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A PRACTICAL METHOD OF ESTIMATING DISEASE RESISTANCE IN CROP PLANTS

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Introductory.—The need for the control of plant diseases is being increasingly recognized all over the world and a variety of preventive and curative methods have been discovered and developed during the last century. The discovery of fungicides in the form of seed steeps, spray fluids and dusts, marks a distinct advance in agricultural science. But such *direct* methods of disease control are at best palliatives of a temporary nature that their limitations are sufficiently patent to the farmer as well as to the student of agriculture. Such methods are, moreover, found to be practicable and economical in so few cases that their successful application is bound to be restricted to a limited number of crop diseases even in the most agriculturally developed countries.

Growing demand for disease resistant stock.—The utilization of natural resistance as an indirect means of fighting pests and diseases is rapidly gaining popularity in the field of agricultural science. Consequently, plant pathologists all over the world are directing their efforts to exploit this avenue as the surest and, in the long run, the cheapest method of disease control. As instances of the achievements of scientists in producing plants resistant to diseases may be mentioned, blight-resistant potatoes, rust-resistant wheats, wilt-proof cottons, mosaic-free sugarcanes, canker-resistant apples, mildew-resistant roses, wilt-free melons, leaf-disease-resistant coffees, etc. These and several other achievements in this line have created an ever-growing demand for breeding crop plants which possess the natural resistance against almost every conceivable kind of disease.

The technique of breeding for disease resistance.—The breeding of crop plants for disease resistance is a brilliant example of team work among specialists in different branches of agricultural science. The agricultural economist leads the way by stipulating the desirable qualities in a plant which find favour with the farmer from the latter's economic point of view. With the acquisition of this valuable knowledge, the pathologist studies the diseases pertaining to the crop, the factors favouring their development, the relative degree of resistance among varieties and the specific characters which govern resistance. The plant breeder in his turn steps in either to select and propagate existing varieties which satisfy the demands of the economist and the pathologist or to evolve new strains in which the desirable characters of one or more varieties are blended.

Methods of evaluating disease resistance.—An important item in the pathologist's duties is the imposition of a rigorous test on the available

varieties and strains and to award them correct locations in a scale of disease resistance. Inoculations of plants with parasitic organisms which are so common a practice in pathological investigations are sometimes used for this purpose. But, often they are of very limited value for the purpose inasmuch as the host plants are perforce raised under artificial conditions and the method is therefore unreliable in correctly adjudging the relative resistance of a number of varieties. An attempt was made at Coimbatore to devise a practical and at the same time reliable means of determining disease resistance among varieties on a relative scale and in this article is described the method designed and developed for the purpose and successfully employed in the case of three important diseases, viz., 'Blast' (*Piricularia oryzae*) of paddy, 'Mosaic' (virus disease) of sugarcane and 'Wilt' (*Rhizoctonia bataticola*) of groundnuts.

The principles underlying the method.—The broad principles to be observed in formulating a method of resistance determination among a number of varieties are :—

(1) Growing of varieties and strains under natural conditions and under identical environment, viz., soil, climate, cultivation, manuring, water supply, etc.

(2) Provision of identical facilities to all varieties for exposure to infection and natural development of the disease.

(3) Growing of a sufficiently large number of individuals in each variety to obviate inevitable errors of observation made on a few individuals.

(4) A close study of an equal number of individuals in a variety and a correct estimation of the incidence of disease.

(5) Evaluation of the extent of disease and the loss due to it among the several varieties under trial.

Lay-out of varieties and the methods of observation.—The details of the lay-out employed for each crop and the methods of observation are outlined in the following paragraphs.

