Environment and Ecology 42 (2A) : 616—621, April—June 2024
Article DOI: https://doi.org/10.60151/envec/KOEY3792
ISSN 0970-0420

Ecofriendly Utilization of Distillery Spentwash for Enhancing Growth and Yield of Pearl Millet

R. Jayashree

Received 11 September 2023, Accepted 4 March 2024, Published on 6 May 2024

ABSTRACT

The Post Biomethanated Distillery Spentwash (PBDSW) is effective organic liquid manure derived from sugar industry waste materials. Spentwash contain high amount of nutrients like Nitrogen, Phosphorus, Potassium, Calcium and Sulfur. In addition, it contains sufficient amount of micronutrients such as Iron, Zinc, Copper, Manganese, Boron and Molybdenum. The spentwash application on land is beneficial to control the water pollution and agricultural production. The experiment was performed with different doses of Post Biomethanated Distillery Spentwash (PBDSW) as a source of nutrients in various proportions with inorganic fertilizer using pearl millet as the test crop. The results of the experiment showed that the application of PBDSW at the rate of 100 KL ha^{-1} in combination with NPK recorded higher ear head, grain and stover yield as compared to other substitution level, split application and control.

R. Jayashree
Associate Professor (ENS)
Department of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore 641003, India
Email : jayashree.r@tnau.ac.in

Keywords PMDSW application, Pearl millet, Growth, Yield.

INTRODUCTION

India is one among the highest sugar producer in the world. Currently, there are 650 sugar mills which yields 13 million tons of molasses (spent wash) for a year. The sugar mill effluent is mainly discharged from floor, wastewater, and condensate water formed by leakage. The disposal of polluted wastewater is one of the main problems of today to be faced in the future with its increased adverse effects (Moazzam *et al.* 2012). Most of the sugar mills are discharging their effluent into the environment without any treatment. According to recent research, soil health and microbiota affected due to application of spentwash with high pollutants. Certain physico–chemical elements released from the effluent has increased the amount of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), cations, anions and heavy metals (Shinde *et al.* 2021).

Irrigation water continues to be the single most important factor dictating the success of crop productivity in arid and semi-arid agro-climatic zones. In the past five decades, the water availability has reduced to half and further reduction is fast approaching. This necessitates using every drop of water that can be recycled back to the crop production. Recycling of waste water has adverse effect on crop growth. Since, effluent is rich in plant nutrients and also easily available, it reduces the cost of fertilizer and water

(Kumar and Chopra 2012).

Unlike other industrial wastewater, the Post Biomethanated Distillery Spentwash (PBDSW) has no harmful chemicals, thus promoting soil health and plant growth. Being originated from a plant source, it contains large amounts of organic carbon, K, Ca, Mg and S and moderate levels of N and P and small quantities of Fe, Zn, Mn and Cu and plant growth promoters like Gibberellic Acid (GA) and Indole Acetic Acid (IAA). Therefore, PBDSW is potent substitute for nutrients which induces plant growth (Kumar and Chopra 2012, Chopra *et al.* 2012).

Pearl millet (*Pennisetum glaucum*) is grown on more than 29 million hectares in the arid and semi-arid tropical regions of Asia, Africa and Latin America. Pearl millet has about the same nutritive quality as corn for domestic animals (Moazzam *et al.* 2012). Thus, it is widely used for food and fodder throughout the world and is considered as fifth foremost crop after wheat, maize, rice, and barley. The biomass of the Pearl millet is extensively utilized in the sectors of animal husbandry and paper industries. Pearl millet is the fourth most important food crop in India. Among the Asian countries, the largest producer of Pearl millet is India with an average productivity of 930 kg/ha during the past three years.

Improper irrigation facilities led to the deprivation of pearl millet by 22% in India (Moazzam *et al.* 2012). Thus, it became a successful survivor of drought. Due to this capability, the pearl millet can also be used as a substitute for food, fodder, and energy production. The response of crop growth with respect to different doses of spent wash application is receiving attention. Hence, proposed study was aimed to find out the utilization of Post Biomethanated Distillery Spentwash (PBDSW) for the maximizing the crop growth and also to enhance soil health.

