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Effect of organic soil amendments on the rhizosphere microflora of tomato

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Abstract. Effect of organic amendments on the microbial population of rhizosphere and non-rhizosphere soils was studied taking a number of dry and green plant materials. All the amendments had marked stimulatory/inhibitory effects on the population of fungi and bacteria in the rhizosphere but the magnitude varied with the amendment as well as variety and age of the plant. They also affected the relative population of different fungi in the rhizosphere. A number of them suppressed the population of Fusaria and stimulated that of Aspergilli.

Keywords. Tomato; rhizosphere microflora; organic amendments.

1. Introduction

Biological control of soil-borne pathogens by inoculating the soil with antagonistic organisms has been attempted by several workers (Baker 1968; Tiwari and Mehrotra 1968; Tigchelair and Dick 1975; Endo *et al* 1976; Mehrotra and Tiwari 1976) but not much success has been achieved so far. Soil amendments with organic materials such as manures, green and dry parts of plants, saw-dust, etc. have been tried and success has been achieved in suppressing the activity of soil-borne pathogens (Stover 1962; Huber and Watson 1970; Linderman 1970; Singh and Singh 1970; Nauman and Lange-De La Camp 1976). Tomato, an important vegetable crop, suffers from a number of soil-borne diseases caused by fungi especially Fusaria (seedling rot, damping off and wilt). In the present investigation, the qualitative and quantitative changes in the rhizosphere microflora of tomato due to organic soil-amendments were studied to evolve effective plant treatments for suppressing the soil-borne Fusaria.

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2. Materials and methods

Marglobe and Pusa Ruby varieties of tomato were included in this study. Plants were raised in earthern pots filled with a mixture of 3 kg of unsterilized soil (University experimental farm) and one of the organic amendments at the rate of 1% by weight of soil. A set of six pots was taken for each amendment. For each variety, a control series was also included. The experiment was performed sequentially such that the first treatment and its control commenced on zero day, the second treatment and its control on the first day, the third treatment and its control on the third day and so on.

The following nine kinds of dry and green organic amendments were incorporated in the soil.

(*a*) Dry (mature)—wheat straw, sorghum straw, sugarcane straw.

(*b*) Green (immature)—leaves of *Datura alba* Nees, *Ipomoea carnea* Jacq. and *Calotropis procera* R. Br.; entire plants of *Lemna paucicostata* Hegelmaier, *Eichhornia crassipes* Solms and *Salvinia natans* Linn.

The plant materials were chopped, sterilized and thoroughly mixed with the soil. The pots were filled with soil and left undisturbed for about two weeks to allow the decomposition of the plant materials. 25 surface-sterilized seeds were sown in each pot and after germination some of the seedlings were removed to retain 10 seedlings per pot. The pots were watered daily and maintained under identical conditions in the greenhouse (average temperature during vegetative stage—25° C, during flowering stage—27° C and during fruiting stage—28° C). Samples of rhizosphere and non-rhizosphere soils (soils from pots without plants) were collected on the 20th, 60th and 90th day (vegetative, flowering and fruiting stages respectively) of plant growth. The soil dilution plate method (Timonin 1940) was employed for counting and/or isolating pure cultures of microorganisms. Dilutions of 1 : 10,000, 1 : 1,00,000 and 1 : 10,00,000 were used for final counting and isolating fungi, actinomycetes and bacteria respectively. A composite sample was used, as counts obtained from soils of individual samples did not substantially vary from those obtained from the composite sample in the preliminary experiments conducted for stabilizing the methods.

The data on population of bacteria, and fungi (factorial experiments) were statistically analysed (Fisher 1936). The microbial population of the rhizosphere was compared with that of non-rhizosphere by using a numerical value, the R/S ratio or the rhizosphere effect.

The media employed to isolate the microorganisms were peptone dextrose agar (Martin 1950) and potato dextrose agar (Riker and Riker 1936) for fungi and soil extract agar (Allen 1957) for bacteria and actinomycetes.

