CROP RESPONSE TO CHEMICAL OXIDISERS.

By

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INTRODUCTION.

Attention has been drawn in previous communications (Subrahmanyan and Siddappa, *Curr. Sci.*, 1933, **2**, 161; Subrahmanyan, Harihara Iyer and R. Rajagopalan, *Curr Sci.*, 1934, **2**, 384; Harihara Iyer, Rajagopalan and Subrahmanyan, *Proc. Ind. Acad. Sci.*, 1934, **I B**, 106; Siddappa and Subrahmanyan, *Proc. Ind. Acad. Sci.*, 1935, **I B**, 928; Harihara Iyer, Rajagopalan and Subrahmanyan, *Proc. Ind. Acad. Sci.*, 1935, **II B**, 108) to the beneficial effects of dressings of small amounts of oxidising agents, like potassium permanganate, ferric oxide and manganese dioxide, on plant growth and crop yield. Evidence has been adduced to show that the increased oxidation of soil organic matter, on the application of these chemicals, is mainly responsible for the enhanced crop production. It has also been indicated that the chemical nature of the oxidising agent employed, the time of its application, and the type of crops grown are factors determining the extent of benefit that may be derived from the treatment.

The residual effect of such applications, however, requires further investigation. It is necessary to determine whether the plant nutrients are still in an available condition and whether the subsequent crop will derive any benefit from the previous treatment. It has also to be investigated whether the nature of the manure employed influences the extent of response of the crops to "oxidiser" treatments. The present paper relates to work done on the above problems.

EXPERIMENTAL.

Field experiments with ragi (Eleusine coracana): *to determine the residual effect of oxidising agents.*—These trials were carried out in a number of small plots, each measuring $11' \times 11'$, where ragi had been grown in the two previous years to determine the fertilizing value of potassium permangante. (Harihara Iyer *et al.*, *loc. cit.*). The plots had been subjected to different treatments as follows.—

(a) Unmanured (control); (b) manured; (c) unmanured and treated with potassium permanganate (150 gms. per plot); (d) manured and treated simultaneously with potassium permanganate (150 gms. per plot) and (e) same as (d) but with permanganate applied as top dressing in two instalments. The manured plots had received per plot 22 lbs. of farmyard manure in 1933 and 14 lbs. of hongay cake in 1934. Four plots had been allotted for the treatments (a), (c), (d) and (e) and eight for (b), the distribution of the plots being by the random method. The plots, after the harvest of the crop in 1934, were lying fallow.

After opening up the soil in the plots to a depth of 9″, seeds of a short duration variety of ragi (K_1, generally grown in summer) were sown in the area on 5th May, 1935. The germination was quite satisfactory. The seedlings were subsequently thinned down to 200 per plot on 29th May, 1935. Owing to scarcity of rain in May and June, the plots were irrigated with tap water during the early part of the crop growth. The plants were harvested on 10th September, 1935.

Periodical observations with regard to tillering and ear formation during crop growth did not disclose striking differences between the treatments. However, as was only to be expected, the plants in those plots which had previously been manured were showing better growth. The final yields have been given below (Table I) as from 484 sq. ft. (1/90th of an acre) in each case.

Meteorological observations.—The season (May to September 1935) in which these experiments were carried out was moderately warm, the maximum temperature ranging from 75°—90°F. There were sufficiently long periods of sunshine, particularly in May and June, to facilitate the healthy development of plants. There were a few showers early in June, followed by plenty of rain in July and August. The relative humidity throughout the period of experimentation was relatively high, the range being 70 to 90 per cent.

TABLE I.

"Residual effect" of permanganate—Yields of ragi.

Treatment	Yield (dry weight) in kg.	
	Grain	Straw
Manure alone ...	8.05	19.3
Permanganate alone ...	6.48	17.0
Manure plus permanganate (simultaneously) ...	9.44	22.3
Manure plus permanganate (top dressing) ...	9.55	22.8
Untreated (control) ...	6.09	16.2

It will be observed that treatment of the soil with potassium permanganate in a previous season had some residual effect on the soil, leading to a slightly increased yield, both in grain and straw. This applies equally well to plots that had and those that had not received any manure in the previous seasons. However, the increase in crop production in the permanganate treated plots over the corresponding controls is not so marked now.