MATERIALS AND METHODS

Collection and preservation of samples

Collection of spent wash from the M/s Sakthi Sugars Ltd (Distillery Division) at Aapakudal, Erode District, Tamil Nadu. The Post Biomethanated Distillery Spentwash (PBDSW) was collected in polycarboryl containers, properly sealed and stored at 4°C for the analysis of physico-chemical and biological properties (APHA 1989)

Field experiment

The experimental trial was conducted at M/s Sakthi Sugars Ltd, Sakthi Nagar, Erode district, Tamil Nadu in order to assess the impact of distillery spentwash application on the physico-chemical properties, plant growth parameters, of Pearl millet (Main crop). The variety choosen was CO (Cu) 9, planted in Randomized Block Design with four replication and spacing of 45×15 cm. The treatment details are T_1–Control – 100% recommended dose of NPK, T_2- PBDSW at the rate of 100 KL ha^{-1} and recommended dose of NPK, T_3–PBDSW at the rate of 100 KL ha^{-1} in split application and recommended dose of NPK, T_4 –50% K through PBDSW and Remaining N, P, K through inorganic source, T_5-00% K substitution through PBDSW and Remaining N, P through inorganic source.

As per the treatment schedule the calculated quantity (For T_1: Nil, T_2: 9.88L m^{-2}, T_3: 3.3L m^{-2}at 0^{th}, 30^{th} and 60^{th} day, T_4 : 0.3L m^{-2}, T_5: 0.1 Lm^{-2}) of biomethanated distillery spentwash for pre-sown application was uniformly applied to the plots. To enhance the aeration and oxidation, the treated plots were inverted with spade after 15 days of spent wash application. In all the plots, entire phosphorus and half dose of nitrogen as per the treatments were applied as basal while remaining nitrogen as per the treatments was applied in two equal splits on 30^{th} and 45^{th} day after sowing. Biometric parameters at different stages of crop growth are assessed and the plant samples (pearl millet) collected from the field at the time of harvest were analyzed for various cations and anions.

Biometric observations-growth attributes

Biometric observations were made by randomly selecting five plants (pearl millet) in the plot area of individual treatments at 30 and 60 days after sowing (DAS) and at the time of harvest. The biometric parameters like plant height, numbers of leaves, stem girth and Leaf Area Index (LAI), yield attributes like

ear head length, ear head girth, ear head weight and thousand grain weight were observed and the mean values recorded were expressed as per the SI system of units.

Grain and stover yield

The ear head were sun dried, shelled, cleaned and grain yield was recorded for individual treatment and expressed in kg ha^{-1}. After the harvest of pearl millet ear head, the stover in the net plot area were cut close to the ground level and left in the field for three days for sun drying. After drying, weight of stover from each treatment was recorded and expressed in kg ha^{-1}.

Collection and processing of plant samples

The plant and seed samples were collected from the field and it was dried in hot air oven. The oven dried samples were powdered in Wiley mill and analyzed for N, P, K, Ca, Mg and Na contents by adopting the methods (APHA 1989). The corresponding nutrients uptake was computed based on the yield of grain and total biomass on oven dry weight basis.

Statistical analysis

The experimental results were statistically scrutinized and the critical difference was worked out at 5% (0.05) probability levels.

RESULTS AND DISCUSSION

Physico-chemical properties of post biomethanated distillery spentwash (PBDSW)

