INFLUENCE OF SPENTHOP ON SOIL STRUCTURE

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The present paper throws light on the effect of Spenthop on the structural development of soils. Two different rates of application together with farm-yard manure and control were studied on alluvial and saline alkali soils of West Bengal. Comparative effect of four treatments in alluvial and saline alkali soils can be presented as Spenthop II > Spenthop I > farm-yard manure > Control. Pot culture experiments were also conducted with crops of safflower and beet root to observe their behaviour with the use of Spenthop. The aggregate stability of the soils was assessed by the status of water-stable aggregates. Addition of Spenthop has registered marked improvement in the soil structure. A review of the findings of the pot culture experiments and changes in the stability of soil structure shows evidence of toxic effect of resins which possess bacteriostatic property. This adverse effect may be mitigated during the process of leaching under field conditions. Thus it may be inferred *inter alia* that spenthop can be a substitute for farm-yard manure in its degree of efficiency to improve soil structure.

The ideal tilth is largely a function of the state of aggregation which in turn maintains the equilibrium between air and water relationship in the soil (Sokolovsky 1933). The present study embraces investigation on the effect of 'spenthop' as soil conditioner in two different soils of West Bengal. 'Spenthop' is a by-product of brewery industry and is now being thrown out as a waste material. During the process of this investigation a comprehensive study was attempted to bring out its effect on the structural stability of alluvial and saline-alkali soils of West Bengal under different treatments together with farm yard manure and control carried out simultaneously. For indicative results, separate pot culture experiment was conducted on different soils with two crops viz., safflower and beet root.

EXPERIMENTAL

Samples of alluvial and saline-alkali soils were collected for investigation. Information regarding the physico-chemical properties of soils under study are presented in Tables I and II.

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TABLE I

Physical properties of soils under different treatments

Soil group	Location	Depth (cm)	Treatment No	Treatment	Rate of application (tons/ac.)	Mechanical constituents				Texture
						Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	
Alluvial	Haringhata	0–22	AS 1	Control	—	2.2	31.26	40.0	24.2	Loam
		0–22	AS 2	Farm-yard manure	5.5	2.2	31.26	40.0	24.2	Loam
		0–22	AS 3	Spenthop I	15.0	2.2	31.26	40.0	24.2	Loam
		0–22	AS 4	Spenthop II	20.0	2.2	31.26	40.0	24.2	Loam
Saline-alkali	Canning	0–22	SS 1	Control	—	—	10.48	43.3	45.6	Silt clay
		0–22..	SS 2	Farm-yard manure	5.5	2.2	10.48	43.3	45.6	Silt clay
		0–22	SS 3	Spenthop I	15.0	—	10.48	43.3	45.6	Silt clay
		0–22	SS 4	Spenthop II	20.0	—	10.48	43.3	45.6	Silt clay

TABLE II

Chemical properties of soils under investigation

Soil group	Location	*p*H	Conductivity (mmhos/cm)	C.E.C. (meq/100 g)	Carbon (%)	Nitrogen (%)	Fe_2O_3 (%)	Al_2O_3 (%)	Calcium (%)	Air dry moisture (%)
Alluvial	Haringhata	6.21	—	21.2	0.31	0.033	3.92	5.8	0.54	2.02
Saline-alkali	Canning	8.5	19.8	12.1	0.06	0.0065	4.32	5.21	0.45	1.61

Humulus lupulus forms the major source of hops used in the brewery industry. Dried hops used in the brewery contain moisture 6–12 per cent, resin 11–21 per cent, volatile oil 0.2–0.5 per cent, tannin 2–4 per cent, nitrogenous matter as protein 13–24 per cent, glucose and fructose 3–4 per cent, pectins 12–14 per cent, ash 7–10 per cent, organic substances and colouring substances (Bently and Triman). The mineral constituents include K, Ca, Mg, as phosphate, silicate and sulphate. The antiseptic properties of hops are due to the presence of soft resinous bodies. The active constituents of resins are bitter acid compounds humulone or α-lupulinic acid ($C_{21}H_{30}O_5$) and lupulone or β-lupulonic acid ($C_{26}H_{38}O_4$). These are highly bacteriostatic against gram-positive and acid-fast bacteria including *Mycobacterium tuberculosis*. Hops that are removed from the distillary after the extraction of lupilin are termed 'Spenthop' which is now under investigation for its effect on soil structure.

