https://doi.org/10.29321/MAJ.10.A03455

Madras agric. J. 61 : (10—12) 992—996 Oct—Dec. 1974.

Effect of Gamma Radiation on certain Microbial and Chemical Properties of Two Soil Types

By

G. ARUNACHALAM,[1] G. OBLISAMI[2] and G. RANGASWAMI[3]

ABSTRACT

Studies on the changes in the microbiological and chemical properties of red and black soils due to varying doses of gamma-irradiation indicated that complete eradication of micro-organisms was possible at 1500 kr and 2000 kr for red and black soils, respectively; fungi were eliminated at 250kr to 1000 kr, actinomycetes at 1500kr and bacteria at 1000 to 2000kr indicating differential radio-sensitivity of the microbes present in the two soils.

A marked decrease in organic carbon content, an increase in available N, marginal increase in available P and a decrease in available K of both the soils due to gamma-radiation were recorded. The soil pH was lowered slightly in the red soil whereas no such change was observed in the black soil by the gamma-radiation. Autoclaving resulted in more significant changes in the above characteristics of both the soils than due to gamma radiation.

The conventional methods of steam or heat sterilization of soil cause major changes in chemical and physical properties of soil (Malowany and Newton 1944; Martin and Aldrich 1952; Eno and Popenoe 1664). For investigations dealing with soil plant root-microbe inter-relationship a method of soil sterilization which will not alter the soil in it rphysico-chemical propertie is needed.

The changes in soil properties due to autoclaving have been reviewed by Warcup (1957) and Eno and Popenoe (1964). The possibility of employing ionizing radiation such as X-rays, gamma rays etc., for effective soil sterilization was discussed by McLaren (1969). In the present study changes in the certain chemical and microbial properties of red and black soils collected from the Tamil Nadu Agricultural University Experimental Farm, by gamma-radiation and stem sterilization are compared.

MATERIAL AND METHODS

Surface soil samples (0-25 cm) were collected from the University Experimental Farm, air-dried, passed through 2 mm sieve and were used in the present investigation. The soil samples were exposed to gamma-radiation in Gamma Chamber-900. Steam sterilization was done by autoclaving the soil at 121°C for 3 hour. The soil pH was estimated electrometrically in a supernatent liquid of 1:2:5 soil-water suspension, after allowing it to stand

1. Senior Reserach Fellow D A E Project. 2. Associate Professor of Microbiology
3. Vice-Chancellor, Tamil Nadu Agricultural University, Coimbatore-641003.

TABLE 1. Effect of gamma radiation on microbial population of red and black soils.

Treatment	Population per gram soil		
	Bacteria ($X10^6$)	Actinomycetes ($X10^5$)	Fungi ($X10^3$)
Red soil			
Control	3.80	0.36	8.59
1 Kr	2.92	0.51	7.62
5 Kr	1.56	0.24	4.54
50 Kr	1.46	0.96	3.66
100 Kr	0.91	0.20	1.99
250 Kr	0.61	0.17	—
500 Kr	0.54	0.17	—
1000 Kr	—	0.20	—
1500 Kr	—	—	—
2000 Kr	—	—	—
Steam sterilizatino.	—	—	—
Black soil			
Control	4.44	0.82	4.70
1 Kr	3.71	0.78	3.03
5 Kr	2.82	0.72	4.20
50 Kr	3.33	0.68	1.27
100 Kr	1.92	0.61	0.73
250 Kr	1.61	0.28	0.30
500 Kr	0.70	0.18	—
1000 Kr	0.20	0.11	—
1500 Kr	0.10	—	—
2000 Kr	—	—	—
Steam sterilization.	—	—	—
C.D.	2.939	0.233	2.923

TABLE 2. Effect of gamma radiation on certain chemical properties of soil

Treatment	pH	Organic carbon %	Available N ppm	Available P ppm	Available K ppm
Red soil					
Control	7.40	0.33	84	13.1	330
1 Kr	7.30	0.33	84	13.1	330
5 Kr	7.50	0.30	86	13.1	320
50 Kr	7.45	0.26	98	13.1	300
100 Kr	7.45	0.24	102	13.1	320
250 Kr	7.40	0.24	104	13.2	260
500 Kr	7.40	0.24	122	13.2	276
1000 Kr	7.20	0.24	140	13.8	260
1500 Kr	7.20	0.12	146	13.8	300
2000 Kr	7.25	0.12	145	13.8	300
Steam sterilization.	6.80	0.12	140	14.9	260
Black soil					
Control	8.70	0.39	140	12.8	500
1 Kr	8.65	0.39	140	12.8	500
5 Kr	8.65	0.39	142	12.8	500
50 Kr	8.65	0.36	148	12.8	490
100 Kr	8.65	0.36	152	12.9	490
250 Kr	8.65	0.36	156	13.6	460
500 Kr	8.65	0.36	156	13.6	460
1000 Kr	8.65	0.36	162	13.6	480
1500 Kr	8.70	0.33	168	13.8	480
2000 Kr	8.70	0.30	168	14.0	480
Steam sterilization.	8.60	0.33	166	14.2	440

for 30 minutes. Organic carbon was estimated following the method of Walkley and Black (1934). available N, P and K were estimated by alkaline permanganate, Subbaiah and Asija's (1956), Olsen's (1954) and Hanway and Heidal's (1952) methods respectively.

RESULTS AND DISCUSSION

The data on the effect of gamma radiation on microbial population are presented in Table 1. Fungal population was more sensitive to gamma radiation in both red and black soils followed by actinomycetes and bacteria. The fungal population gradually decreased with the increasing dose of radiation and was completely eliminated at 250 to 500 kr dosages, which results are similar to the ones of Davis *et al.* (1956), Stotzky and Mortensen (1959), Newbould and Lucas (1959) and McLaren *et al.* (1962). A dose of 1000 to 2000 kr was necessary to kill all the bacteria in the two soils. For complete eradication of the actinomycetes 1500 kr dose was required. Popenoe and Eno (1962) recorded that the bacterial population survived even after 1000 kr treatment.