The major physico-chemical and biological properties of the Post Biomethanated (PBDSW) samples that were obtained from M/s. Sakthi Sugars Limited were shown in Table 1. The appearance of the distillery spent wash was greenish brown, and it also had an awful burnt sugar smell. Spent wash had a specific gravity of 1.12 g cc^{-1}. The spent wash was neutral in pH (7.75) with an EC of 37.8 dS m^{-1}. The organic carbon content of the spent wash was 26,110 mg L^{-1}. It contains large amount of total suspended solids (6,850 mg L^{-1}), total dissolved solids (45,120 mg L^{-1}) and total solids (51,970 mg L^{-1}). The Distillery Spent Wash (DSW) had a Biochemical Oxygen Demand (BOD) of 8,740 and a Chemical Oxygen Demand (COD) of 37,476 mg L^{-1}. It contains nitrogen (1,700 mg L^{-1}), phosphorus (450 mg L^{-1}) and high level of potassium (11,550 mg L^{-1}). Relatively large amount of calcium (2,272 mg L^{-1}) was present than magnesium (1,580 mg L^{-1}). The sodium content of spent wash was 845 mg L^{-1}, with the sodium absorption ratio of 4.56. Chloride and sulphate were found in larger amounts followed by bicarbonate, while carbonate was nil. The treated spentwash encounters the following values: 4.56, 9.87, -61.20 meq L^{-1}, 258.24 meq L^{-1}, Soluble Sodium Percentage (SSP), Residual Sodium Carbonate (RSC), and Potential Salinity (PS), according to sequence.

Table 1. Characteristics of post biomethanated distillery spentwash (PBDSW).

Characteristics	Values*
Color	Dark brown
Odour	Unpleasant
Moisture (%)	82
Specific gravity (g cc^{-1})	1.12
pH	7.75
EC (dS m^{-1})	37.8
Total suspended solids (TSS) (mg L^{-1})	6,850
Total dissolved solids (mg L^{-1})	45,120
Total solids (mg L^{-1})	51,970
Organic carbon (mg L^{-1})	26,110
BOD (mg L^{-1})	8,740
COD (mg L^{-1})	37,476
Nitrogen (mg L^{-1})	1,700
Phosphorus (mg L^{-1})	450
Potassium (mg L^{-1})	11,550
Calcium (mg L^{-1})	2,272
Magnesium (mg L^{-1})	1,580
Sodium (mg L^{-1})	845
Chloride (mg L^{-1})	888.5
Carbonate (mg L^{-1})	Absent
Bicarbonate (mg L^{-1})	54.12
Sulphate (mg L^{-1})	75.70
SAR	4.56
RSC (meq L^{-1})	-61.25
SSP	9.87
PS (meq L^{-1})	258.24

*Mean of three samples

Effect of PBDSW application on pearl millet crop growth parameters

Growth attributes

The results of growth attributes at 30 DAS are present-

Table 2. Effect of PBDSW on pearl millet growth characteristics during the vegetative stage (30 DAS) and flowering (60 DAS) stage.

Treatments	Vegetative stage (30 DAS)				Flowering stage (60 DAS)			
	Plant height (cm)	Plant girth (cm)	No. of tillers/plant	LAI	Plant height (cm)	Plant girth (cm)	No. of tillers/plant	LAI
T_1	54.3	2.25	4.3	1.22	138.0	4.50	3.2	2.65
T_2	71.9	2.65	4.9	1.26	169.2	5.30	3.6	3.20
T_3	66.5	2.52	4.7	1.26	160.1	5.13	3.6	2.98
T_4	60.1	2.40	4.5	1.25	149.3	4.90	3.4	2.85
T_5	56.0	2.30	4.4	1.24	144.0	4.69	3.3	2.73
Mean	**61.7**	**2.42**	**4.6**	**1.25**	**152.1**	**4.90**	**3.4**	**2.88**
SEd	3.22	0.03	0.05	0.01	7.83	0.07	0.06	0.04
CD	7.01	0.07	0.12	0.03	17.07	0.16	0.13	0.10

ed in Tables 2–3. From the results, it is evident that the highest plant height (71.9 cm), plant girth (2.65 cm), no. of tillers plant^{-1} (4.9) and Leaf area index (1.26) was recorded in the treatment that received PBDSW at the rate of 100KL ha^{-1} along with recommended dose of NPK (T_2). The lowest plant height (54.3 cm), plant girth (2.25 cm), no. of tillers plant^{-1} (4.3) and LAI (1.22) (Table 3) was recorded in the control–RDF. The treatment with varying amounts of PMDSW did not any show significant ($p<0.05$) difference for leaf area index.