3. Results and discussion

The R/S ratios calculated on the basis of total numbers of bacteria and fungi in the rhizosphere and non-rhizosphere soils (table 1) show that as against the non-rhizosphere region, the rhizosphere of both the varieties of tomato harboured a higher population of fungi as well as bacteria throughout their life. They further indicate that the rhizosphere of 'Pusa Ruby' was extremely conducive for the growth of bacteria during the flowering stage.

Table 1. R : S ratios of the microflora under different amendments of the two tomato varieties.

Organism/amendment	Marglobe			Pusa Ruby		
	Age of plant in days			Age of plant in days		
	20	60	90	20	60	90
Bacteria						
Wheat straw	34·19	13·37	5·91	1·17	0·37	5·00
Sorghum straw	0·80	0·33	15·50	0·03	0·50	121·00
Sugarcane straw	0·22	78·00	1·60	0·23	15·00	1·00
Ipomoea leaves	6·62	81·75	0·34	2·80	1·16	0·52
Calotropis leaves	0·22	0·06	0·53	1·68	0·38	0·61
Datura leaves	5·50	0·05	3·55	124·34	1·94	22·55
Lemna	8·47	0·66	0·78	54·63	0·05	0·35
Salvinia	3·02	8·47	0·78	6·79	2·78	1·08
Eichhornia	2·78	8·00	0·27	22·84	101·45	0·30
Control (None)	1·17	1·44	1·20	2·44	74·55	1·48
Fungi						
Wheat straw	5·67	4·50	1·83	6·38	2·47	0·64
Sorghum straw	0·17	5·33	15·52	0·58	3·94	42·10
Sugarcane straw	2·35	0·46	18·21	1·30	1·37	3·42
Ipomoea leaves	1·57	42·20	5·75	1·87	16·30	16·43
Calotropis leaves	1·33	0·91	15·63	2·16	1·63	12·09
Datura leaves	3·72	2·75	61·20	1·13	9·50	11·40
Lemna	3·33	6·41	11·68	0·63	5·16	2·54
Salvinia	0·15	1·98	25·60	0·43	1·05	8·80
Eichhornia	2·57	5·43	17·69	5·95	9·50	5·69
Control (None)	5·37	6·35	2·62	3·72	10·72	4·05

All the nine amendments had either marked inhibitory or stimulatory effect on the bacterial and fungal population which in turn depended on the variety and age of the plants. As regards the bacterial population, a marked stimulatory effect was exhibited by wheat-straw amendment at the vegetative stage and sugarcane-straw as well as *Ipomoea* leaf amendments at the flowering stage in ' Marglobe '. In the case of ' Pusa Ruby ', a similar effect was noted with *Datura* leaves at the vegetative and fruiting stages, with *Eichhornia* plants at the vegetative and flowering stages, with *Lemna* plants at the vegetative stage and with sorghum-straw at the fruiting stage.

With respect to the fungal population, a strong stimulation was exhibited by *Ipomoea* leaves at the flowering stage and by *Datura* leaves and *Salvinia* plants at the fruiting stage in the Marglobe variety. But in the case of ' Pusa Ruby ', a similar effect was noted only with sorghum-straw at fruiting.

The population of actinomycetes in the rhizosphere as well as non-rhizosphere soils was much lower than that of fungi and bacteria and none of the treatments showed any noteworthy stimulatory or inhibitory effect.