The results on the changes in chemical properties of soils due to gamma-radition and autoclaving are compared in Table 2. The changes in the pH in red soil was not consistent with the doses of gamma-radiation whereas steam sterilization showed a drastic reduction. In the black soil the pH decreased only slightly upto 1000 kr treatment as also due to steam sterilization. Stotzky and Mortensen (1959), treating the peat soil upto 250 kr found that soil pH was not influenced by gamma-radiation. Decomposition of organic matter was reported to lower the soil pH (Sen and Bains, 1955) and in the present study a similar reduction in organic carbon content was recorded with an increase in the dose of gamma-radiation, in turn lowering the soil pH. The organic carbon content in red soil decreased with increasing doses of gamma-radiation. Steam sterilization also caused a decrease of organic carbon which was equal to that of 2000 kr dose. In black soil there was a gradual decrease in the organic carbon content due to alpha-radiation as well as steam sterilization. In the case of gamma radiation perhaps the initial increasing doses oxidised some of the easily oxidisable organic matter, whereas the resistant organic matter was not affected even at higher doses in both the soils. The organic matter in soil is mostly bound to clay fractions than silt and other coarse fractions (McKeague, 1971) and perhaps this accounts for higher resistance to gamma radiation in black soil than in red soil.

Available N increased in both the soils due to different doses of gamma radiation and autoclaving. Irradiation increased the amount of N mineralised and N extractable in soil (Stanovick *et al.* 1961; Eno and Popenoe, 1963). The increase of N might be due to release of nitrogenous substances by the dead microorganisms, together with the effect of radiation on soil organic matter as suggested by Stanovick *et al.* (1961) and Eno and Popenoe (1963).

Available P also increased due to gamma-radiation and autoclaving, the effect of the later being more than the former. Eno and Popenoe (1963) and Bowen and Cawse (1964) observed that the increased available P due to radiation might have arisen from the dead microbes or from the effect of radiation on soil organic matter. Available K decreased with doses of gamma-radiation and also by autoclaving. The decrease might be due to fixation of potassium by clay complex. Heating of soil has been reported to cause potassium fixation (Bray and de Turk, 1938).

In general, gamma-radiation resulted in less significant changes in the chemical properties of soil only below 100 kr dosages, which dosage is not sufficient for effecient soil sterilization. At the higher doses of gamma-radiation, all the chemical properties (excepting pH in black soil) were altered.

REFERENCES

BOWEN, H. J. M. and P. A. CAWSE. 1964. Effect of ionizing radiation on soil and subsequent crop growth, *Soil Sci.* 97:252-9.

BRAY, R. H. and E. E. DE TURK. 1938. The release of potassium from non-replaceable forms in Illinois soils, *Soil Sci. Soc. Amer. Proc.* 3: 101-6.

DAVIS, R. J., V. L. SHELDON and S. I. AVERBACH 1956. Lethal effects of gamma radiation upon segments of a natural microbial population. *J. Bact.* 72:505-10.

ENO, C. F. and H. POPENOE. 1963. The effect of gamma radiation on the availablity of nitrogen and phosphorus in soil. *Soil. Sci. Soc. Amer. Proc.* 27:299-301.

ENO, C. F. and H. POPENOE. 1964. Gamma radiation compared with steam and methyl bromide as a soil sterilizing agent. *Soil. Sci. Soc. Amer. Proc.* 28:533-5.

MALOWANY, S. N. and J. D. NEWTON. 1944. Studies on steam sterilization of soils. I. Some effects on physical, chemical and biological properties, *Can. J. Res.* C 25:189-208.

MARTIN, J. P. and D. G. ALDRICH. 1952. Effect of fumigation on soil aggregation. *Soil Sci. Soc. Amer. Proc.* 16:201-3.

MCKEAGUE, J. A. 1971. Organic matter in particle size and specific gravity fractions of some Ah horizons. *Can. J. Soil Sci.* 51:499-505

MCLAREN, A. D. 1969. Radiation as a technique in soil biology and biochemistry. *Soil Biol. Biochem.* 1:63-73.

MCLAREN, A. D., R. A. LUSE and J. J. SKUJINS. 1962. Sterilization of soil by irradiation and some further observations on soil enzyme activity. *Soil Sci. Soc. Amer. Proc.* 26:371-7.

NEWBOULD, P. and P. L. LUCAS. 1959. Effect of the level of microbial population on isotopically exchangeable phosphate in soil. *Nature 184:*1155-56.

POPENOE, H. and C. F. ENO. 1962. The effect of gamma radiation on microbial population, of soil. *Soil Sci. Soc. Amer. Proc. 26*:164-7.

SEN, S. and S. S. BAINS. 1955. Effect of farmyard manure and superphosphate on berseem yield, nodulation and on nitrogen and available phosphorus contents of the soil. *J. Indian Soc. Soil Sci. 3*:41-9.

STANOVICK, R., J. GIDDENS and R. A. MCCREERY. 1961. Effect of ionizing radiation on soil organisms. *Soil Sci. 92:*183-7.

STOTZKY, G. and J. L. MORTENSEN. 1959. The effect of gamma radiation on growth and metabolism of microorganisms in an organic soil. *Soil Sci. Soc. Amer. Proc. 23:* 125-7.

WARCUP, J. H. 1957. Chemical and biological aspects of soil sterilization. *Soils & Fert., 20:*1-5.