Manganese distribution in the plots.—To find out the extent to which manganese previously added as potassium permanganate had reverted to insoluble forms, the distribution of manganese in the experimental plots was followed. Representative specimens of the soil were collected on 14th May, 1935—a fortnight after the sowing of ragi seeds for the residual effect experiments,—air dried and analysed for water-soluble, acid-soluble and total manganese (Harihara Iyer and Rajagopalan, *Jour. Indian Inst. Sci.*, 1936, **19A**, 57). The results have been presented in Table II. For comparison, the corresponding data of 1934 have been presented side by side.

The results indicate that the distribution of manganese remained the same as in 1935 and that the major part of the added manganese (nearly 25 out of 40 parts per million, corresponding to the increase in tolal manganese in the plots treated with potassium permanganate over the corresponding controls) remained practically for a long time in the acid-soluble condition. It may be inferred that the slightly enhanced yields in the permanganate-treated plots was due to the added manganese bringing about the favourable biochemical changes in the soil as in the previous years. It would therefore appear that the added manganese remains quite active for a long time and is therefore capable of functioning as an oxidiser for some years.

TABLE II.

Distribution of manganese in the experimental plots.

Treatment given to the plot	Manganese in parts per million					
	1935			1934		
	Water-soluble	Acid-soluble	Total	Water-soluble	Acid-soluble	Total
Unmanured (Control) ...	Traces	86.2	350.4	Traces	89.5	360.8
Manured ...	,,	87.2	356.2	,,	85.8	371.8
Unmanured plus $KMnO_4$ ...	,,	110.4	394.5	,,	118.8	398.0
Manured plus $KMnO_4$ (simultaneously) ...	,,	109.2	390.5	,,	107.8	393.6
Manured plus $KMnO_4$ (stages) ...	,,	113.7	383.3	,,	118.8	387.2

The extent of crop response to oxidising agents as influenced by different manurial treatments.—In the previous studies with iron and manganese oxides (Harihara Iyer, Rajagopalan, and Subrahmanyan, *loc. cit.*) only one type of organic manure (hongay cake) was employed. As the C/N ratio of this material is narrow (10:1) and as the C/N ratio of the manure determines to a very large extent its mode of decomposition in the soil (Jensen, H.L., *Jour. Agric. Sci.*, 1929, **19**, 71; also, Waksman 'Humus', 1936) it was felt desirable to carry out experiments with other manures as well. In the present investigation, stable manure and a compost prepared from town refuse and cow-dung have been used.

Pot culture experiments with ragi (Eleusine coracana).—The pots were made up with mixtures of 22 lbs. of red earth and 8 lbs. of sand. The pots were divided into three sets: to one set, hongay cake was added at 30 gms. per pot; to another, 100 gms. of compost (carbon 13.95, nitrogen 0.6) was added and to the last, 100 gms. of stable manure (carbon 21.07, nitrogen 1.12). All the pots received complete minerals consisting of potassium nitrate (2g.), potassium sulphate (1.5g.) and superphosphate (non-acid, concentrated 3.g.). Each set of pots was further divided into five batches of 6 pots and the contents of each batch treated with different oxidising agents as follows.—(1) manganese dioxide, 7.5 g. as basal dressing; (2) manganese dioxide as top dressing, a month after sowing; (3) ferric oxide (30 g.) as basal dressing; (4) ferric oxide as top dressing and (5) control (untreated).

In each pot, six seeds of ragi (K_1) were sown on 30th July, 1937. After the seedlings had grown to some height, they were thinned down to leave four uniform healthy seedlings in each pot. The ears appeared in the first week of October and the plants were ready for harvest by the middle of November.

Periodical observations showed that in the pots receiving top dressings of the oxides the plants were coming up best in all the cases. With basal dressings, it was found that the plants in pots manured with hongay cake did not respond quite favourably to ferric oxide, though those raised on compost and stable manure were doing better. The final results are presented in Table III.

