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Manures and their effects on incidence of diseases in crops

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Manures are applied to provide nutrients to crop plants. Proper nutrition is necessary for the normal growth and reproduction of plants. It is recognised that malnutrition or deficiencies in the nutrients lead to several diseases in men and cattle. Plants are also similarly affected by unbalanced manuring or by the lack of one or more components of plant food. The effects may be directly visible as different types of 'hunger' signs (chiefly chloroses and reduced growth) exhibited by the crop, depending on the particular component in deficit. But these become evident only when the deficiency is pronounced. The influence may also be felt by the upsetting of the equilibrium of host—parasite relationship between the crop plants and disease-causing organisms. Consequently the intensity of incidence of diseases caused by parasites may be altered.

Balanced manuring results in well-nourished, robust plants. These are able to withstand the onset of diseases better than ill-nourished weak ones. Well-fed plants are able to outgrow the early set-back produced by initial infection while the underfed ones are not able to readily replace the affected parts or outgrow infection by quick and vigorous growth and as a result often succumb to diseases. This is mainly applicable to those varieties of crops which are not immune or highly susceptible to particular diseases, but which exhibit normally a certain amount of resistance. Even here there are exceptions. Obligate parasites like rusts and mildews infect robust plants more readily than the weaklings. The more healthy the hosts, the more do the mildews prosper. *Septoria apii* causing blight of celery occurs generally on well-fed crops. But the majority of other parasites however, are able to infect undernourished plants much more readily. Some diseases like smuts are not appreciably influenced by the manure applied.

In scientific literature a distinction is made between manures and fertilizers. The former consist of those materials which predominantly supply humus with lesser components of nitrogen, phosphorus and potassium, while the latter are those which mainly supply the three components mentioned above with little or no humus content. But in the present context the term has been used in a comprehensive manner, including both the organic and inorganic (mineral) types. The influence of manures on the incidence of crop diseases caused by parasites varies according to the disease, the crop and the proportion of the various ingredients, so that no sweeping generalisation is possible. However, reliable results have been otained in field and water-culture experiments with several crops in different parts of the world indicating the nature of reaction between particular components of the manures and the intensity of certain diseases, especially those affecting the foliage. An overall picture of these results is presented here.

Nitrogen occupies a significant place among the nutrients which markedly influence the disease disposition of the crop. It has been observed in several instances that more nitrogen leads to more disease. The experiments on the influence of graded doses of nitrogen either as ammonium sulphate or as groundnut cake to supply 40, 80 or 120 pounds of nitrogen per acre, on the incidence of blast disease of rice *(Piricularia oryzæ)* at Coimbatore, have clearly demonstrated over several seasons that the incidence of the disease increased in direct proportion to the dosage of nitrogen. This reaction was significant in moderately resistant and susceptible varieties. But in the highly resistant variety Co. 4 there was no increase in blast even with 120 lb. nitrogen per acre. Root rot of sugarcane caused by a species of *Pythium* was on the increase in a neighbouring ryot's land after a heavy application of ammonium sulphate. The increase in the intensity of root-rot of sugarcane caused by *Pythium arrhenomanes* following high doses of nitrogenous manures has been reported from Hawaii and the Philippines (Carpenter, 1934). Rust susceptibility of wheat is heightened by liberal applications of nitrogenous manures. Nitrogen favours the metabolism of the plant and protein content of the leaves increase. A parallel rise in rust susceptibility is also evident. But a generalisation like this is likely to be erroneous. In some varieties of wheat, susceptibility to certain races of rust is increased by increased nitrogen but decreased to other races. A similar behaviour was reported in the reaction of certain varieties of beans to bean rust. No simple explanation can be given for this differential reaction to varied nitrogen supply regarding susceptibility to rusts. At all levels of nitrogen tried, the immune varieties remained immune and highly susceptible ones highly susceptible. The alteration in the reaction was evident only in varieties of intermediate susceptibility. Susceptibility to late blight of potato is increased by large applications of nitrogenous manures. *Phytophthora infestans* utilises amino-acids as a source of energy. The increased nitrogen content of the plants consequent on high doses of nitrogenous manures provides a favourable substraate for the rapid development of the fungus and hence to increased infection. Resistance to bacterial storage rots in potato is also broken down when the plants had been manured with excess of ammonium sulphate or calcium cyanamide. Cralley (1939) carried out extensive field and pot-culture experiments to find out the effects of nutrition on the incidence of stem-rot of rice (*Sclerotium oryzae*). In culture solutions a high nitrogen content increased the susceptibility of the plants to the disease while with low nitrogen the susceptibibility was reduced to a minimum. Similar reactions were observed in the field also. Reyes (1929) and Nakata, (Padwick 1930) also observed that the nitrogenous fertilizers increased the intensity of the disease.