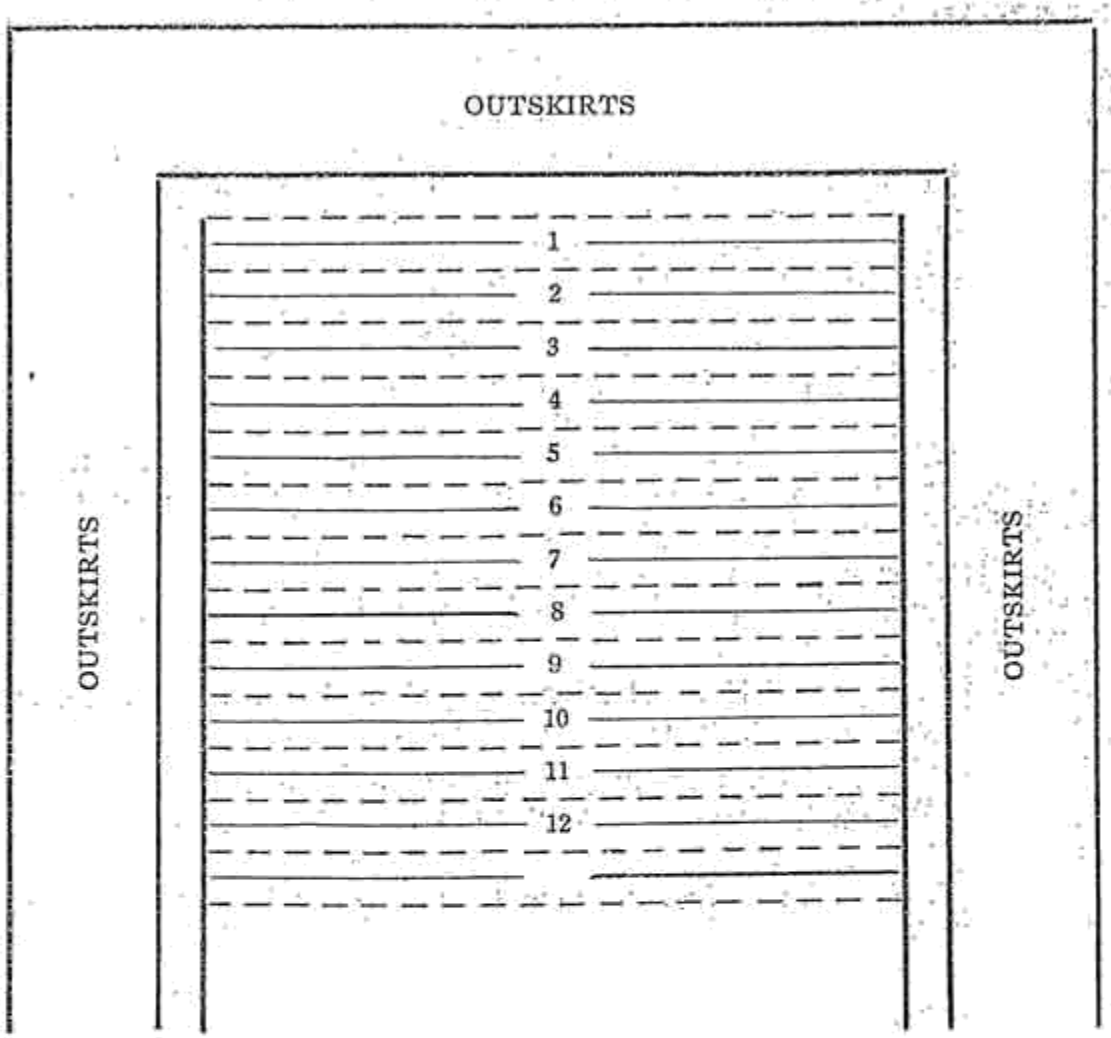
I

Crop.—PADDY. (IRRIGATED) *Disease.*—'BLAST.'

Cultivation of Paddy.—Seedlings are raised from seed in nurseries under swampy conditions. Transplanted in land ploughed and puddled under swampy conditions after remaining 5 to 6 weeks in the nursery. Crop matures in 5 to 6 months.

Nature of the disease.—Caused by a fungus (*Piricularia oryzae*). The fungus forms leafspots and rotten necks and nodes which bear myriads of spores. Spores are spread by wind and rain from plant to plant. Affected plants either dry up completely or produce chaffy ears ; in the latter case the amount of chaff is proportionate to the intensity of the attack on the necks, nodes and ears.

The lay-out of the field was as in the accompanying plan



———— Varieties under resistance test.

