$$R = 1 - \frac{6\,\Sigma d^2}{n^3 - n} = 1 - \frac{216}{990} = 0{\cdot}78$$

from which we can calculate.

$$\text{Students 't'} = R\sqrt{\frac{n-2}{1-R^2}} = 0{\cdot}78\sqrt{\frac{10-2}{1-0{\cdot}78^2}} = 3{\cdot}5.$$

The 1% level of Students 't' with n—2=8 degrees of freedom is 3·36. We therefore conclude that the observer's ranking correlates significantly with the true ranking.

Spearman's rank correlation co-efficient is thus a very useful technique in finding out (a) whether two independent observers show significant agreement between them in ranking a set of types and (b) whether an experimentalist is proficient enough to judge the various types by ranking them without any actual measurement.

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Some Studies of 2, 4-D Toxicity in Soils in Herbicidal Concentrations

by

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It has been pointed out by many investigators in several instances that 2, 4-Dichlorophenoxy acetic acid, applied in herbicidal concentrations leaves toxic effects in the soils. Attempts have been made by workers to assess the persistence of its toxicity and in almost all these studies the emergence of certain seedling like tomato, cucumber and beans have been used as criteria. Nutman et al (1945) reported that 2, 4-D when applied in small quantities of herebicidal concentrations had some toxic effect on soil but it disappeared in a course of 36 days. Mitchell and Marth (1948) found soils kept in dry conditions were toxic even at the end of 18 months. De Rose (1946) Taylor (1947) and Kries (1947) all noted that 2, 4-D persists in soils and supresses germination and growth of plants. Brown and

Mitchell (1948), Carlson and Hamner (1948), Hernandez and Warren (1948), Akamine (1951) have shown that the inactivation of 2, 4-D was greatly influenced by factors like temperature, soil moisture, pH, soil type, organic matter, autoclaving, rainfall, and other environmental factors.

While all this work relates to temperate conditions of climate and soils, very little work has been done under tropical conditions in India. Some experiments were therefore conducted under regulated conditions in laboratory, in the Department of Agriculture, Annamalai University, using two types of soils showing two different pH values to study the toxic effects of 2, 4-D in the soils in a preliminary way.

Materials and Methods: The germination and growth of Indian flat beans *(Dolichos lablab)* sown at 2 week-intervals in treated and non-treated flats were used as critera for assessing the persistence of 2, 4-D toxicity in soils. Two types of soils, clayey and sandy loam with pH values of 7·8 and 6·5 respectively, were used in the experiment. Wooden flats of 18"x12"x9" were filled with the soil to a depth of 6". 2, 4-D was applied in pure acid form as a surface dust calculated at 2 lb. per acre. Fifty bean seeds were sown in each flat and at the end of 2 weeks, the extent of germination and number of normal and abnormal seedlings in treated flats were noted and the results compared with the control. These seedlings were pulled out and another sowing was made immediately. Cropping was thus continued until the germination and growth of seedlings in treated flats when expressed as a percentage of control was 95%, it was assumed that the toxicity was lost. For each type of soil two flats were treated and two flats were non-treated. The factor of leaching was prevented by allowing water in quantities just sufficient for germination and growth of plants. To be sure that the chemical had not been reached to the bottom, at the conclusion of the experiment the soil in the flats was inverted and bean seeds were sown and the germination and growth of seedlings observed.

Results: 2, 4-D showed toxic effects in sandy soils upto 8 weeks and in clayey soils upto 6 weeks. The toxicity was lost two weeks earlier in clayey soils. Irrespective of soils germinating bean seeds and seedlings exhibited various pattern of abnormalities in treated flats. The chief modifications were formation of swollen hypocotyl loop in certain seeds, reversion in germination, formation of an irregularly thickened cancerous growth at base of stems from which roots were given off, and alteration of size, shape, texture and

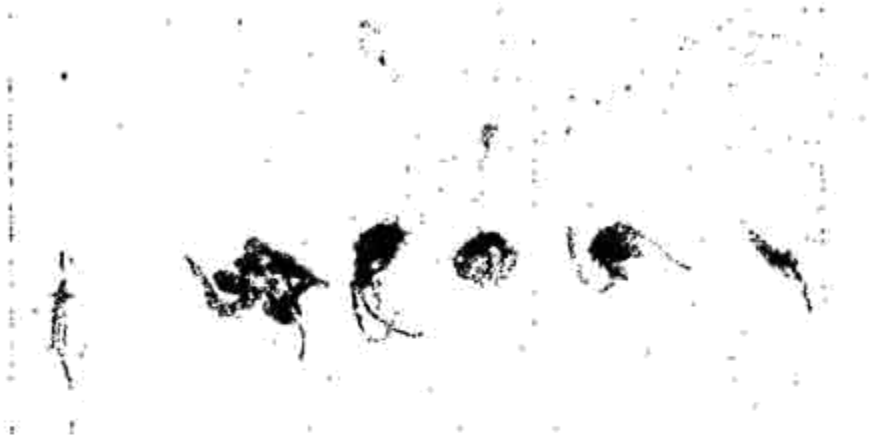

FIG. 1.

Cancerous growths at the base of stems of bean seedlings induced by 2,4-D. Left extreme: Control.

