1} along with recommended N and P through inorganic fertilizer (T_4) recorded the highest net returns (Rs. 19,612 ha^{-1}) and benefit cost ratio (1.90 : 1). An additional income of Rs. 11,317 ha^{-1} is attributed solely for pre-sown application of BDS @ 100 m^3 ha^{-1} along with recommended N and P through inorganic fertilizer (Table 4).

Conclusion

The result of the present study revealed that entire quantity of inorganic potassium fertilizer requirement could be saved by the application of BDS @ 100 m^3 ha^{-1}

as pre-sown along with balance NP through inorganic fertilizer, with improving yield attributes, yield and quality parameters of groundnut. The highest net profit of Rs.19,612 ha^{-1} and maximum benefit cost ratio of 1.90 were also recorded in the treatment that received pre-sown application of BDS @ 100 m^3 ha^{-1} along with recommended NP against Rs.19,612 ha^{-1} and 1.38 respectively in recommended NPK as chemical fertilizers. Hence, the biomethanated distillery spentwash can be conveniently used as the source of plant nutrients for groundnut crop cultivation as an eco-friendly manner.

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