— — — — — *Korangu Samba rows.*

No. of varieties	...	...	12
Length of varietal row	...	...	30 ft.
Distance between adjacent rows		...	1 ft.
Distance between seedlings in a row		...	9 inches.
Number of seedlings per row	...	...	41
Area occupied by each series	...	...	24 ft. × 30 ft.
Nnmber of replications	...	...	4

Outskirts bulk-planted with *Korangu Samba.*

Seedlings of the varieties for trial are raised in special nursery strips from pure seed (pure line selections). Healthy seedlings of uniform growth are transplanted in a series in parallel equidistant rows 30 feet long, each row representing a variety as in the plan. The distance between two adjacent varietal rows was two feet and that between seedlings in a row 9 inches. Every varietal row was alternated by a row of *Korangu Samba*, a variety known to be highly susceptible to Blast disease. The series (of

12 varieties) was replicated four times, so that the four series (including the alternate rows of Korangu Samba) occupied a rectangular area 96 feet by 30 feet. Leaving a path two feet wide on all sides, the outskirts of the block was bulk-planted with *Korangu Samba*, so that once the *Korangu Samba* outskirts and from them the *Korangu Samba* rows have taken the infection, the varietal rows which are surrounded by this susceptible variety on all sides will have equal opportunities of spore infection.

Methods of observation and recording of results.—Each varietal row is harvested as soon as the grains are ripe and all the tillers in a row are individually examined and classified as 'healthy' or 'infected' according to the presence of fungus attack on the nodes, neck and panicle, the latter class being again sub-classified as 'lightly infected' or 'heavily infected' according to the extent to which grain development suffers. The crop from each row is separately threshed, the grain and chaff separated by water, dried, and the percentage of chaff determined by volume.

The results are recorded in the tabular form given below :—

Number	Series	Variety	Duration (in days)	No. of plants	No. of tillers	No. of infected tillers	Percentage	No. of heavily infected tillers	Percentage	Yield (by volume)	Grain (by volume)	Chaff (by volume)	Percentage of chaff	Remarks

The order of resistance is determined with reference to the percentage of heavily infected tillers and the percentage of chaff.

II

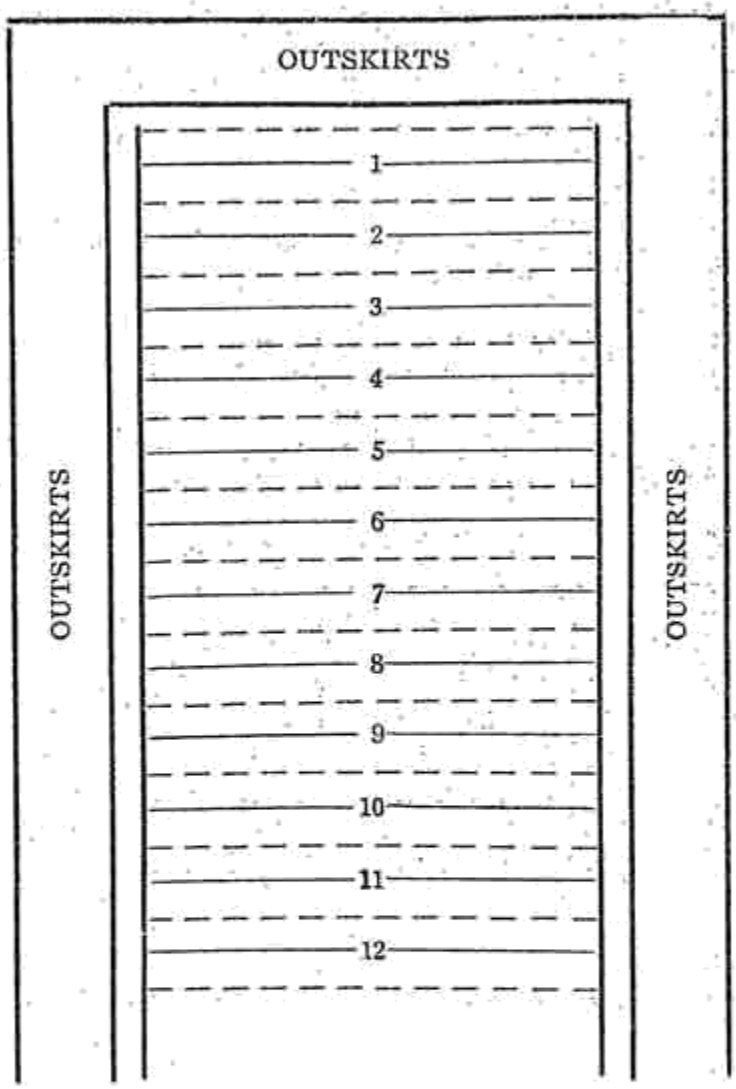
Crop.—SUGARCANE. *Disease.*—'MOSAIC.'