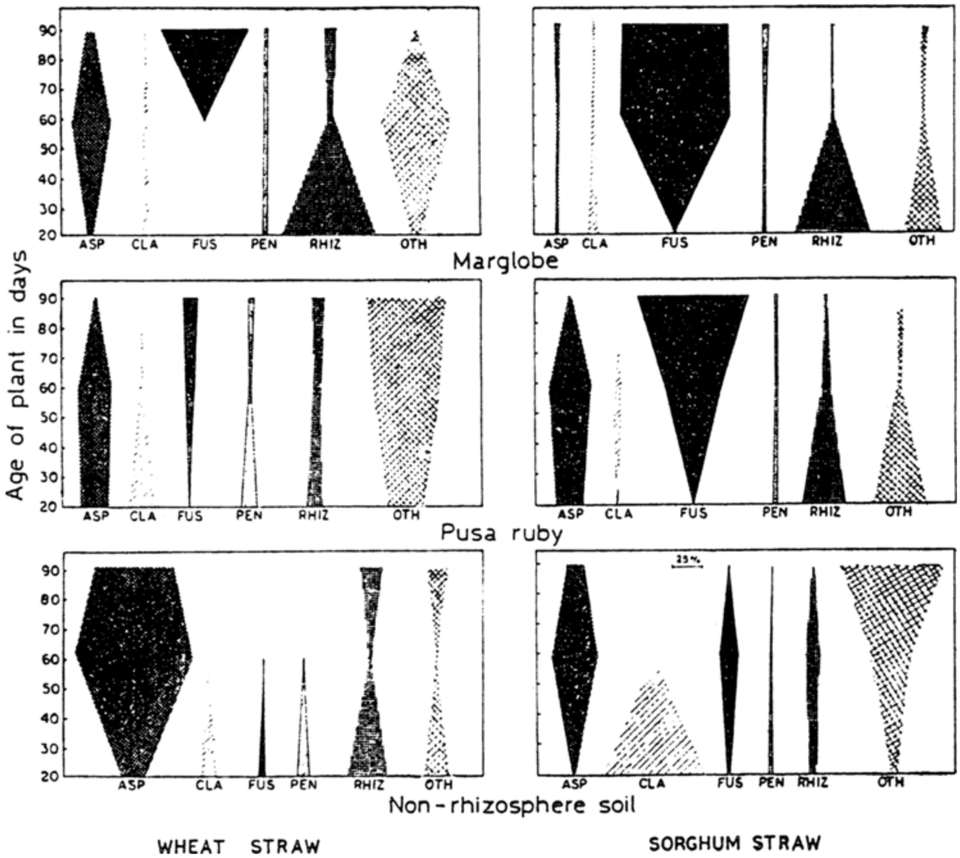

Figure 1.

The results presented in figures 1–5 show marked quantitative differences between the fungal flora of rhizosphere and the non-rhizosphere regions. In the unamended soils, rhizosphere of both the varieties stimulated the population of *Fusarium* but had no effect on that of *Aspergillus* and *Rhizopus*. In the non-rhizosphere region, nearly all the amendments had a stimulatory effect on the population of *Aspergillus* and *Cladosporium*. None of the amendments could, however, change the population of *Fusarium* and *Rhizopus*. In the rhizosphere region, the effect of amendments on the population of fungi varied with the plant variety. The marked suppression of *Fusarium* population in the rhizosphere of 'Pusa Ruby' was noted with wheat-straw, *Calotropis* and *Salvinia* and in that of 'Marglobe' with

