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Foliar Application of Distillery-Spent Wash as a Liquid Fertilizer for Betterment of Growth of *Sorghum vulgare* and *Cajanus cajan*

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ABSTRACT

The distillery spent wash contained all necessary elements and biofertilizer microbes (*Rhizobia, Azospirilla, Azotobacter,* and phosphobacteria) to support the growth of plants. Application of the spent wash, as it is without dilution, did not cause deformities and derangement of plant metabolism. The successful use of distillery spent wash as a liquid fertilizer for augmenting crop productivity in C3 and C4 plants has been demonstrated.

Index Entries: Foliar fertilizer; distillery wastes; spent wash; *S. vulgare; C. cajan;* chloroplast pigments.

INTRODUCTION

Little or no work has been done on utilization of distillery wastes for crop growth and productivity (*1*), despite many publications on the toxic nature of the materials released from distilleries (*1–6*). The Trichy Distilleries and Chemicals Proprietary Limited produces 10,000 gal of alcohol/d, thereby generating a voluminous amount of spent wash (200 kL/d) as well as large amounts of sludge. Spent wash and sludge are the two major pollutants discharged by distilleries. In the present study, foliar spray of the spent wash was investigated to determine whether it could be tried as a liquid fertilizer for betterment of crop growth and plant

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productivity, rather than using it for irrigation of different dilutions (7). The crop plants employed include both monocot and dicot, since monocots are considered to be more pollution-tolerant. The above- and below-ground biomass and leaf chemical constituents were investigated.

MATERIALS AND METHODS

The spent wash was collected from the Trichy Distilleries and Chemicals Proprietary Limited, Tiruchirapalli, India. The raw material used for the production of alcohol is molasses collected from the sugar factory. The seeds of *Sorghum vulgare* L.cv.IS 3541 and *Cajanus cajan* (L.) Millsp var.SA-1 were collected from the National Pulses Research Center, Vamban, Tamilnadu. Healthy seeds were selected and sown in an open field in rows. The soil had the following nutrient composition: N (10 mg/g), P (0.63 mg/g), and K (0.88 mg/g) with total organic matter of 3.12% and total organic carbon of 1.99%. The soil had a bulk density of 0.64 g/cc, and water-holding capacity of 22% with percentage pore space of 37. After germination, the 7-d-old seedlings were foliar-sprayed uniformly with different concentrations (0–100%) of spent wash at 2-d intervals. For control, plants were sprayed with tap water. Spraying was done at about 1.00 PM to facilitate easy absorption. The seedlings were raised in an open field in rows under a natural photoperiod (26 $\pm$ 1 W/m^2) with a day temperature of 28–32°C and a night temperature of 22–25°C. After 60 d of growth, the plants were uprooted for plant growth analysis.

The bicarbonate, chloride, and total organic carbon of the spent wash were determined by standard methods. The spent wash was screened for various microorganisms, such as *Rhizobia, Azospirilla, Azotobacter,* and Phosphobacteria by following the standard methods. The leaves were collected and shade-dried for analyses of chemical constituents. For chloroplast pigment analyses, fresh leaves from the third node from the top were used. Elemental analyses of the spent wash were carried out by flame photometry. Leaf area was determined by using a portable leaf area meter (Licor, Inc., USA). For dry matter determination, the different organs of the plants were dried in a hot-air oven at 60 $\pm$ 2°C for 48 h. The approximate moisture content of the garden soil was 55–60%. All the data were statistically analyzed using Student's *t*-test.

RESULTS AND DISCUSSION

The spent wash had a pH of 6.32 $\pm$ 0.17 and an EC value of 5.38 $\pm$ 0.29 mS/cm. The spent wash contained the following levels (g/L) of organic compounds, such as total sugars (1.61 $\pm$ 0.12), phenolics (0.26 $\pm$ 0.02), sucrose (0.15 $\pm$ 0.01), starch (0.85 $\pm$ 0.09), soluble proteins (1.75 $\pm$ 0.23), and organic nitrogen (11.12 $\pm$ 0.98). The spent wash contained an meq of bicarbonates (5017 $\pm$ 125), chlorides (37,600 $\pm$ 1500), and g/L of nitrates

Table 1
Plant Growth Analyses of 60-d-old *S. vulgare* and *C. cajan* as Treated by Foliar Application of Spent Wash