Cultivation of sugarcane.—Plants are raised from setts (cuttings of the cane) which are buried flat in the soil and irrigated. The latent buds develop into seedlings which in their turn produce several tillers. The crop matures in 10 to 12 months.

Nature of the disease.—The disease is caused by a virus which is transmitted through diseased setts and from infected plants to healthy ones by an insect agency[1]. Infection extends for a period of five months between the third and eighth months of the crop. Infected plants show a peculiar mottling of the leaves which produces a mosaic pattern on the leaves and sometimes on the lowest internodes of the cane. Infection is judged by the eye, the surest test for infection being the examination of the spindle or the unfolding central leaf. The disease invariably occurs in plants raised from infected setts.

[1] The exact insect vector which carries mosaic infection in Coimbatore has not been determined. The burden of evidence, however, is in favour of *Aphis maidis* which is known to transmit the disease in other countries.

The plan of experiment to determine relative resistance among sugarcane varieties is given below :—



— — — — — Rows of infected Red Mauritius.

———— Varieties under resistance test.

Distance between adjacent rows ...	2½ feet.
Distance between plants in a row ...	1 foot.
Number of clumps in a row	31
Number of varieties tested	24
Area occupied by a series	60 feet × 30 feet.
Number of replications	2

Outskirts bulk planted with diseased setts of *Red Mauritius*.

The plan of the experiment is very much as in the case of Blast disease of paddy. But instead of planting the outskirts and the alternate rows with a potentially susceptible variety, they were planted up with infected acne setts which invariably produce diseased seedlings. The varietal rows

are raised from selected healthy setts which give rise to healthy seedlings but the disease gradually spreads to them from the outskirts and from the diseased rows alternating them (1). Chardon and Veve (2) have described a method by which insect transmission of cane mosaic was carried out by planting diseased and healthy setts alternately within a field cage. But that method is obviously impracticable for a comparative test of several varieties. Kunkel (3) used a similar method but without the use of a cage, for determining the loss caused by mosaic on commercial canes. The writer had no access to either of these when the present method was originally tried and considers that the Coimbatore method is better adapted for the purpose of determining disease resistance when a number of varieties are concerned.

Methods of observation and recording of results.—Fortnightly observations are made of each varietal row and the number of healthy and infected canes in them noted. The final figures are recorded in the tabular form below:—

No.	Series	Variety	No. of clumps per row	No. of infected clumps	Percentage of infected clumps	Effect of the disease on the crop	Remarks

The order of resistance is determined by the percentage of infection among the varieties.