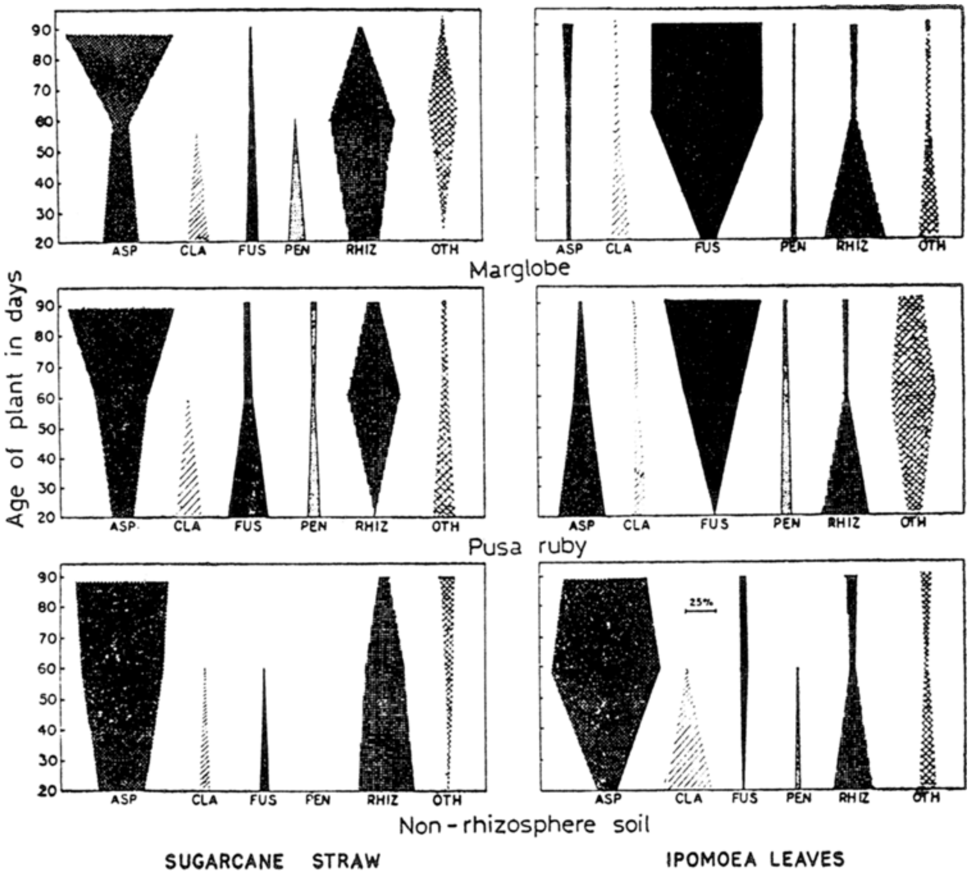

Figure 2.

sugarcane-straw and *Lemna*. The majority of the amendments stimulated the population of *Aspergillus* in the rhizosphere of both tomato varieties. The effect on other fungi varied with the amendments and the variety. In the case of 'Pusa Ruby' many of them had an inhibitory effect on *Cladosporium* but did not materially change the population of *Rhizopus*. Similarly in the case of 'Marglobe' many of them had inhibitory effect on the population of *Rhizopus* but did not materially change the population of *Cladosporium*.

The changes brought about by amendments in the rhizosphere microflora may be either due to their direct effect on the soil microflora or their effect on plant