Verticillium wilt of tomatoes is encouraged by nitrogenous manuring. The cell sap rich in nitrogenous compounds favours quicker growth of the parasite while the fungus is unable to maintain itself when there is a shortage of nitrogen. Apple scab caused by *Venturia inæqualis* has been known to be aggravated by nitrogenous manuring. The incidence of the disease is considerably reduced by not applying nitrogen to the orchard. Though the disease is minimised by this method the size of the crop gets reduced. Evidence has been obtained to show that the juice of leaves of N – deficient trees is more toxic to the spores of the pathogen than the juice from the manured trees. The club root disease of cabbage *(Plasmodiophora brassicæ)* was increased either by excess or by lack of nitrogen.

Thus there is considerable evidence to show that more nitrogen encourages more disease. How this is brought about can be explained in certain diseases. Nitrogen favours rank vegetative growth. This produces a thick stand with increased humidity within the crop which is favourable for the reproduction and spread of the causal fungi. The maturation of the crop is delayed and the pathogens have more chances of infecting plants and causing higher incidence of disease. Rusts of cereals (e.g. black rust of wheat) in many cases affect the crop in maturing stages and if this phase is prolonged more infection will result. Further, the host tissues became soft and the protective cuticle remains thin. Under these conditions the fungus is able to infect the hosts more readily and cause more disease. In addition several fungi are able to infect and grow in tissues with a higher nitrogen content much more readily than in those with a lower content. Vasudeva (1930) has shown that *Botrytis allii* which is normally non-pathogenic to apples produced definite infection if supplied with nitrogenous substances. Heavy applications of nitrogen make the plants more vulnerable and also stimulate the growth of the pathogen. The nitrogen effect depends on the relative balance of potassium and phosphorus (Gaumann 1948).

There are a few instances however, of diseases which could be minimised by the application of nitrogenous manures. Beneficial results have been reported from the U. S. A. in the control of Texas root-rot of cotton caused by *Phymatotrichum omnivorum* by nitrogenous manuring. Leach and Davey (1942) have stated that the damage caused by *Sclerotium rolfsii* rot of sugarbeet in California was considerably reduced by the addition of nitrogenous fertilizers. Pea root rot due to *Aphanomyces entelichcs* has been retarded by the use of nitrate of soda or ammonium sulphate. Smith (1944) mentions the decrease of bacterial wilt of tobacco caused by *Pseudomonas solanacearum* in some of the states of the U.S.A. by the addition of nitrogenous fertilizers. Loest (1939) has reported that the dry root of oranges caused by *Diplodia natalensis* in South Africa was common under conditions of nitrogen starvation. Application of large amounts of nitrogen is recommended as one of the measures for controlling the disease. These instances serve to indicate how obscure the interactions to nutritional experiments may be even with components which have given the most consistent reaction.

The influence of phosphatic manures on the incidence of diseases has been varied. One of the effects of phosphate manuring is to accelerate maturation processes of the plants with the result that the crop may escape infection. The influence of phosphates depends to a large extent on the available nitrogen and potassium levels. When phosphorus is present in excess relative to potassium and nitrogen, resistance to diseases is heightened. Browning root-rot of wheat caused by *Pythium arrhenomanes* has been found to flourish in soils with a high nitrogen and low phosphorus content. Vanterpool (1940) has shown that the addition of phosphatic manures removes this unbalanced nutritional condition and controls the disease. A similar response is shown by sugarcane to infection by the root rot caused by species of *Pythium*. In the unbalanced nutritional condition the host tissues are not able to resist infection but with the addition of phosphates the parasites are not able to make any progress. Clump rot of cardamoms prevalent in some of the plantations in South India is caused by *Pythium vexans* and

P. aphanidermatum. The retults of experiments carried out at Singampatti have shown that applications of two to four ounces of superphosphate or ammonium phosphate per clump kept down the disease. Here again it appears to be a case of unbalanced nitrogen-phosphorus content of the soil which favoured the disease. There is evidence to show that phosphorus increased the resistance of wheat to brown rust *(Puccinia triticina)*.