III

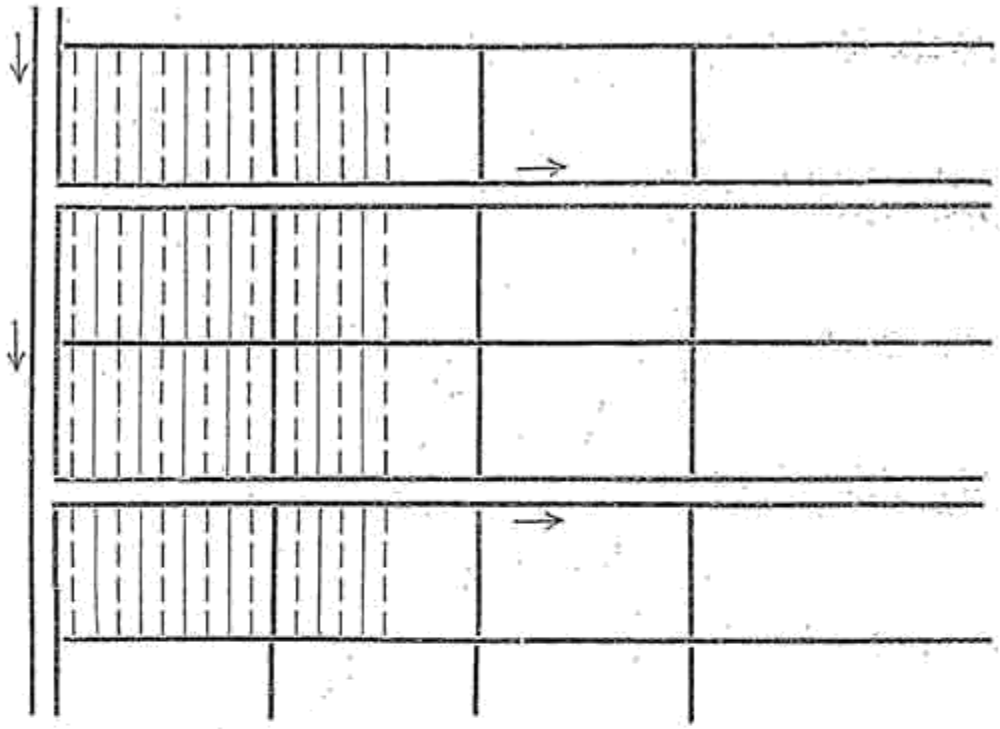
Crop.—GROUNDNUTS (IRRIGATED). *Disease.*—'WILT.'

(*Macrophomina phaseoli* = *R. bataticola*).

Cultivation of Groundnuts.—The crop is raised in rectangular beds 8 feet by 6 feet which are irrigated through channels running between alternate rows of beds. There are two distinct types of plants, viz. (1) the spreading type, and (2) the erect or bunchy type.

Nature of the disease.—The disease is caused by a fungus which produces Sclerotia in the soil and on the underground portions of infected plants. Infected plants either wilt completely or the pods (which are borne underground) are attacked and their development stiffled. In the former case, Sclerotia are formed on the roots and collar of wilted plants and in the latter on the pods.

The lay-out of the field is done in a previously infected field as in the plan below :—



——— Varieties under resistance test.

— — — — Rows of an erect variety (*Gudiatam bunch*).

Size of beds	...	8 ft. × 6 ft.
Length of rows	...	24 ft.
Distance between rows	...	1 foot.
Distance between plants in a row	...	9 inches.
Number of replications	...	4

⟶ Direction of irrigation water.

The varieties for trial are planted in rows which run through the beds but alternate rows are planted up with a bunch variety (non-experimental) with a view to prevent the interlocking of the plants and the consequent mixture of the pods when two spreading varieties are planted side by side. The rows adjacent to the margins of ridges and channels are also planted up with the same bunch variety and treated as non-experimental outskirts.

Methods of observation and recording of results.—Soon after germination a record is taken of the number of plants per row. The wilted plants are periodically noted and marked. As the crop matures the varietal rows are separately harvested. the pods individually examined and classified as infected or free.

The results are recorded in the tabular form below :—

No.	Series	Variety	No. of plants per row	No. of wilted plants	Percentage	Total number of pods	Number of infected pods	Percentage	Remarks

The order of resistance is determined with reference to the percentage of completely wilted plants and the percentage of infected pods.

It will be found from the above notes that while the broad principles underlying the trial of different varieties are essentially the same in all cases, suitable modifications are necessary in the lay-out of the fields to suit the differences in the methods of cultivation and the nature of the disease. When several replications are made, the order of planting the varieties may be randomized in order to minimise errors which may arise from differences in soil conditions.

Possibilities of extension in the application of the method.—The method outlined in the foregoing paragraphs appears to be suitable for evaluating disease resistance in all crop plants which are prolific in varieties. While the writer's experience is confined to three annual crops, it is presumed that this method is admirably suited for gauging resistance among varieties not only of annual crops but also of perennial crops like Coffee, Coconuts, Tea, Mangoes, Apples, Cinchona, etc., where there is the obvious advantage of carrying out observations through several years and under different conditions of rainfall, humidity, temperature, etc. With suitable modifications, the method promises to be useful not only for diseases caused by fungi, bacteria and viruses but also for diseases and pests caused by protozoa, insects, nematodes, mites, etc.

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