

CITRUS CULTURE IN THE DRY ZONE

DUTY OF WATER AND IRRIGATION PRACTICE—I

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FIELD tests and observations mentioned in this article were carried out with the co-operation of Mr. V. E. P. Guneratne, Manager of Government Experimental Station at Minneriya. My grateful thanks are due to this officer who not only took a keen interest in the work but also gave valuable suggestions to get accurate and useful results.

During the time I was in charge of Minneriya Irrigation Scheme there was a proposal to start a citrus orchard by the Department of Agriculture. The Department was not satisfied with the small experimental plot (which proved beyond doubt the possibility of citrus culture in the dry zone), but it wanted to demonstrate on a large scale not only the agricultural side of the experiment but also its economic side. Correct irrigation being most important for the success of such a venture in the dry zone, its study and field observations were undertaken by me then. As this farm is going to be a *fait accompli* in the near future, I have decided to record the observations and studies in the form of an article, not for its own sake but to raise further interest in the subject.

It is unfortunate that there are not many reference books on the subject except scattered notes and articles in various agricultural and engineering journals published under the direction of different governments. In this respect American States come to the fore and recently Italy and Palestine. References were made to these when available to compare the results obtained under local conditions.

Nothing new is said when I say that Minneriya is in the heart of the dry zone. But it is strange to call a place dry with an annual rainfall of 73·53 when Colombo, Negombo, &c., also have similar average annual rainfalls but are known to be

wet. Dry! yes, because here the rains keep to a definite seasonal period. Though the average rainfall is good there is a prolonged drought distinctly separated from the wet season.

In any kind of agricultural undertaking the first problem to be studied is the soil; next the supply of water and water requirements. This second question is called irrigation and is closely related with the soil, as it must suit the soil conditions in that area. Our observations and experiments were made to study this relationship between irrigation and soil. Therefore I think it is necessary to touch upon a few physical properties of soil that interest an Irrigation Engineer before I take up the actual question of orchard irrigation and duty of water.

In irrigation engineering and its application to agriculture, soils are grouped into three general classes, *viz*: light, medium and heavy soils. I have taken the term "soil" to mean that depth of soil from which roots can assimilate moisture. Soils below this depth are called sub-soils. Light soils show a high percentage of sand, medium soils a high percentage of loam and heavy soils a high percentage of clay. In nature it is common to get several other variations which the soil chemists have a way of their own to classify. For engineering we use these three terms to express general conditions. For orchard irrigation light and medium soils with a suitable sub-soil are favourable.

Soils as they occur in nature contain a percentage of voids or empty spaces between particles. This varies according to the texture of soil. Such variation under field conditions may be anything from 20 per cent. to 50 per cent. by volume. In irrigation we depend on these voids for the storage of moisture for plant use; the amount of water retained depends on the percentage of voids in the soil. Three samples of cultivated soils from the fruit area of Minneriya Experimental Station gave an average void content of 30 per cent. by volume.

To get a correct idea of the soil texture even in one field is rather difficult as it may vary. The difficulty is all the greater as such variations may occur both horizontally and vertically as it often happens in most of the soils in the dry zone. Hence our theoretical deductions must to a certain extent be adjusted to suit actual field conditions gained by experience.

Since voids are expressed as a percentage, moisture content in soils is also expressed as a percentage on account of their relationship. But we convert it to an equivalent depth in inches per ft. depth of soil for comparing readily irrigation and rainfall.

