

GENERAL.

THE EFFECT OF GRASS ON TREES.

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I. INTRODUCTION.

Although trees flourish generally when surrounded by communities of grasses and herbs, cases have been known to occur in which grass is able to suppress certain species of trees. One such example is that investigated by Bedford and Pickering at the Woburn Experiment Station where it was found that fruit trees such as apples, pears, plums and cherries failed to flourish under grass on a heavy clay soil. Forest trees are better able to resist the effect of grass than fruit trees. Thus in the tropics, grass-land after enclosure becomes covered by shrubs and trees with remarkable rapidity.

The injurious effect of grass on trees was attributed by Bedford and Pickering to a soil toxin produced by the growth of grass and which acted as a poison towards the roots of trees. This soil toxin has never been isolated. It was found to disappear in a very short time when the drainage water containing it was aerated, and was not observed on permeable, well-aerated soils. The problem therefore needed further investigation. Since 1914 the influence of grass on trees has been the subject of investigation at the Pusa Research Institute. Two problems have been kept in view, namely, (1) why grass is so injurious to fruit trees; (2) the nature of the weapons by which forest trees vanquish grass.

(1) *The factors.*—Pusa is situated on the old alluvium of the Gangetic plain. The soil is a highly calcareous, silt-like loam. There is no line of demarcation between soil and sub-soil. The percentage of Calcium Carbonate is over 30. The phosphate content is below the average. Nitrogen shortage is rectified by the addition of organic matter. The water level is 20 feet below the surface. The average rainfall is 47.5 in., most of which falls during the monsoon period (June 15th to October 15th). The temperatures of air and soil begin to rise from about the middle of February till the end of May.

(2) *Growth of Trees and Grass at Pusa.*—In the case of trees flowering the production of new leaves and shoots takes place during the hot season (March to May). The growth of grass corresponds, with one exception, to the growth of trees. In the hot dry months of March, April and May, grasses cease to grow when there is no competition between the grass and trees.

(3) *The Experimental Fruit Plot.*—In 1914, eight species of fruit trees were planted out in three acres of uniform land. Twenty-four trees of each kind, raised from a single parent were set out 20 feet apart each way. The trees

were:—1. Plum, 2. Peach, 3. Custard apple, 4. Guava, 5. Mango, 6. Litchi, 7. Sour lime, 8. Loquat. Two years after planting (1916) when the trees were fully established, a strip about the middle of the plot comprising nine trees of each of the eight species was laid down to grass—*Cynodon dactylon*. The two end plots served as controls.

In 1917, three years after planting, when the grass was well established and its injurious effects on the young trees was clearly marked, the three southern trees of the grass plot were provided with aeration trenches, 18 inches wide and 24 inches deep, filled with broken bricks. Three trenches were made at equal distances between the lines of trees. In 1921 to ascertain the effect of grass on established trees in full bearing, the southern strip of the northern control plot was grassed over and has been so since.

The harmful effect of grass on fruit trees at Pusa was found to be more intense than on clay soils like those of Woburn in Great Britain. Several species were destroyed altogether within a few years. As great differences in root development were observed between the trees under grass, under grass with aeration trenches, and under clean cultivation, the first step in investigating the causes of the harmful effect of grass was a study of the root-system (under clean cultivation) and correlation of this with the growth of the above-ground portion of the trees. Detailed work was carried out in 1921 and was repeated in 1922 and 1923.

II. THE ROOT SYSTEMS OF FRUIT TREES UNDER CLEAN CULTIVATION.

The root systems of three deciduous trees, the plum, peach and custard apple were studied.

The plum has a two-root system firstly the superficial and consisting of large, freely branching roots running more or less parallel to the surface in the upper 18 inches of soil. From the under side smaller members are given off which grow vertically downwards to just above the water-table. During the hot period root absorption is confined entirely to the deeper layers of soil. In heavy monsoonic weather only the surface roots are active.

The root system of the Peach is similar to that of the Plum.

The Custard apple flowers in early April and the fruit ripens in August and September. The root system is similar to that of the plum and the peach.

The root systems of the Mango, Guava and Litchi—ever-greens—resemble in many respects those of the three deciduous species already described. The large superficial roots give off smaller branches to the deep soil layers which maintain the growth in hot season. The early rains bring the surface roots into action.

In the Guava the reddish roots are very strongly developed. There is an abundant superficial system which gives off numerous branches which grow vertically downwards. As in the plum, peach and custard apple the whole of the root system was found to be active at the beginning of the hot weather. Irrigation during hot weather is a decided advantage.

