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EFFECT OF AN ACIDIC ORGANIC INDUSTRIAL EFFLUENT ON DISSOLUTION OF CALCITE, GERMINATION AND DRY MATTER YIELD OF SORGHUM (*SORGHUM BICOLOR* (L) MOENCH.)

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ABSTRACT

An acidic molasses based Hisar distillery raw effluent ELD was a test effluent. A 85 days pot experiment was carried out in screen house to quantify the effect of irrigating a calcareous (Typic Ustochrept) soil with ELD at its various water dilution on calcite dissolution, carbonate and bicarbonate anionic balance, germination and dry matter yield of sorghum cv HC 260. The water dilution treatments of ELD were such as to contain biological oxygen demand (BOD) equal to 250, 500, 750, 1000, 1250, 2000, 4000, 8000, 16000 and 32000 mg L^{-1}. Dissolution percentage of soil calcite increased with decreasing ELD water dilutions. During irrigation soil carbonate concentration remained almost static while that of bicarbonate increased with decreasing water dilutions of ELD. Irrigation with diluted effluent increased germination and dry matter yield to reach maxima at 500 and 750 mg L^{-1} effluent. Critical BOD for these parameters was 1100 mg L^{-1}. This study has shown that application of diluted acidic organic industrial effluent may provide a feasible and suitable technology for managing calcareous soils.

INTRODUCTION

Owing to the rapid growth of distilleries, there has been a substantial increase in their liquid waste, causing varying degrees of pollution of water, air and soils. Liqueur distillery effluent ELD is acidic in nature and contains plant nutrients which may enhance the growth of plants in alkaline soils in general and calcareous soils in particular. Calcareous soils, common in arid and semi-arid regions present a physical problem of hard calcite layer at some depth in root zone. Application of acidic ELD may enhance the plant growth by dissolving calcium carbonate in such soils.

The objectives of this study are (i) to observe the effect of liqueur distillery effluent irrigation at its various water dilutions on calcite dissolution and (ii) to observe its effect on germination percentage and dry matter yield of sorghum.

MATERIAL AND METHODS

Hisar (India) molasses liqueur distillery raw effluent (ELD) was collected in washed polythene carboys. Experiment was conducted in screen house in 30 cm internal diameter and 25 cm high earthen polythene lined pots at Haryana Agricultural University, Hisar. Five kg of calcareous 2 mm sieved oven dried soil was filled in the pots at a bulk density of 1.40 g cm^{-3}. The soil was from a composite sample of Hisar sandy loam soil profile (0-90 cm) classified as Typic Ustochrept (Soil Taxonomy 1978).The pots were irrigated to field capacity (18% w/w) with different BOD (250, 500, 750, 1000, 1250, 2000, 4000, 8000, 16000 and 32000 mg L^{-1}) effluents which were prepared by diluting the ELD with deionized water to 0.72, 1.44, 2.1, 2.9, 3.6, 5.8, 11.6, 23.2, 46.4, and 92.8 per cent concentrations, respectively. The BOD of pure water was zero. Ten seeds of sorghum (cv HC-260) were sown on June 14, 1990. Seedling germination was counted daily upto constant emergence in each pot. Seed germination was taken equal to seedling emergence. Rate of germination (RG) was calculated as:

$$RG = \frac{\text{Seedling daily emerged (\%)}}{\text{Time in days (cumulative)}} \qquad ...(1)$$

Thinning was done on 15th day of sowing to 3 plants per pot. The treatments where seedings died upto 15th day of sowing (irrigation water having BOD >1250 mg L^{-1}) were terminated. Remaining pots were continued to be irrigated with 200 ml of prepared waters of different BOD at alternate days upto harvesting at 85 days of sowing. Dry matter yield was recorded at harvest. The treatments were replicated thrice in completely randomized design. Initial (before sowing) and final (after harvest) soils were analysed for Ca CO_3 and organic carbon by standard procedures. Biological oxygen demand was calculated by multiplying the organic matter content by 0.711. The amount of $CaCO_3$ dissolved during 85 days of experimental period was estimated from the difference between the concentrations of initial and final soil samples. Soil extract (1:2) were analysed for EC, pH, carbonate and bicarbonate as described by Richards (1968).

RESULTS AND DISCUSSION

Liqueur distillery effluent is highly acidic having pH below the tolerance limit (Leeper 1978). It is also saline (EC 13 dSm^{-1} SAR 9.8) crossing the acceptable irrigation water limit (Richard 1968, Table 1).

Initial soil concentrations (CA_o) and final concentrations (CA) of $CaCO_3$ are given in Table 2. Amount of dissolution of $CaCO_3$ as given by CA_o-CA/CA_o is found to increase linearly with square root of effluent BOD as presented in Fig. 1. It may be seen that the dissolution per cent was 16.5% in pure water.