The results (Table III) indicate that in all the cases top dressings of the oxides were most efficacious. Also, manganese dioxide as a basal dressing is useful, though not to the same extent as when applied later. The low yield with the hongay cake set, that received ferric oxide as a basal dressing, may point out to the influence of the manure in determining the crop response to the oxidiser and the time of its application.

Pot culture experiments with tomato.—King Humbert, a heavy yielder, was the strain used for these trials. The treatments were precisely the same as with ragi. The seeds were sown on

TABLE III.

Effect of manganese and ferric oxides on the yields of ragi.

Treatment	Hongay cake		Stable manure		Compost	
	Grain	Straw	Grain	Straw	Grain	Straw
Manganese dioxide as basal dressing ...	220	738	78	192	63	142
Do as top dressing...	262	826	94	216	79	174
Ferric oxide as basal dressing ...	167	627	69	171	66	153
Do as top dressing...	244	761	88	189	74	165
Untreated (control) ...	189	690	62	158	52	114

TABLE IV.

Effect of manganese and ferric oxides on the yields of tomato.

Treatment	Hongay cake	Stable manure	Compost
Manganese dioxide as basal dressing ...	2457	685	372
Do as top dressing ...	3393	774	491
Ferric oxide as basal dressing ...	2181	613	381
Do as top dressing ...	2996	798	514
Untreated (control) ...	2042	542	304

17th August, 1937 at eight per pot. When the seedlings had made a fortnight's growth, they were thinned down to three per pot. The plants began to yield fruits by the first week of November. The fruits were collected periodically and their fresh weights determined. The results have been presented in Table IV.

It was observed that the plants raised on stable manure and compost were making an extremely poor growth, owing mainly to the high manurial needs of the tomato plant. The differences observed between the treatments were practically the same as with ragi and require no repetition.

DISCUSSION.

In the previous studies on the subject, it has been shown that the fertilising action of the oxidising agents is mainly due to the greater evolution of carbon dioxide which naturally leads to increased photosynthesis and plant growth (Lundegårdh, *Soil Sci.*, 1927, **23**, 417 ; Subrahmanyan and Siddappa, *loc. cit.*). The question however arises as to whether the depletion of the soil organic matter, as a result of such treatments, would not seriously lower the humus status of the soil as to interfere with the growth of the succeeding crop. The trials carried out to determine their residual effect would suggest that the loss of organic matter, owing to increased decomposition, had been offset by the production of larger crops, with the result that larger quantities of plant residues had reached the soil and were converted to humus.

Further work is, however, necessary to find out whether an oxidiser applied in a particular season, can function as a fertilizer for a number of successive seasons to bring about the maximum decomposition of the applied organic manure, with ultimate benefit to the crop. In such a case, the necessity for supplementing the organic manures every season with chemical oxidisers is obviated.

The trials with different manures have indicated that, to a very large extent, the chemical nature of the organic manures determines the influence of oxidisers on crop production. Thus, while basal dressings of ferric oxide to soil manured with hongay cake were unfavourable to plant growth, the response was better when the soil received compost or stable manure. Presumably, in the former case, ferric oxide (in the amounts used) brought about considerable decomposition of the hongay cake and released large amounts of plant nutrients before the plants could come up to the stage when they could profit therefrom. It will be of interest therefore to follow the changes in the chemical composition of the organic matter in the soil on treatment with oxidisers and thus arrive at a knowledge of the mechanism of their action.

SUMMARY.

(1) Plot trials with ragi have shown that the oxidisers have a residual effect on the soil and that the succeeding crop derives benefit to a certain extent from the treatment.

(2) Manganese applied to the soil as permanganate remains in the acid-soluble condition for a long period; this indicates the possibility of obviating the additions of the oxidisers every season.

(3) Plot trials with ragi and tomato have confirmed the previous findings with regard to the usefulness of top dressings of ferric oxide and manganese dioxide. They have also demonstrated that the nature of the manure added influences the extent of response to oxidisers.

The authors' thanks are due to Prof. V. Subrahmanyan, for his keen interest in the progress of this work.

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[Received, 17-6-1939]

Printed at the Hosali Power Press, Ulsoor, Bangalore, by D. N. Hosali, Proprietor.