	Spent wash—foliar spray, %									
	S. vulgare					*C. cajan*				
Agrobotanical characters/plant	0, Control	30	50	80	100	0, Control	30	50	80	100
Shoot length (cm)	82.13 ± 1.21	90.42 ± 1.22 (110)^a	95.41 ± 1.23 (116)^b	98.63 ± 1.22 (120)^b	105.61 ± 1.25 (129)^b	46.71 ± 1.17	52.14 ± 1.18 (112)^a	69.13 ± 1.19 (148)^b	115.61 ± 1.19 (248)^b	129.92 ± 1.19 (278)^b
Root length (cm)	12.24 ± 0.41	14.32 ± 0.42 (117)^b NS	15.54 ± 0.41 (127)^b	18.73 ± 0.42 (153)^b	18.74 ± 0.42 (153)^b	14.47 ± 0.41	15.26 ± 0.43 (105)^a	16.41 ± 0.43 (113)^a	18.73 ± 0.43 (129)^b	20.32 ± 0.44 (140)^b
Internodal distance (cm)	6.73 ± 0.08	6.72 ± 0.09 (100)	7.13 ± 0.09 (105)^a	7.17 ± 0.10 (107)^a	7.16 ± 0.11 (106)^b	14.31 ± 0.14	15.34 ± 0.16 (107)^a	16.55 ± 0.17 (116)^b	18.86 ± 0.17 (132)^b	23.47 ± 0.18 (164)^b
Total leaf area (cm^2)	954 ± 28	1025 ± 30 (107)^a	1117 ± 32 (117)^b	1324 ± 36 (139)^b	1494 ± 38 (157)^b	642 ± 31	933 ± 32 (145)^b	1130 ± 33 (176)^b	1825 ± 34 (284)^b	2120 ± 35 (330)^b
Average fresh wt (g) of										
Root	2.41 ± 0.05	4.52 ± 0.05 (188)^b	6.73 ± 0.06 (238)^b	6.74 ± 0.06 (266)^b	7.31 ± 0.06 (303)^b	5.27 ± 0.12	7.16 ± 0.13 (136)^b	8.44 ± 0.14 (160)^b	18.12 ± 0.14 (344)^b	21.21 ± 0.14 (402)^b
Stem	8.81 ± 0.11	12.24 ± 0.11 (139)^b	18.41 ± 0.13 (209)^b	24.52 ± 0.13 (278)^b	28.63 ± 0.13 (325)^b	14.76 ± 1.13	30.83 ± 1.13 (209)^b	45.21 ± 1.14 (306)^b	85.72 ± 1.15 (580)^b	110.18 ± 1.78 (746)^b
Leaf	9.62 ± 0.98	19.47 ± 1.01 (202)^b	25.31 ± 1.07 (263)^b	30.24 ± 1.04 (314)^b	36.15 ± 1.07 (376)^b	7.86 ± 0.75	15.47 ± 1.14 (197)^b	28.58 ± 1.14 (364)^b	39.49 ± 1.19 (502)^b	48.21 ± 1.17 (613)^b
Average dry wt (g) of										
Root	1.17 ± 0.04	2.67 ± 0.08 (228)^b	2.92 ± 0.08 (250)^b	3.07 ± 0.08 (262)^b	4.28 ± 0.08 (366)^b	3.46 ± 0.11	NS 3.54 ± 0.12 (102)	4.69 ± 0.13 (136)^b	8.87 ± 0.15 (256)^b	11.20 ± 0.15 (326)^b
Stem	3.42 ± 0.08	6.62 ± 0.09 (194)^b	13.97 ± 0.09 (408)^b	15.92 ± 0.09 (465)^b	19.54 ± 0.09 (517)^b	7.38 ± 0.41	12.93 ± 0.52 (175)^b	20.98 ± 0.54 (284)^b	36.16 ± 0.56 (490)^b	63.28 ± 0.58 (859)^b
Leaf	5.51 ± 0.11	10.57 ± 0.12 (192)^b	12.72 ± 0.12 (231)^b	14.63 ± 0.12 (266)^b	18.44 ± 0.12 (335)^b	3.36 ± 0.11	6.54 ± 0.12 (195)^b	12.68 ± 0.13 (377)^b	20.92 ± 0.14 (623)^b	22.91 ± 0.14 (682)^b

Values are means of five different experiments ± SE.
Student's *t*-test, $^a p < 0.05$, $^b p < 0.01$, NS, not significant.
The data in parentheses indicate % control values.