New growth of the Litchi begins in December, flowering takes place in February and the fruit ripens in May. As in the mango, the extensive

superficial roots give off branches which pass down into the deep soil layers. The deep root system, however, is not so strongly developed as in the mango, hence it is grown where the ground water is comparatively near the surface.

The root system of the Lime is similar to that of the Litchi.

The Loquat flowers twice a year, first in August and again in January and February. Only the latter flowers set fruit. The loquat has two root systems and the periodicity of root activity closely resembles that of the Mango.

III. THE INJURIOUS EFFECT OF GRASS ON FRUIT TREES.

This varies with the species and with the period of life of the trees when grass was planted. Young trees are more adversely affected than fully developed individuals. Deciduous species suffer more than evergreens.

(1) *The Effect of Grass on Young Trees.*—The custard apple is the most sensitive of the young trees studied. The trees were killed within two years after the grass was planted. Next in order of susceptibility were the loquat, plum and the lime, all of which were killed by grass. The peach, litchi, mango and guava are the most resistant. In addition to restricting the amount of growth, grass affects the leaves, branches, old wood and fruit, as well as the root system. The foliage produced under grass appear smaller, yellower and fall prematurely. The trees under grass flower late and sparingly. The fruit is small, tough, very highly coloured and ripens earlier than usual.

The effect of grass, except in the guava, on the superficial system is to restrict greatly the total amount of root development, to force the roots downwards below the grass, and to reduce the amount of active rootlets during the monsoon.

The grass has no appreciable effect on (either) the development or the activity of the deep roots.

Grass not only affects the roots underneath, but also the development of those of the neighbouring trees under cultivation. Such roots either turn away from the grass, or else turn sharply downwards before they reach it.

Two conclusions can be drawn from a study of the root system.—(1) Trees under grass are able to form the deep root-system and to make use of the moisture and minerals in the lower soil layers as in case of trees under clean cultivation. (2) In the second place, trees under grass (except in the case of the guava) form a very weak superficial system and produce but few active rootlets in the surface soil. The contrast between the trees under cultivation in this respect is very striking and significant.

The Effect of Grass on Established Trees.—The damage is less than in the case of young trees but the order of susceptibility is very much the same. At first the grass grew poorly, but with the rains a carpet was formed, and the effect became more marked.

Similar effects were observed as in the case of young trees under grass, viz., a greatly restricted development of absorbing roots on the surface

system compared with the controls. There were no differences in the dormancy or activity of the deep root-system.

The Effect of Aeration Trenches on Young Trees under Grass.—There was no effect on the custard apple or lime, both of which died. The aeration trenches markedly increased growth in the litchi and the mango. The root-system showed superficial roots much larger and better developed than those under grass, except in the guava where no difference in size could be detected. The roots were attracted towards the trenches. The trenches develop the deep-root system, as is to be expected. Even the temporary removal of the grass leads to a profound effect, viz., an immediate increase in growth, accompanied by the formation of larger and darker coloured leaves.

The experiments showed—

- (1) The extremely deleterious effect of grass on young trees.
- (2) The less harmful effect of the same treatment on mature trees.
- (3) The partial recovery which resulted from the aeration trenches particularly in the case of loquat, mango and litchi.
- (4) The failure of the aeration trenches to save plums, limes and custard apples.
- (5) The exceptional nature of the results with the guava, where the trees were able to grow under grass, but with reduced vigour and where the aeration trenches had little or no effect.

IV THE CAUSE OF THE HARMFUL EFFECT OF GRASS.

A study of the root-system showed— (1) the grass affected the superficial system only and had little or no effect on the deep roots. Only in the guava, which is the least susceptible to grass, was anything like a normal superficial system developed. The general effect of grass was to check the growth of the surface roots and to reduce greatly the number of active rootlets.

(2) The various root systems exhibited a remarkable reaction to improved aeration.

(3) As soon as the surface system become active in the early rains, there was a marked increase in the growth of the leaves and shoots. This was a period of active nitrification. A similar, but far less pronounced increase took place in the trees under grass. Grass was harmful in two ways (1) by restricting aeration of the surface roots in the monsoon, (2) reducing the supply of combined nitrogen.

The effect of two other factors—soil temperature and soil moisture—which may possibly have operated were examined, but gave negative results.