Table 1. Physico-chemical characteristics of liqueur distillery effluent

Colour	Dark brown
Cdour	Pungent
Total solid	93160 mgL^{-1}
pH	4.8
EC	13. dS m^{-1}
SAR	9.8
Carbonate	Nil
Bicarbonate	3401 mg L^{-1}
Chloride	5680 mg L^{-1}
Sulphate	80 mg L^{-1}
Calcium	296 mg L^{-1}
Magnesium	250 mg L^{-1}
Potassium	6147 mg L^{-1}
Sodium	805 mg L^{-1}
Total Nitrogen	420 mg L^{-1}
Total P	487 mg L^{-1}
BOD	34750 mg L^{-1}

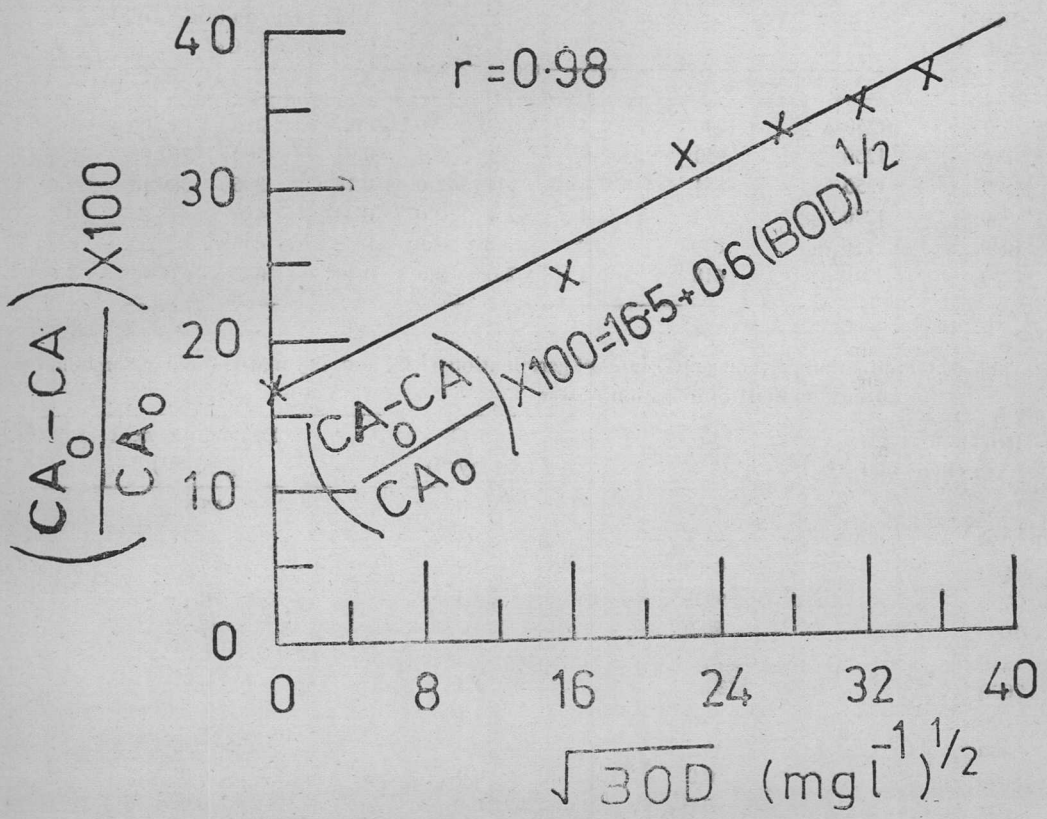

Fig. 1. Calcite dissolution percentage as a function of $\sqrt{BOD}$ of the effluent

The amount of carbonate in soil system remained unaffected during irrigation with effluent of different BOD but bicarbonate concentrations increased with BOD of effluent (Table 2). Somasundaran and Agar (1967) and Novozamsky and Beek (1976) have also reported the predominance of bicarbonate forming reactions at high pH values. Large scale deficiency of bicarbonate occurred in the final soil samples as compared to the initial total bicarbonate input at each BOD levels (Table 2). This may have been due to escape of CO_2 (g) into the atmosphere in the open soil system of the pots.

Germination percentage, rate of germination and dry matter yield recorded significant inital increase than decrease with increasing effluent BOD (Table 3). Maxima and minima for germination percentage and dry matter yield were 500, 750

Table 2. Dissolution of calcium carbonate and mass balanc of carbonate and bicarbonate during effluent irrigation of different BOD

Irrigation water (BOD) mgL^{-1}	Calcium carbonate		Carbonate		Bicarbonate				
	Initial	Final	Initial	Final	Initial				Final
					Soil	ELD	Dissolution of $CaCO_3$	Total	
	me kg^{-1} soil								
0	1250	1040	2.4	2.2	2.0	0	210	212.00	2.4
250	1250	950	2.4	2.2	2.0	0.08	300	302.08	2.8
500	1250	854	2.4	2.4	2.0	0.16	396	389.16	3.0
750	1250	834	2.4	2.4	2.0	0.24	416	418.24	4.6
1000	1250	814	2.4	2.0	2.0	0.32	436	438.32	5.2
1250	1250	618	2.4	2.0	2.0	0.40	632	634.40	5.6

Table 3. Germination percentage (G) rate of germination (RG) and dry matter yield of sorghum as affected by BOD of irrigation waters