Table 2
Analyses of Leaf Chemical Constituents in 60-d-old Plants of *S. vulgare* and *C. cajan* Sprayed with Different Concentrations of the Spent Wash

	Spent wash—foliar spray, %									
	S. vulgare					*C. cajan*				
Biomolecules, mg/g dry wt	0, Control	30	50	80	100	0, Control	30	50	80	100
Chlorophyll *a* (mg/g fresh wt)	1.10	1.20 (109)^b	1.31 (119)^b	1.43 (130)^b	1.45 (132)^b	1.82	1.94 (107)^a NS	2.01 (110)^a	2.27 (124)^b	2.52 (138)^b
Chlorophyll *b* (mg/g fresh wt)	0.72	0.76 (106)^a	0.81 (113)^b	0.85 (118)^b	0.94 (131)^b	0.81	0.84 (104)	0.91 (112)^b	0.95 (117)^b	0.98 (120)^b
Total carotenoids (mg/g fresh wt)	0.34	0.36 (106)^a	0.39 (115)^b	0.40 (118)^b	0.42 (124)^b	0.29	0.41 (141)^b	0.47 (162)^b	0.52 (179)^b	0.63 (217)^b
Total phenols	12.93	23.13 (179)^b	23.90 (185)^b	24.10 (186)^b	24.25 (188)^b	1.85	4.80 (259)^b	5.92 (320)^b	6.00 (324)^b	7.02 (379)^b
Total soluble proteins	140	189 (135)^b	192 (137)^b	209 (149)^b	211 (151)^b	109	191 (175)^b	209 (191)^b	213 (195)^b	243 (223)^b
Total free amino acids	15.73	29.25 (186)^b NS	29.98 (191)^b	32.61 (204)^b	35.63 (227)^b	9.65	19.28 (199)^b	27.35 (283)^b	28.10 (291)^b	29.45 (305)^b
Total soluble sugars	176	181 (103)	193 (110)^b	198 (112)^b	199 (113)^b	79	121 (153)^b	129 (163)^b	182 (230)^b	187 (236)^b
Total soluble starch	40.79	49.73 (122)^b	52.07 (128)^b	54.27 (133)^b	67.54 (166)^b	48.04	63.84 (133)^b	68.08 (142)^b	72.25 (150)^b	80.98 (168)^b
Total soluble sucrose	22.78	30.82 (135)^b	38.67 (170)^b	39.27 (172)^b	40.98 (180)^b	21.84	31.35 (144)^b	34.75 (159)^b	40.34 (185)^b	44.28 (202)^b
Total free proline	0.34	1.46 (429)^b	1.73 (508)^b	2.12 (623)^b	2.41 (708)^b	1.60	3.10 (193)^b	3.18 (199)^b	3.52 (220)^b	4.12 (257)^b
Total nitrogen	143	151 (106)^a	162 (113)^b	167 (116)^b	192 (134)^b	167	212 (127)^b	246 (147)^b	289 (173)^b	297 (178)^b

Values are means of three different experiments.
Student's *t*-test, $^ap < 0.05$, $^bp < 0.01$, NS, not significant.
The data in parentheses indicate % control values.

(0.46 ± 0.03) and sodium (20.41 ± 0.59). High contents (ppm) of K (169 ± 16) and Ca (2600 ± 27) were observed in the spent wash. The spent wash contained native microbes (MPN colonies × 10^7) like *Rhizobia* (143 ± 17), *Azotobacter* (481 ± 27), *Azospirilla* (760 ± 24), and phosphobacteria (362 ± 17). The heavy load of organic molecules in the spent wash supported the growth of microbes.

Soon after foliar spray, the 60-d-old plants were uprooted and the agrobotanical characters were studied (Table 1). All the agrobotanical characteristics were found to be influenced by the foliar spray. The growth parameters of *C. cajan* were more influenced than *S. vulgare*. Even 100% application of the spent wash as foliar spray did not cause any deleterious effect or deformities in either *C. cajan* or *S. vulgare*. The significant increase in several agrobotanical characteristics may be attributed to the spent wash containing lot of organics, elements, and microbes of biofertilizer importance (*8*).

The levels of chloroplast pigments and other organic molecules, such as total phenols, proteins, amino acids, sugars, starch, sucrose, proline, and nitrogen, increased in the leaves of the treated plants (Table 2). There is a possibility of spillage of spent wash on the soil only at the seedling stage during foliar spray. As the seedlings develop into mature plants, the spill is very much minimized because of spread of foliage. Planting crops in succession in the same field year after year did not reveal any symptoms of injury or abnormal growth in plants. Conductivity and pH analyses of the soil before and after planting in a season did not reveal any significant difference. The spent wash did not contain any deleterious heavy metals. Salts, such as bicarbonates, nitrates, potassium, and calcium, present in the spent wash are essential for growth and development of crop plants. In fact, the requirement of sodium is very well known in C4 plants. Incidentally, this is evident from inocuous bioaccumulation of salts in the treated plants (data not shown), which grow luxuriantly compared to the control. Therefore, we conclude that the spent wash can be used as liquid fertilizer for crop improvement.

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