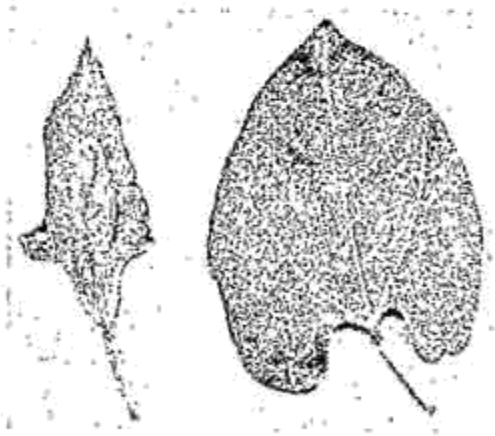

FIG. 2.

Alteration in shape, size and venation of bean leaves induced by 2,4-D. Left: Treated. Right: Control.

venation of leaves in many cases. Fig. 1 shows the cancerous growth at the base of stems, and Fig. 2 the alteration of size, shape and venation of leaves. Table I shows the normal bean seedlings expressed as percentage of control until the toxicity was lost in both soils. Data were also collected with regard to the emergence of abnormal seeds and seedlings in flats treated with 2, 4-D at 2 weeks intervals in both soils until toxicity was lost and it is shown in Table II. The perusal of the data in Table I will indicate that there was a complete failure of emergence of normal seedlings for the first 4 weeks in flats treated with 2, 4-D irrespective of the soil types. It was interesting to note that while in sandy soils the emergence of normal seedlings gradually increased from the 4th to 8th week, it was rather abrupt in clayey soils. By the end of 4 weeks, there was sudden emergence of normal seedlings almost equalling the control in clayey soils.

TABLE I.

Percentage of emergence of normal bean seedlings at two week intervals in sandy and clayey soils treated with 2, 4-D.

	Sandy Soils			Clayey		
Interval between treatment of 2, 4-D and sowing seeds (in weeks)	Counts regarding emergence of normal seedlings					
	Treated	Non-treated	Normal seedlings expressed as % of control	Treated	Non-treated	Normal seedlings expressed as % of control
1·0	Nil	77	Nil	Nil	95	Nil
2·2	Nil	70	Nil	Nil	96	Nil
3·4	17	75	22·67	77	84	91·67
4·6	89	95	93·68	87	88	98·86
5·8	94	95	98·95	..	..	..

TABLE II

Abnormal seeds and seedlings expressed as a percentage of control at two week intervals in sandy soils and clayey soils treated with 2, 4-D

	Sandy soil			Clayey soil	
	Interval between application of 2, 4-D and sowing of bean seeds (in weeks)	Abnormal seeds and seedlings	Interval between application of 2, 4-D and sowing of bean seeds (in weeks)	Abnormal seedlings
1.	0	85·74	0	91 89
2.	2	80·00	2	75·00
3.	4	46·66	4	5·71
4.	6	5·26	6	Nil
5.	8	Nil	..	..

Discussion: In the results obtained with our experiments it is seen that sandy soil with 6·5 pH has retained toxicity for a longer time than the clayey soil with a pH value of 7·8. In these experiments except the variation in soil type and pH, every other factor of environment, like temperature, moisture etc. was the same for the different treatments. Akamine (1951) working in soils reported that soils high in pH value inactivated 2,4-D more rapidly than those low in pH value. In our experiments also soils with a higher pH value has shown inactivation nearly 2 weeks earlier than the soils lower in pH value. Thus our results are in consonance with those of Akamine. In general it is further noted that abnormal seeds and seedlings were altogether greater in sandy soils than in clayey, although during the first sowing, the abnormal seedlings were somewhat higher in clayey soils. Further, the sandy soil in the case of our experiment has shown longer period of retention of 2, 4-D than clayey soils. These suggest that 2,4-D is more toxic in sandy soils than clayey one. Nutman et al (1945) in attempting to find out the toxic effects of 2,4-D in different soil types report that in Rothamsted soil, a clayey one, 2,4-D had less marked effect than in Wouburn soil, a sandy one. It was also interesting to note in our experiments that while emergence of normal seedlings was gradual in sandy soil, it was rather abrupt in clayey soil. Modifications exhibited by bean seeds, and seedlings were similar to those described by Zimmerman and Hitchcock (1942), De Rose (1946) and Kries (1947).

It should be noted that the experiments were conducted under conditions where leaching was not permitted. When conducted under field conditions, the amount of rainfall in a place is also likely to influence the inactivation of 2,4-D and this has been pointed out by De Rose (1946).

Summary and Conclusions: 2,4-D was applied as surface dust in two types of soils with pH values 6·5 and 7·8 respectively at calculated rate of 2 lb. per acre. The germination and growth of bean plants were used as criteria for assessing toxicity of 2,4-D in herbicidal concentrations. The results within the limitations of the experiments indicate that soil type and pH considerably affect the inactivation of 2,4-D in herbicidal concentrations. Soils with high pH value inactivated the herbicide earlier than the soil with a lower pH value. The germination of bean seeds irrespective of soil types exhibited various patterns of abnormalities characteristic of the compound 2,4-D. It was also noted that there was total failure of

emergence of normal seedlings in soils treated with 2,4-D for the first 4 weeks but thereafter the emergence of normal seedlings was gradual in sandy soils while it was abrupt in clayey soils.

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