At the harvest stage the control - RDF recorded the lowest plant height (218.00 cm), plant girth (5.71 cm), no. of tillers plant^{-1} (2.8) and LAI (0.88). The elevated plant height (273.00 cm), plant girth (6.25 cm), no. of tillers plant^{-1} (3.5) and LAI (1.88) were noted during the period of treatment, that supplied PBDSW at the rate of 100KL ha^{-1} along with recommended dose of NPK (T_2) (Table 4).

Table 3. Effect of PBDSW on growth characteristics of pearl millet at harvest stage (90 DAS).

Treatments	Harvest stage (90 DAS)			
	Plant height (cm)	Plant girth (cm)	No. of tillers/plant	LAI
T_1	218.0	5.71	2.8	0.88
T_2	273.3	6.25	3.5	1.98
T_3	256.4	6.10	3.4	1.95
T_4	239.0	5.90	3.2	1.92
T_5	231.0	5.82	3.1	1.87
Mean	**243.5**	**5.96**	**3.2**	**1.72**
SEd	12.56	0.08	0.03	0.02
CD	27.37	0.18	0.08	0.04

Yield attributes

The results of ear head length, ear head girth, single ear head weight and 1000 grain weight are presented in Table 4. Among the different treatments, the highest ear head length (52.00 cm), ear head girth (8.30 cm), single ear head weight (68.37 g) and 1000 grain weight (11.35 g) was recorded in the treatment that supplied PBDSW at the rate of 100KL ha^{-1} along with suggested NPK dosage (T_2) followed by T_3 (PBDSW at the rate of 100KL ha^{-1} in split dose along with suggested NPK dosage which recorded ear head length (46.00 cm), ear head girth (7.95 cm), single ear head weight (63.50 g) and 1000 grain weight (10.49 g), respectively. Control - RDF recorded the lowest ear head length (30.00 cm), ear head girth (6.10 cm), single ear head weight (52.41 g) and 1000 grain weight (9.30 g), respectively when compared with all other treatments. Regarding the 1000 grain weight and ear head girth T_2 and T_3 are on par with each other.

Table 4. Effect of PMDSW on yield characteristics of pearl millet.

Treatments	Ear head length (cm)	Ear head girth (cm)	Single ear head weight (g)	1000 grain weight (g)
T_1	30.0	6.10	52.41	9.30
T_2	52.0	8.30	68.37	11.35
T_3	46.0	7.95	63.50	10.49
T_4	39.0	7.30	57.70	9.90
T_5	36.0	6.60	55.13	9.73
Mean	**40.6**	**7.25**	**59.42**	**10.15**
SEd	2.16	0.13	3.08	0.17
CD	4.72	0.29	16.72	0.38

Table 5. Effect of PBDSW on growth characteristics of pearl millet.

Treatments	Ear head yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	5510.0	2802.0	3120.0
T_2	6450.0	3178.0	3575.0
T_3	6235.0	3088.0	3455.0
T_4	5835.0	2980.0	3372.0
T_5	5712.0	2870.0	3280.0
Mean	**5948.4**	**2983.6**	**3360.4**
SEd	149.6	72.5	79.0
CD	325.9	157.9	172.1

Yield

The results of growth characteristics in pearl millet are furnished in the Table 5. The highest ear head yield (6450 kg ha^{-1}), grain yield (3178 kg ha^{-1}) and stover yield (3575 kg ha^{-1}) were observed in the treatment that received PBDSW at the rate of 100 KL ha^{-1} along with suggested NPK dosage (T_2) followed by T_3 (PBDSW at the rate of 100KL ha^{-1} in split dose along with recommended dose of NPK) which recorded ear head yield (6235 kg ha^{-1}), grain yield (3088 kg ha^{-1}) and stover yield (3455 kg ha^{-1}). The lowest ear head yield (5510 kg ha^{-1}), grain yield (2802 kg ha^{-1}) and stover yield (3120 kg ha^{-1}) were observed for the control – RDF (Table 5). Naveed *et al.* (2018) reported that the application of 5% spent wash (SW) significantly enhanced the plant growth, and yield components. Photosynthesis rate, transpiration rate, and stomatal conductance in rice crop.