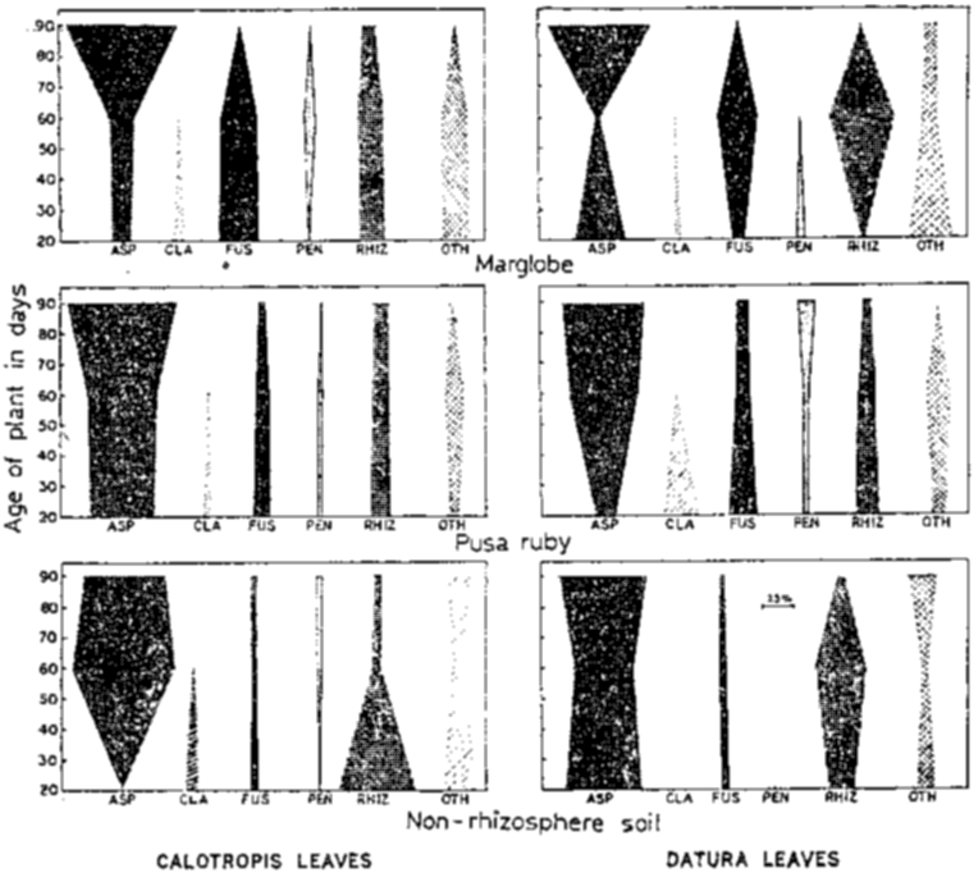

Figure 3.

growth and metabolism. The effect on plant growth and metabolism may create new exudation patterns which in turn may selectively modify the microflora in the rhizosphere. The results of the present study indicate that all the amendments exerted a marked effect on the population of bacteria, fungi and actinomycetes as well as on the relative proportions of different fungi in the soil. However, a comparison of changes brought about by them in the non-rhizosphere soils with those in the rhizosphere soils shows that the changes in the rhizosphere microflora were not the direct repercussions of the changes in the soil microflora. Indirect effects *via* microorganisms on pathogens and plant growth appear to be mainly responsible for these changes.

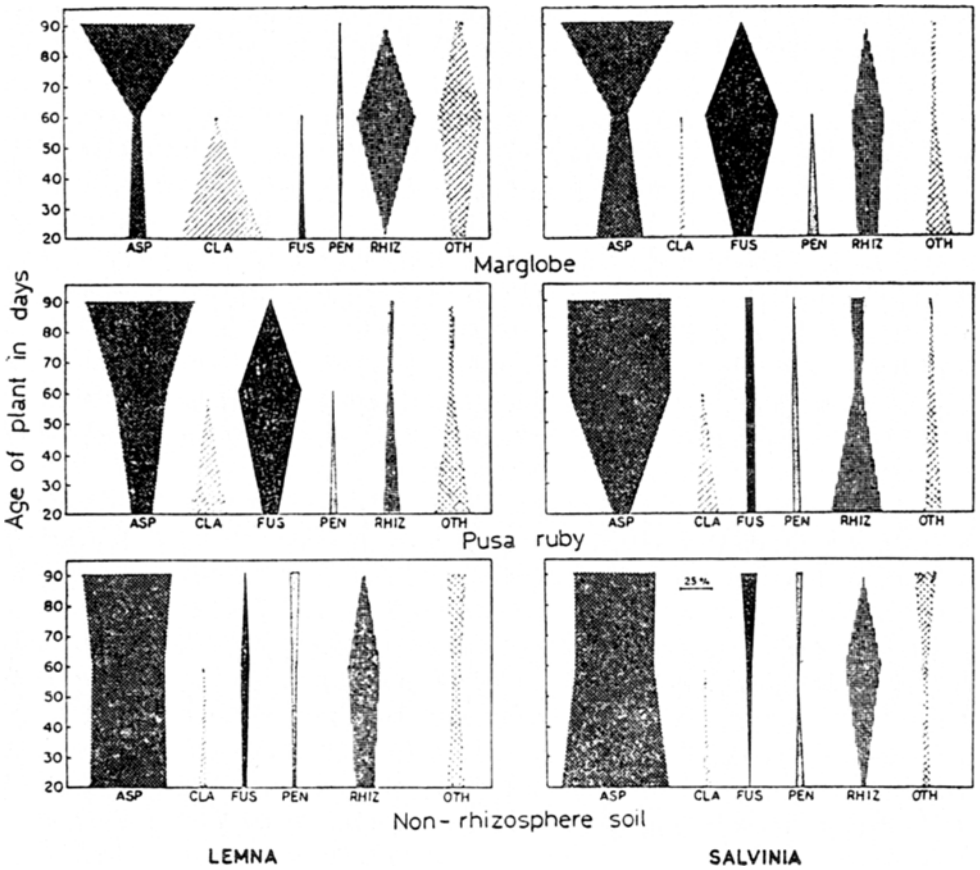

Figure 4.

