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Soil properties and crop yields on a vertisol in India with application of distillery effluent

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Abstract

Distillery effluent, a foul smelling, dark coloured by-product of distillery industries, is usually applied as irrigation water or as an amendment to arable land in some areas which are in the vicinity of the distillery industries. A field experiment on soybean–wheat system was conducted for 3 consecutive years in a Vertisol of central India to evaluate the effect of distillery effluent (DE) as an amendment on soil properties and crop productivity. The treatments were control (no fertilizer or manure or DE, T_1), 100% NPK + FYM @ 4 Mg ha^{-1} to soybean (T_2) and four graded levels of DE, viz.: 2.5 cm DE to soybean and wheat on residual nutrition (T_3), 2.5 cm DE to soybean and 1.25 cm to wheat (T_4), 5 cm DE to soybean and wheat on residual nutrition (T_5), 5 cm DE to soybean and 2.5 cm to wheat (T_6). The organic carbon, microbial biomass carbon and electrical conductivity (EC) of the surface (0–10 cm) soil increased significantly with application of DE compared to T_1 and T_2, but the soil pH was not affected. The EC increased from 0.47 dS m^{-1} and 0.58 dS m^{-1}, respectively, in T_1 and T_2 to 1.52 dS m^{-1} in T_6, where highest dose of DE was applied. This indicated a slight build-up of salinity with DE application. The application of DE showed a significant improvement in the physical properties of the soil. The mean weight diameter (MWD), saturated hydraulic conductivity, water retention at field capacity and available water content were significantly ($P < 0.05$) higher, while bulk density (BD) and penetration resistance of the surface soil were significantly lower ($P < 0.05$) in all DE treated plots except in T_3 than those in T_1 and T_2. The fractions of WSA of more than 1 mm diameter in T_6, T_5 and T_4 were, respectively, 141%, 107% and 116% more than the control. The MWD showed a positive linear relationship with the organic carbon ($r = 0.84^{**}$) and microbial biomass carbon ($r = 0.90^{**}$) of the soil. A significant ($P < 0.01$) negative linear relationship ($r = 0.70^{**}$) was found between soil organic carbon and BD. Except T_3, all the DE treated plots recorded significantly higher total and microporosity of the soil than control. Water retention at permanent wilting point and macroporosity of the soil were not affected by treatment. The seed yield of soybean in all the DE treatments was similar with T_2 (1.86 Mg ha^{-1}) but significantly more than control (1.28 Mg ha^{-1}). The DE application levels have not affected the seed yield of soybean. In wheat highest grain yield was recorded in T_2 (3.47 Mg ha^{-1}), which was similar with T_4 (3.16 Mg ha^{-1}), T_5 (3.22 Mg ha^{-1}) and T_6 (3.46 Mg ha^{-1}). DE application up to T_4 level was found suitable from productivity, salinity and sustainability point of view. The study showed that judicious application of DE as an amendment to the agricultural field could be considered as a viable option for safe disposal of this industrial waste.

Keywords: Distillery effluent; Soil physical properties; Organic carbon; SMBC; Electrical conductivity; Vertisols

1. Introduction

Distilleries, one of the most important agro-based industries in India, produce ethyl alcohol from molasses. They generate large volume of foul smelling coloured wastewater known as spent wash. For production of each