Deficiency of phosphorus weakens the plants and renders them more susceptible to fungal parasites. But sometimes this weakening of the tissues has the opposite effect. The tissues become hyper sensitive to certain strains of rusts and die quickly. Thus the obligate parasite is not able to make further progress and the plants remain free from infection.

Increased incidence of disease has been associated with phosphate manuring in several instances. Wilt of redgram caused by *Fusarium udum* behaves in this manner. The rusults of manurial experiments conducted over several years at Pusa have shown that the incidence of wilt is significantly increased by the addition of phosphatic manures. Similar reaction was found in the case of cotton wilt *(Fusarium vasinfectum)* in America where the disease was increased in plots manured with acid phosphate. From the United States it was reported that the infection by flax rust, *Melampsora lini* was increased in plots receiving phosphates. The growth of the plants in phosphate manured plots was much more luxuriant and the incidence of rust was proportional to the luxuriance of the crop. The results of water-culture experiments have shown that phosphoric acid alone increased the susceptibility to rusts. Plentiful supply of phophorus increased the susceptibility to rusts. This effect may be large enough to nullify the rust-inhibiting effect of potassium. Hence in regard to rust infection, potassium and phosphorus are often antagonstic to each other. While investigating the effects of nutrition on the stem rot of rice Cralley (1934) found that phosphatic manures in general tended to increase the incidence of the disease. Nitrogen and phosphorus applied together resulted in heavier infection than when applied separately, though the yield of rice also was more from the combined applications. But when potash was also applied along with nitrogen and phosphorus (6 parts ammonium sulphate, 8 parts superphosphate and 24 parts of potassium sulphate) the severity of infection was low. It thus becomes evident that when ammoninm sulphate and phosphorus are applied to rice crops in localities where the stem rot is common (Tanjore and Krishna) the fertilizers have to be balanced by potash also.

Potash increases resistance to diseases in several crops. The results of extensive investigations carried out at various centres in the U. S. A. have clearly shown than that the wilt of cotton *(Fusarium vasinfectum)* is most severe in potash-deficient plots. Application of potash resulted in a marked decrease of this disease. It has been reported that in the permanent manurial plots at Rothamsted high incidence of rust of wheat was always in the potash-starved plots and least in those receiving potash manure.

Incidence of certain fungus diseases of tomato grown in glass-houses in England has been checked by potash manuring. Resistance to dry rot of potatoes *(Fusarium coerulum)* was fund to be highest in tubers from plants receiving excess of potash and lowest in those from plants deprived of potash. The leaf disease of coconuts at Pilicode (Malabar) with which *Gliocladium roseum* is associated is found to be greatly reduced by potash manuring. Potash manuring is sometimes recommended as one of the methods of reducing damage caused by various parasitic fungi. Potash hardens the tissues by intensifying the cell-wall development and this is correlated with increased resistance to infection by fungi. Further the plants mature early and escape infection. The action of potassium is generally opposite to the nitrogen effect. In some instances it is able to counteract the effects of excess of nitrogen. But in others it has been found that the increased susceptibility of plants brought about by excess of nitrogen cannot be fully counteracted by any amount of potash.

There are a few intances however of the adverse effects of potash manuring on the incidence of diseases. Club root of turnips *(Pasmodiophora brassicæ)* was in some varieties found to be more in plots where potassium was in excess and lack of potash greatly reduced it. In comparing the effects of N., P and K separately and in diffent combinations it was observed that potato leaf roll was markedly higher in plots where K was applied. Among the various combinations the incidence was highest in N K plots and lowest in the K P plots.

Of the other mineral nutrients the influence of lime on disease disposition has been investigated in some instances. Calcium exerts its influence directly on the plant and indirectly by amending the reaction of the soil. Increase in calcium enhances resistance to spread of infection by bringing about the hardening of the tissues especially the cell wall. The root rot of groundnut prevalent in irrigated crops and caused by *Macrophomina phaseoli* is often minimised by application of lime. Club root of cabbage *(Plasmodiophora brassicæ)* is common on acid soils. Amendment of the soil reaction by heavy applications of fresh burnt lime (2 to 3 tons per acre) eight to twelve months in advance of planting time is the accepted method of combating the disease.