Marked suppression of *Fusarium* population in the rhizosphere of both the varieties by some of the organic amendments is important from the viewpoint of biological control. Soil amendments with wheat-straw, *Calotropis* and *Salvinia* in ' Pusa Ruby ' and with sugarcane-straw and *Lemna* in ' Marglobe ' may be employed for suppressing the activity of *Fusaria* in the rhizosphere. However, before making final recommendations it is imperative to test the efficacy of these amendments in relation to specific pathogens, variety and local microflora. The work on these lines is in progress and will be published later.

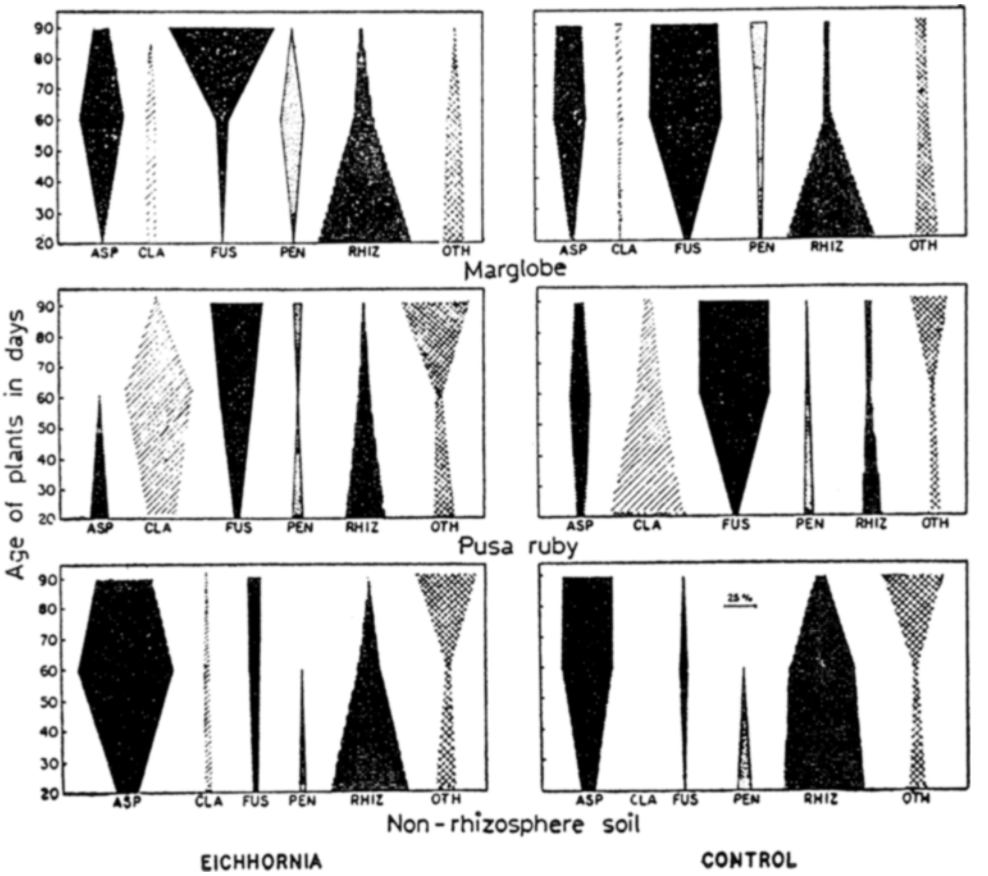

Figure 5.

Figures 1–5. Percentage occurrence of different fungi in the unamended (control) and amended rhizosphere (Marglobe and Pusa Ruby varieties) and non-rhizosphere soils. ASP—*Aspergillus* spp. ; CLA—*Cladosporium* spp. ; FUS—*Fusarium* spp. PEN—*Penicillium* spp. ; RHIZ—*Rhizopus* spp. ; OTH—Other fungi.

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