The advantage to the trees of the increased aeration provided by the trenches suggested that an examination be made of the soil gases. Determinations of the amounts of Carbon dioxide in the soil air at a depth of from 9 to 12 inches were carried out during 1919 under grass, under grass with aeration trenches and under cultivated soil.

It was found that the grass increased the amount of Carbon dioxide in the soil air and particularly during the rains, at a time when the superficial root system was most active. The trenches improved the aeration. The

presence of Carbon dioxide, and not the diminished oxygen supply, was therefore the harmful factor. During the monsoon the volume of Carbon dioxide in the pore spaces under grass was increased about five-fold in comparison with the soil air of cultivated land. Carbon dioxide being far more soluble in water than oxygen, it is probable that the root-hairs are actually subjected to a very much higher percentage of Carbon dioxide. This is but one factor of several which might cause the harmful effect on the fruit trees. Apart from this the presence of grass is bound to influence the supply of food materials. On analysis of the nitric nitrogen in the top 18 inches of soil, it was found that the combined nitrogen was defective. The grass carpet does reduce very considerably the amount of nitric nitrogen. This in land under grass was found to be only 10 to 20% of that in clean cultivated land. The second effect of grass on fruit trees therefore was the diminishing of available nitric nitrogen in the soil.

A third possible reason for the harmful effect of grass on fruit trees was the presence of a soil toxin produced by the grass. An experiment was tried with the guava—the roots of which could withstand large quantities of Carbon dioxide in the soil air—to ascertain whether the harmful effect of the grass was due to a soil toxin. The defect due to the nitric nitrogen factor was eliminated by the addition of sulphate of ammonia at the rate of 10 cwt. to an acre. The response was immediate—the leaves increased in size, the internodes lengthened and the colour of the foliage deepened in tone. This proved that no soil toxin was formed, but that in the guava the harmful effect of grass was due to its interference with the supply of combined nitrogen.

In the case of the litchi and the loquat the roots of which are unable to aerate themselves during the rains, the harmful effect remained even after the addition of nitrate of soda at the rate of 900 lb. per acre.

The harmful effect of grass on fruit trees seemed to be due therefore to two causes, both of which were related to the aeration of the soil. (1) The direct effect due to accumulation of large quantities of Carbon dioxide in soil; (2) the greatly diminished supply of combined nitrogen—one of the consequences of the long continued growth of grass.

V. FOREST TREES AND GRASS.

The relations between grass and a number of common Indian Forest trees were under observation at Pusa for the last three years, and an attempt was made to ascertain the nature of the weapons by which these trees were not only able to thrive under grass but to vanquish the grass in free competition.

The trees flower and come into new leaf in the hot weather, but a distinct visible change is noticeable in the colour and appearance of the foliage after the first rains. A study of the root system showed:—(1) that the superficial roots functioned in wet weather, (2) abundant active, normally developed rootlets in the upper two or three inches of soil which competed successfully with grass for minerals and oxygen, (3) that the deep root system functioned in the dry weather.

The chief weapons of forest trees to oust grasses and herbs are therefore (1) the deep root system which admits of growth during the dry

season when the grass is dormant and enables the trees to utilise moisture and food materials in the soil down to at least 20 feet: (2) The habit of the trees—a great advantage in the struggle for light. (3) The active roots of the surface system which are resistant to poor soil aeration and are able to successfully compete with grass for oxygen and minerals

The surface roots of forest trees resist the harmful effects of the atmosphere of Carbon dioxide, unlike those of fruit trees.

SUMMARY.

Experiments carried out at Pusa since 1914 by A. Howard to test the effect of grass on fruit trees have demonstrated the following:—

(1) That grass is injurious to fruit trees, several species of the latter being killed as a result of establishing a cover of grass on an area of young fruit trees, some of the species being more susceptible than others.

(2) Young trees are more susceptible to the harmful effects of the grass than those fully established.

(3) Aeration trenches in the case of some of the species render the effect of the grass less injurious.

The causes of the harmful effect of grass were ascertained by (1) a study of the root systems of the different species under clean cultivation, under grass, and under grass with aeration trenches; (2) the analysis of the soil air, (3) manurial experiments.

This harmful effect has been ascribed to the following causes:—

(1) The accumulation of large quantities of Carbon dioxide in soil under grass.

(2) The greatly diminished supply of combined nitrogen.

The injurious effect of grass is not due to the presence of soil toxins. Forest trees are able to flourish in soil under grass, as their surface roots are able to resist the harmful effects of the Carbon dioxide of the soil, and their natural habit enables them to take full advantage of the light.