Irrigation water (BOD mgL^{-1})	G (%)	RG (day^{-1})	Dry matter yield (g pot^{-1})
0	90.0	23.6	15.6
250	93.3	25.2	16.7
500	96.7	25.7	17.4
750	93.3	24.4	20.4
1000	90.0	24.2	17.5
1250	76.7	19.2	0 0
2000	33.3	9.5	0.0
4000	26.7	7.1	0.0
8000	16.7	4.8	0.0
16000	0.0	0.0	0.0
32000	0.0	0.0	0.0
C.D. at 5%	15.1	2.7	0.5

and 16000, 1250 mg/L^{-1} BOD, respectively. The corresponding figures for *Cicer arec-tinum* L are reported to be relatively higher for ELD (Srivastava and Sahai 1987). These were : 1000, 2000 and 40,000, 30,000 mg L^{-1} BOD respectively. This may have been due to lower salt content. Captainganj distillery effluent. Higher salt content of Hisar ELD was due to the brackish underground water used in the distillery unit. Similar germination, growth and yield behaviour of initial increase followed by a decrease with increasing BOD of ELD has been reported by Sahai et al. (1983), (1985) and Srivastava and Sahai (1987) in non-calcareous alkaline soils.

The initial increase in germination percentage and dry matter yield with increasing BOD of the effluent may have been due to the specific ion effect of some of the nutrient elements present in the effluent. The decrease in germination percentage and dry matter yield seems to be of the high osmostic pressure in soil solution due to the higher salt concentratration in ELD. It may be seen from Table 4 that EC of the soil extract (1 : 2) crosses the permissible limits (8 dsm^{-1}) at 1000 mg L^{-1} BOD (Richards 1968).

Table 4. Chemical properties of irrigation water of different BOD and their effect on these properties of soils after 85 days of sorghum pot culture experiment

Irrigation effluent			Soil		
BOD (mgL^{-1})	pH	EC (dSm^{-1})	pH (1:2)	EC (dSm^{-1})	Organic carbon (%)
Initial*	—	—	8.40	0.182	0.41
0	7.00	0.095	8.45	0.248	0.41
250	6.95	0.391	8.45	0.410	0.42
500	6.90	0.754	8.40	0.496	0.45
750	6.87	1.049	8.40	0.630	0.48
1000	6.82	1.336	8.35	0.954	0.52
1250	6.70	1.718	8.30	1.240	0.54

* Initial pertains to the soil before sowing.

Dose response curve of effluent BOD versus relative germination percentage and dry matter yield are shown in Fig 2. Critical limit of BOD is defined as that BOD of the effluent which causes 10 per cent reduction in germination and dry matter yield. Thus, it may be seen from Fig. 2, that critical limits of germination percentage and yield are 1100 mg L^{-1} BOD. Indian Standard Institution (ISI, 1979) critical limits of BOD for land applicatiou (500 mg L^{-1}) is fairly on the safe side.

This study thus shows that application of distillery effluent at its proper dilution with water may be an effective method for dissolution of calcite.

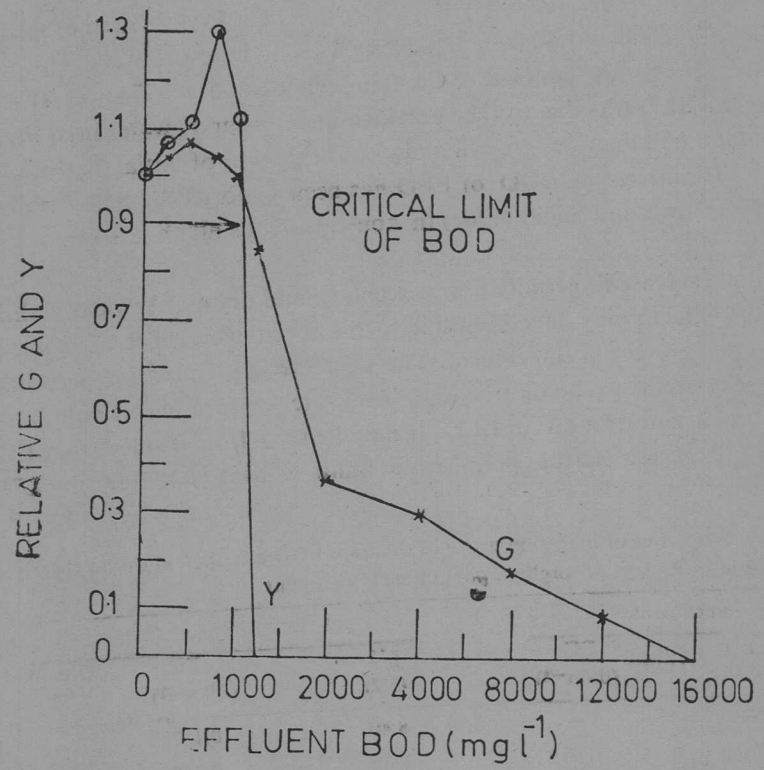

Fig. 2. Relative germination (G) percentnge/dry matter yield (Y) of sorghum as a function of BOD of the effiuent.

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