Small amount of chemical fertilizer along with PMDSW is required to supplement the demand of the crop nitrogen at initial stage of crop growth. On the other hand, nutrients derived from PMDSW could satisfy the pearl millet crop's nutritional requirements in later stages of crop growth.

Thus, the plant nutrients will be available as per the plant demands resulting in better growth, development and yield components. Similar beneficial effects of distillery waste water on crop yield were also reported by Moazzam *et al.* (2012). Bhindi yield was enhanced with a single application of 100% spent wash in the field. With one treatment, the maximum fruit yield of 9,884 kg ha^{-1} and dry matter output of 2,341 kg ha^{-1} were reported (Sugumaran and Maheswari 2020). Additionally, there was a 15–28% increase beyond the control. The immense quantity of plant nutrients identified in remaining wash present a great chance to use it as a liquid fertilizer when mixed with irrigation water, encouraging farmers to reduce their fertilizer costs while simultaneously boosting crop yields (Sugumaran and Maheswari 2019). Application of PMDSW enhanced the beetroot's yield characteristics by making more nutrients available. The lowest yield (7.5 t/ha) was achieved at T_1 (Absolute control), while the greatest yield (10.80 t/ha) was obtained at T_5 (PMDSW@ 288.33 KL^{-1} ha^{-1}) (Sugumaran and Akila 2020).

CONCLUSION

The field experiment with one time application increased the nutrients content of the soil. The growth characteristics viz., plant height, plant girth, number of tillers per plant, leaf area index and yield parameters viz., ear head length, ear head girth, ear head weight and grain yield were relatively high in PBDSW at the rate of 100KL ha^{-1} along the dosage recommended with NPK. Among the different doses PBDSW at the amount of 100KL ha^{-1} along with recommended dose of NPK recorded the enhanced yield of ear head, stover and grain yield and further more research is needed to find the influence and nutrient uptake potential of different crops.

REFERENCES

APHA (1989) American Public Health Association. "Standard methods for the examination of water and wastewater". 19th ed., Washington, USA, pp 83.

Chopra AK, Pathak C, Prasad G (2012) Scenario of heavy metal contamination in agricultural soil and its management. *J Appl Nat Sci* 1: 99 —108.

Kumar V, Chopra AK (2012) Fertigation effect of distillery effluent on egronomical practices of Fenugreek. *Environ Montor Assess* 184 (3) : 1207—1219. https://doi.org/10.1007/s10661-011-2033-7.

Moazzam AK, Shahid S, Shahzab AA, Hamda A (2012) Growth and yield responses of pearl millet irrigated with treated effluent from waste stabilization ponds. *Paki J Bot* 44 (3) : 905—910.

Naveed S, Abdur Rehim , Muhammad Imran, Anwar MS, Hussain S (2018) Effect of distillery spentwash fertigation on crop growth, yield, and accumulation of potentially toxic elements in rice. *Environ Sci Poll Res* 25 : 31113—31124. https://doi.org/10.1007/s11356-018-3067-y.

Shinde PA, Ukarde TM, Preeti HP, Powar H (2021) Distillery spent wash: An emerging chemical pool for next generation

sustainable distilleries. *J Environ Mgt* 290 (3):112523—112544.

Sugumaran MP, Akila SM (2020) Effect of postmethanated distillery spentwash on the growth and yield of beetroot. *J Pharmacog Phytochem* 9 (6) : 126—130.

Sugumaran MP, Maheswari M (2019) Impact of post biomethanated distillery spentwash on the growth, yield and quality of Bhindi crop. *Indian J Environ Sci* 23 (2) : 67—68.

Sugumaran M, Maheswari M (2020) Effect of postmethanated distillery spentwash on the growth and yield of Bhendi. *International Journal of Chemical Studies* 8(5) : 2721—2723. https://doi.org/10.22271/chemi.2020.v8.i5ak.10730.