Pots were filled with standardised aggregates having diameter 2.0 to 5.0 mm range prepared by dry sieving method to ensure identical initial soil structure for all the treatments. Aggregates were mixed with spenthop and farm-yard manure according to the prescribed rates mentioned in Table I. Optimum moisture condition (60 per cent of water-holding capacity) was maintained throughout the experiment which was carried out underroom temperature and partial shade. Analyses of treated soil samples were conducted at 30 days interval. Structural stability of the aggregates in water was determined by Yoder's (1936) wet sieving method. Organic nitrogen was estimated by modified Kjeldahl method (Piper 1950). *p*H was electrometrically measured by photovolt *p*H meter in 1:1.5 soil water suspension. Cation exchange capacity was deter mined by using neutral ammonium acetate (Piper 1950). Aluminium and iron oxide were determined in the same manner as described by Jackson (1964) by fusion analysis. After the separation of sesquoxide, calcium was determined by precipitating it as oxalate at *p*H 4.5 (calcium oxalate precipitation method) as described by Jackson (1964). Saturation extract was prepared as per experiment No. 3(a) in the U.S.D.A. Hand Book No. 60 and electrical conductivity of the saturation extract was measured by solu bridge. Mechanical analysis of the soil was done by the International pipette method (Piper 1950). Plasticity index was estimated by using casagrande apparatus. Water-holding capacity and sticky point were estimated as per procedure described by Piper 1(950).

Pot culture experiments were separately conducted to study and compare the effect of spenthop in crop response. Two crops, safflower and beet root, were selected in view of the wide range of adaptability of crops to soil reaction and salinity, economic importance of the crop coupled with short duration.

Results and Discussion

Percentage distribution of water stable aggregates in alluvial and saline alkali soil under various treatments are reported in Table III. The data reveal the positive response of Spenthop to that of farm-yard manure and control. In alluvial soil the treatment AS 3 shows an increase of 5.4 and 2.9 per cent to that of treatments AS 1 and AS 2 respectively. The treatment AS 4 shows an increase of 2.5 per cent than AS 3. In saline-alkali soil treatment SS 3 exhibited an increase

TABLE III

Percentage distribution of water stable aggregates in alluvial and saline alkali soil under different treatments

Soil group	Treatment	Rate of aggregation >0.1 mm (%) in months					
		Oct.	Nov.	Dec.	Jan.	Feb.	March
Alluvial	Control						
	AS 1	25.11	27.40	28.28	30.35	33.39	43.86
	As 2	21.29	28.29	38.16	42.33	40.08	44.35
	AS 3	35.64	40.69	47.21	52.49	51.72	47.21
	AS 4	37.60	39.05	43.15	51.27	51.24	49.74
Saline alkali	SS 1	2.72	5.51	6.95	8.49	9.22	9.39
	SS 2	2.06	6.53	9.06	8.64	10.72	11.21
	SS 3	2.81	9.72	14.60	20.60	22.86	22.27
	SS 4	2.75	9.52	12.76	18.41	23.80	24.92

of 12.9 per cent and 11.1 per cent to that of SS 1 and SS 2 respectively. Treatment SS 4 recorded an increase of 2.6 per cent more than SS 3. Thus it is observed that the general trend in the aggregation status is more or less similar in both the soils under various treatments.

From the figures presenting the behaviour of treatments in saline alkali soil it may be inferred that even after five months the aggregation was in progress which can clearly be seen in the treatment SS 4 whereas the treatment SS 3 shows a reduction, possibly due to the application of less quantity of spenthop. Alluvial soil presents a descending tendency in the treatments AS 3 and AS 4 after the fifth month indicating the probability of complete decomposition of Spenthop.

Although the rate of aggregation does not present a uniform pattern it is evident that during the initial periods progress of aggregation is at a low rate which subsequently recorded a progressive trend in the status of aggregation. A higher initial increase observed in the case of treatment AS 2 might be due to the presence of easily decomposable material. As in alluvial soil a descending tendency is shown by the treatment SS 3 in saline soil. This further substantiates the inference of a possible complete decomposition of the organic matter after February, since the quantity of material added is 15 tons per acre in comparison with that of 20 tons per acre in treatment AS 4. Comparative effect of four treatments in alluvial and saline alkali soils can be presented as Spenthop II>Spenthop I>farm-yard manure>control.

In alluvial soil the effect of the treatments on the status of aggregation does not maintain such wide range of variation, whereas saline alkali soil presents distinct difference in the status of aggregation.

Water regime in both the soils under different treatments is given in Table IV.

Alluvial soil maintains favourable water regime. Although the treatment AS 3 and AS 4 had shown better aggregation, corresponding increase is not seen in the

TABLE IV

Physical properties of alluvial and saline alkali soil under different treatments

Treatment	Water-holding capacity		Plasticity index		Sticky points	
	Dec.	March	Dec.	March	Dec.	March
AS 1	56.82	57.14	13	12	34.5	31.5
AS 2	56.88	57.6	12.3	11.3	27.3	25.9
AS 3	56.81	56.10	12.0	11.8	27.3	27.9
AS 4	57.02	54.0	11.5	11.1	26.1	25.1
SS 1	52.0	53.0	22.0	21.4	42.0	42.7
SS 2	52.0	52.0	20.5	20.0	40.1	30.0
SS 3	51.0	48.0	20.4	19.8	41.1	39.0
SS 4	52.0	50.0	20.0	19.2	40.0	39.0

water-holding capacity. It leads to the assumption that this might be due to the increase in non-capillary pore space which retards the water-holding capacity. The transmission constant being a function of soil porosity, pore space plays a key role in the water-holding capacity. Burger (1926) holds the view that the infiltration rate depends upon the non-capilary porosity. In saline alkali soil the treatments SS 1 and SS 2 showed slight increase in the water-holding capacity, whereas treatments SS 3 and SS 4 recorded a reduction in water-holding capacity which may be attributed to the possible reduction in the capillary pores due to the progressive trend in aggregation status of the soils. However, the differences observed are within a small range.