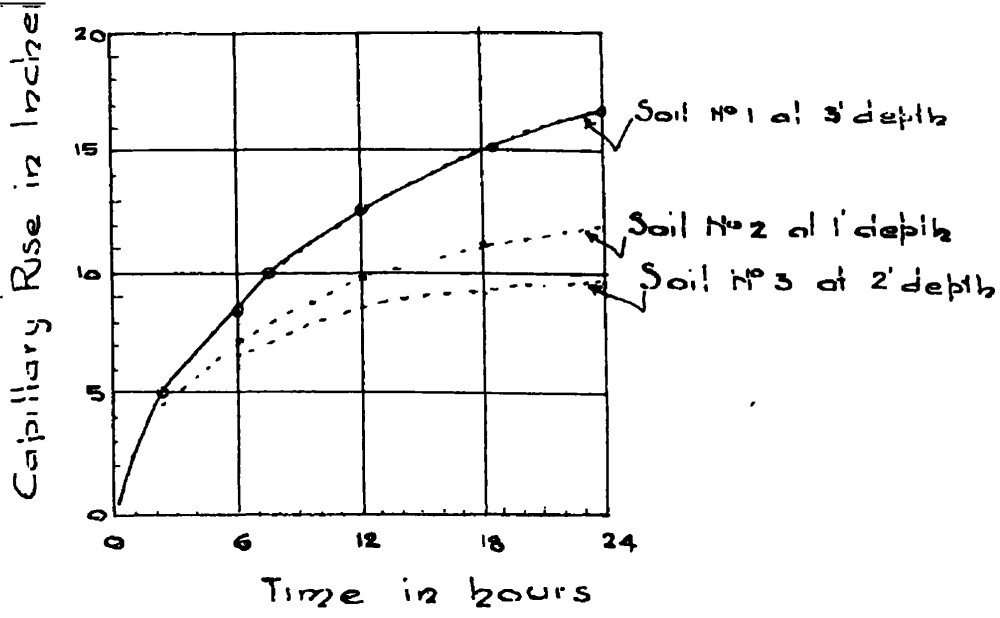
Irrigation water moves in the soil by gravitation and capillarity. When there is an excess of water over the void content principal movement is by gravitation. As the water content decreases capillary movements and adjustments take place actuated by capillary forces.

Different degrees of moisture content in a soil are expressed by the following terms: moisture saturation: this is the amount of moisture required to fill all the voids in a known volume of soil as it occurs in nature. It is expressed as a percentage of the volume or equivalent depth. Field capacity is the percentage of moisture held in the soil against the action of gravity. In this state only a part of the voids is occupied by moisture. In light soils it varies from 10 to 20 per cent.; in medium soils it varies from 20 to 28 per cent. by volume. If there is a further depletion of moisture from the soil a state will be reached at which plant roots will find it difficult to assimilate the moisture from the soil. This is called the minimum desirable moisture content. Again the next state of interest to us is the point at which plants begin to wilt. In the dry zone a plant may droop during the hot hours of the day but will recover overnight if the moisture content has not reached the wilting point. Permanent wilting will occur if the soil cannot give the requisite amount of moisture for plant growth. This is a condition that must be avoided in an orchard if water is available as it would affect the crop of several seasons to come.

It will be explained shortly what bearing the foregoing has on duty of water in irrigation. Roots require both moisture and air for their development, hence if a soil gets saturated too often or for a long period air is expelled from the soil and this will injure the plant. This is what we mean by water-logging of soil. However, saturation of the top soil cannot be avoided immediately after an irrigation. With a good sub-soil in medium soils this will not last more than a few hours. In heavy soils or with poor sub-soil it may last a few days. With such soils it is best to under-irrigate, rather than over-irrigate, at each irrigation and to adjust the irrigation period accordingly. This difficulty will not arise in semi-aquatic crops like paddy. In orchards correct irrigation to suit the particular soil is very necessary to produce a good crop.