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litre of alcohol, 12–15 l of effluent is produced. Approximately 40 billion litres of effluent is generated per annum from 285 distilleries in the country (Chonker et al., 2000). The effluent causes concern of environmental pollution owing to its very high organic content. Many a times this wastewater is discharged in the water courses either untreated or partially treated condition, resulting in depletion of oxygen because of proliferation of microbial population in the water bodies and courses causing wide spread mortality of fish and other aquatic organisms. As the effluent contains considerable amount of organic matter and plant nutrients, particularly potassium and sulphur, this can be applied to arable land as irrigation water and as an amendment. When applied to crops it may act as a source of plant nutrients and has been reported to increase the yield of the crops (Zalawadia and Raman, 1994; Pathak et al., 1999). Thus, application of distillery effluent (DE) to arable land as irrigation water and as a source of plant nutrients offers a promising alternative for its safe disposal. Many a farmers in the vicinity of sugar factories in Northern and Western India apply DE and DE containing products in their field as manure. However, as the DE contains a significant quantity of salt (EC: 25.3 dS m^{-1}), its indiscriminate use may affect the physical and physico-chemical properties of soil in the long run. Availability of information on the effect of continuous application of DE on physical properties of soil is meagre. Pathak et al. (1999) studied the effect of DE on soil properties and reported an increase in the saturated hydraulic conductivity and decrease in bulk density of the soil after harvest of wheat. Escober (1966) had earlier observed an increase in hydraulic conductivity and infiltration rate and improvement in aggregate stability following addition of distillery slops and molasses to the columns of a saline sodic soil. Singh and Bahadur (1998) reported a significant increase in infiltration rate and the bulk density of an Inceptisol with application of DE. Zalawadia and Raman (1994) found that application of DE improved the water retention characteristics of the soil, whereas Jadhav and Savant (1975) indicated that non-judicious use of DE might adversely affect the crop growth and soil properties by increasing soil salinity. Keeping in view the above facts, a field experiment was conducted to study the effect of graded doses of DE application on the physical and physico-chemical properties of a deep black soil and its impact on yield of soybean and wheat.

2. Materials and methods

An experiment on soybean–wheat cropping system was conducted for 3 years between 1999 and 2002 at the experimental farm of the Indian Institute of Soil Science, Bhopal, India (23°18′N, 77°24′E, 485 m above mean sea level) on a deep heavy clay soil (Typic Haplustert). The soil of the experimental site was low in organic carbon (4.1 g kg^{-1}), available N (112 mg kg^{-1}) and available P (2.6 mg kg^{-1}) but high in available K (227 mg kg^{-1}), having pH 7.9 and cation exchange capacity 46 $cmol_c$ kg^{-1}. The bulk density, mean weight diameter and saturated hydraulic conductivity of the surface soil (0–15 cm) before the start of the experimentation was 1.30 Mg m^{-3}, 0.56 mm and 9.0×10^{-6} m s^{-1} while the moisture retention capacity on a volume basis was 33.0% and 24.5% at 0.033 MPa and 1.5 MPa suctions, respectively. The experimental site is characterised as hot sub-humid eco-region (Sehgal et al., 1990). The mean monthly maximum and minimum temperatures and rainfall during the experimental period are given in Fig. 1.

The experiment was laid out in a randomised complete block design with six nutrient treatments and

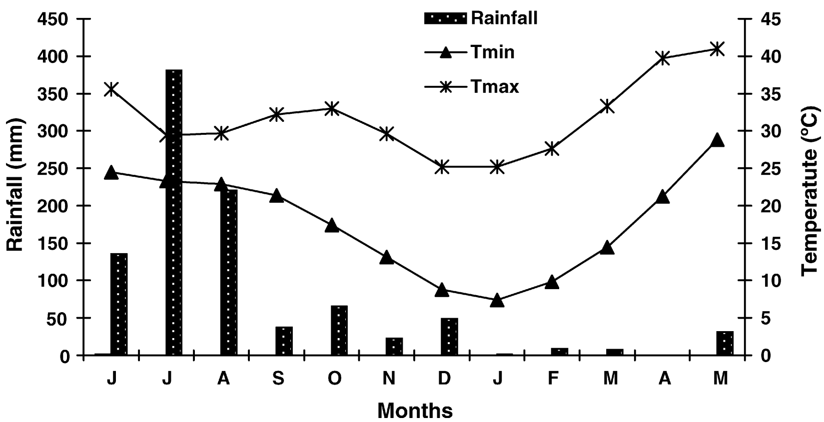

Fig. 1. Mean monthly maximum and minimum temperature and rainfall of the experimental site during the experimental period (1999–2001).