A gradual reduction in the plasticity index is noticed with the treatments AS 3, AS 4, SS3 and SS 4. Sticky point too maintains the same trend as seen from the Table IV.

Results of pot culture experiment in respect of the status of aggregation under the different crops—beet root and safflower—are furnished in Tables V and VI.

Data presented in Tables V and VI compared with that of treated soils during corresponding period vividly bring out the difference in the status of aggregation due to the influence of crops which enhances granulation and porosity through root activity. Though the precise assessment of the nature and magnitude of soil aggregation is not attempted here, it may be due to the influence of root pressure, binding qualities of roots, the addition of organic matter, moisture regime or any root excretions. Spenthop treatments recorded better soil structure in both the soils with a maximum status of aggregation by Spenthop II. The Figures in Tables V and VI are self explanatory to show the effect of different crops on soil structure. Importance of this was brought out by the earlier workers like Sokolovsky (1933). In the present study the beet root gave an increased rate of aggregation in the early periods than the crop safflower. But in the final stage, performance of the safflower in the structural development of soil is superior. This may be explained by the difference in time required for the root development of the crop in question. Results obtained from the increment of growth further testifies this phenomenon.

TABLE V

Percentage distribution of water-stable aggregates under crop beet root in soils under different treatments

Treatment	State of aggregation > 0.1 mm				pH	C.E.C. (meq/100 g)
	Oct.	Nov.	Dec.	Jan.		
AS 1	26.93	28.01	28.32	31.23	6.85	22.8
AS 2	25.10	29.95	39.00	45.01	6.75	23.65
AS 3	27.91	42.80	49.61	55.50	6.85	23.95
AS 4	39.50	43.01	49.91	52.31	6.85	23.90
SS 1	3.12	7.01	7.15	8.64	8.3	11.5
SS 2	3.0	7.91	10.98	9.51	8.2	11.75
SS 3	3.51	10.90	16.21	22.40	8.1	13.50
SS 4	3.91	11.05	15.56	19.98	8.15	13.40

TABLE VI

Percentage distribution of water-stable aggregates under crop safflower in soil under treatments

Treatment	State of aggregation > 0.1 mm				pH	C.E.C. (meq/100 g)
	Oct.	Nov.	Dec.	Jan.		
AS 1	25.0	27.9	26.9	32.5	6.85	22.4
AS 2	22.9	28.0	38.9	46.5	6.75	23.4
AS 3	35.4	40.9	46.5	57.0	6.8	24.1
AS 4	37.18	42.87	47.03	53.41	6.85	24.1
SS 1	3.0	6.91	6.95	9.1	8.35	11.1
SS 2	3.0	7.58	10.51	10.19	8.15	11.6
SS 3	3.14	10.12	14.09	23.30	8.05	12.5
SS 4	3.71	11.0	13.21	21.05	8.10	12.4

In all the treatments the general trend of aggregate size distribution is towards the lower limit where it records the highest percentage of water-stable aggregates. The stability of these smaller class of aggregates is more than the higher ones. Findings of Weakly (1967) also supports this observation. It may be inferred from the low rate of aggregation in the size group 0.5 to 0.25 mm shown by original soil (AS 1 and SS 1) compared with other treatments in the pot culture experiment may be due to the increased microbial activity and organic matter. In saline-alkali soil under various treatments there is a distinct shift in the aggregate groups towards smaller grades for which the finer fractions predominant in the soil may be one of the reasons.

From the biometric data collected, final height and green matter weight of crops were taken to assess the performance of the crop. Comparative effects of treatments is shown below. In alluvial soil, performance of safflower is in the following order AS 2 > AS 1 > AS 3 > AS 4 and that of beet root is AS 2 > AS 1 > AS 3 > AS 4 > whereas in saline alkali soil, safflower is in the order of SS 2 > SS 1 > SS 3 > SS 4 and in beet root SS 2 > SS 1 > SS 4 > SS 3. This difference in crop response in relation with the status of aggregation may be attributed to the presence of bacteriostatic resins that inhibits microbial activity which reflects on the adverse crop response.

Cation exchange capacity shows positive response with the aggregation status in different treatments under alluvial and saline alkali soil with both the crops (Table V and VI). *p*H does not show any favourable response in relation to aggregation.

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