Some diseases are however favoured by addition of lime to the soil. Root disease of flax caused by *Phythium megalacanthum* increased with excess of calcium, in Holland. In Australia infection by flag smut of wheat *(Urocystis tritici)* was enhanced by the addition of calcium (Millikan 1939). There was correlation between the calcium content of the plant and reaction to the smut.

Silica has been reported to increase the resistance of rice to blast *(Piricularia oryzæ)* and blight *(Helminthosporium oryzæ)*. Addition of silicic acid resulted in the increased silicification of the cell walls in the leaf and stem. In water culture experiments Yoshi (1941) was able to note that with increasing amounts of silicic acids to the solution, the resistance of rice leaves to blast was increased. Susceptibility to blast was inversely proportional to the silica content of the leaves. A similar response was noticed in wheat plants to infection by *Erysiphe graminis* when silica was added. The resistance to powdery mildew was heightened by the silica.

Among the other minor elements the addition of zinc to soils has been found to have different effects on different diseases. Millikan (1938) found in Australia that the disease of wheat caused by root rotting fungi like *Helminthosporium sativum*, *Curvularia ramosa* and *Fusarium culmorum* could be minimised to a great extent by the application of 15 to 30 pounds of zinc sulphate per acre to the soil. The action of this substance was not so much on the host plant but in affecting the sporulation of these soil fungi. Spore formation was also found to be inhibited when the substance was added to the cultures of the fungi. Lack of sporulation must have resulted in minimising infection. Zinc nitrate caused heightened susceptibility of wheat to rust (yellow) and mildew (Spinks, 1913).

Addition of lithium has been found to have a marked influence in increasing resistance to rust. Watering the plants with dilute solutions of lithium chloride enhanced the resistance of wheat seedlings to brown rust. Resistance to powdery mildew of wheat also followed a similar trend. Seedlings of *Phaseolus vulgaris* were able to resist infection by *Botrytis cinerea* when lithium chloride was added to the soil. In localities where there is boron deficiency the susceptibility of sunflower to *Erysiphe cichoracearum* is found to be increased. Increased susceptibility of wheat to *Septoria nodorum* is reported to be a concomitant of magnesium deficiency.

The role of the trace elements may be in improving the conditions of the host plants or in the inhibition of soil pathogens. There is some evidence to show that lithium and molybdenum inhibit sporulation of *Fusarium vasinfectum* (Sadasivan 1951). In some instances the multiplication of saprophytes is stimulated. How far this knowledge can be utilised for soil amendment with these substances for the control of soil-borne diseases caused by *Fusarium* and similar fungi is a problem for future investigations.

The other types of manures to be examined are the organic manures. These have been considered as the 'life of the soil'. Besides improving the texture and adding to the fertility of the soil these manures have been reported to profoundly influence the incidence of diseases. Apostles of the 'humus' school go the extent of firmly believing that application of organic matter to the soil in the form of farmyard manure or composts will keep off all diseases. They denounce the use of mineral fertilizers and attribute the incidence of diseases of crops to the continued use of these fertilizers. In support of their view they point to the virgin forests which grow in soils rich in humus and in which diseases are alleged to be absent. The latter supposition is not correct for diseases are found in forest trees also. But owing to the mixed type of the population the occurrence of disease is not as clearly apparent as in the case of 'one plant' cultivated crops.

It is contended that when organic matter is present in sufficient quantities in the soil the development of mycorrhiza is encouraged. These fungal growths form sheaths to the finer root ends and thus help to increase the surface area of the roots. Further they help in the greater absorption of nutrients from the soil and small quantities of growth-promoting substances are also reported to be absorbed by the plants from the mycorrhiza. Howard is of the firm opinion that if proper mycorrhizal connections are established the growth of the plants would be very vigorous and plant diseases would disappear. Leaving aside this extreme view, evidence is forthcoming to show that organic manures do help in keeping down some soil-borne diseases. It is attributed not so much to the mycorrhizal development in all cases as to the encouragement of the multiplication of numerous saprophytic organisms by the presence of the organic matter. These organisms by competition and by biological antagonism lead to reduction and gradual disappearance of the pathogens from the soil.

It has been demonstrated that perfect control of the cotton root-rot (*Phymatotrichum omnivorum*) can be achieved by heavy applications (15 to 30 tons per acre) of farmyard manure or alfalfa hay. Certain root diseases caused by *Fomes* are common in light soils, especially when the organic content is low. By the addition of heavy doses of organic manures the incidence of such diseases have been brought down. But the addition of organic manures has not been always of unmixed benefit. Experiments conducted over a number of years at Pusa have shown clearly that applications of farmyard manure always resulted in increasing the wilt disease of red gram (*Fusarium udum*). Diseases caused by *Rosellinia* are more in evidence when the organic matter content of the soil is high. These instances are against the opinion of the humus school.

But addition of organic matter in the form of green manures have given consistently favourable results in controlling a number of diseases caused by soil-borne pathogens. Red gram wilt (*Fusarium udum*) is significantly reduced when sunnhemp (*Crotalaria juncea*) is ploughed in as green manure. Fulton (1907) has stated that ploughing under of cowpeas and other leguminous crops decreased the amount of wilt of cotton (*F. vasinfectum*). Potato scab caused by (*Actinomyces scabies*) has been reported to be controlled successfully by liberal dressings of green manures in small holdings. (But in some field-scale trials green manuring has not been so successful owing to the fact that the mixture of soil and green manure had not been so homogenous). This procedure encouraged the development of saprophytic forms of *Actinomyces* which swamped out the pathogenic species. Even powdery scab caused by *Sponogspora subterranea* common in lighter soils has been known to be checked by incorporating green manures. Thus green manures have been uniformly useful in reducing incidence of soil-borne diseases.

Thus enough evidence has accumulated to show that different diseases respond differently to the changes in the nutrition of the host, so that sweeping generalisations are out of the question. Many of the reactions are not easly explained. It can be seen that in many instances heavy doses of nitrogen increase disease. This is seen in diseases caused by airborne infection on foliage as well as in soil-borne diseases affecting roots Potash invariably increases resistance. Phosphates are useful for reducing the alkalinity of the soil and for the control of diseases flourishing under alkaline reactions (*Pythium* root-rot). But in many other instances the results obtained from phosphatic manures have been conflicting. When the same manure decreases the incidence of a disease and directly increases yield it can be safely recommended as a useful measure of control e. g. green manuring. But when the manures that are used increase the incidence of disease and also lead to high yield other methods of combating diseases have to be sought. Nitrogenous manures increase scab of apples and also the yield. On this account application of nitrogen cannot be stopped. Other methods of control like spraying with fungicides will have to be resorted to. It is better to have a heavier crop with some disease rather than a poor crop with no disease. Balanced manuring has to be followed to improve the vigour and growth of plants so that they may be able to stand the strain of the incidence of disease if it occurs and at the same time produce a remunerative crop.

REFERENCES.

Butler, E. J. & Jones, S. G.	(1949)	Plant Pathology. MacMillan & Co., London, 172–180.
Carpenter, C. W.	(1934)	Hawaiian Planter's Record, *38*, 279–338.
Cralley, E. M.,	(1939)	Rev. App. Myc. *18*, 815.
Garret, S. D.	(1944)	Root disease fungi., Chronica Botanica, Waltham.
Gaumann,	(1950)	Principles of Plant Infection. Eng. Ed. by W. B. Brierly, London.
Howard, A.	(1950)	An Agricultural Testament. Oxford University Press, London.
Leach, L. D. & Davey, A. E.	(1942)	*Journ. Agric. Res. 64*, 1–18.
Kelley, A. P.	(1950)	Mycotrophy in Plants. Chronica Botanica. Waltham.
Millikan, C. R.	(1938)	*Journ. Dept. Agric.* Vict. *37*, 302–8.
,, ,,	(1939)	*Journ. Dept. Agric.* Vict. *37*, 302–8.
Padwick, G. W.,	(1950)	Manual of Rice Diseases, C. M. I. 53.
Reyes, G. M.	(1929)	Philipp. Agri. Res. *22*, 313–31.
Sadasivan, T. S.	(1951)	*Proc. Indian Acad. Sci. 33.*
Smith, T. E.	(1944)	U. S. *Dept. Agric. Circular*, 692.
Spinks, G. T.	(1913)	*Journ. Agric. Sci. 5*, 231.
Suzuki, H.	(1935)	J. Coll. Agri. Tokyo, *13*, 235–321.
Vanterpool, T. C.	(1940)	*Sci. Agri. 20*, 735–749.
Vasudeva, R. S.	(1930)	*Ann. Bot. 44*, 469–493.
Yoshii, H.	(1941)	*Rev. Appl. Myc. 21*, 159–160 (1942).