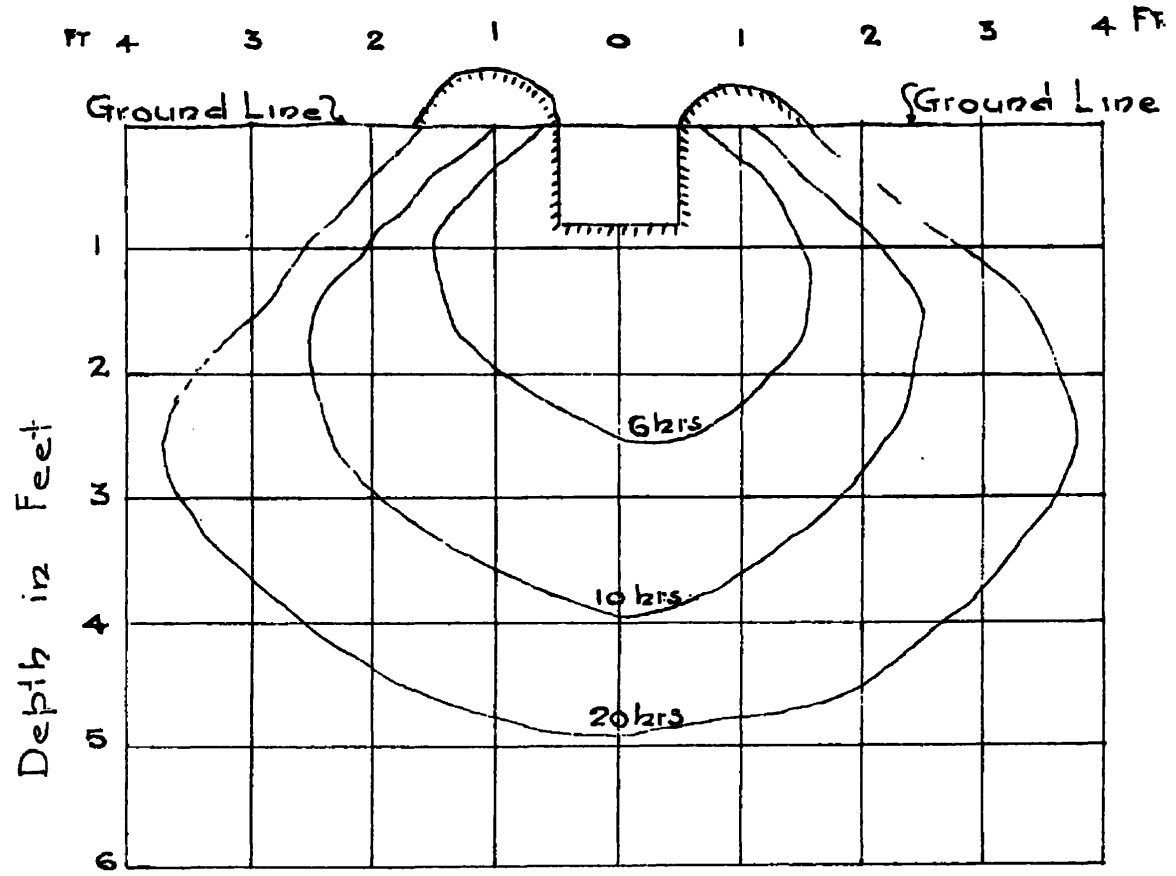
It has been proved beyond doubt by a large number of experimentors in America that the ideal moisture content in orchard soils is to maintain it at a stage between field capacity and the minimum desirable. When the soil has reached this second limit an irrigation must be applied to the soil to bring it to field capacity. The irrigation period is decided by these two limits which can be fixed by field tests and observations.

FIG: 1



RATE OF CAPILLARY RISE OF MOISTURE
IN SUN DRY SOILS OF MINNERIE

FIG 2



MOISTURE MOVEMENT AFTER IRRIGATION
IN MINNERIE CITRUS AREA SOIL

Moisture is lost to plants by deep percolation and evaporation. Unless the sub-soil is very gravelly, the greater loss is by evaporation. Moisture travels upwards to the dry surface soil by capillarity and then it is evaporated. Such movement was studied in the case of 3 samples of sun-dried soils of Minneriya. Observations are recorded in Fig. I. This indicates that such a movement towards dry soil can take place from a considerable depth and will bring the moisture-content in the root regions to the minimum desirable quicker than desired. This experiment was incomplete insofar as that evaporation losses could not be measured for lack of facilities but it gives useful information as to the rate of upward movement.

Though the presence of both moisture and air is essential in the soil for plant growth it is extremely difficult to find the optimum proportions in which these should be present. Purely on theoretical grounds supported by experiments and observation it is known that the soil must be maintained between field capacity and the minimum desirable to obtain good results in orchards practice. The regime of these two limits after an irrigation will vary according to the textural variations of the soil and climate. A series of tests were made to study moisture movement and duration of this regime in various places in the Experimental Station at Minneriya. Voids content of the soil averaged 30 per cent. Results are shown in Fig. II. It was observed that between 2 to $3\frac{3}{4}$ gallons of water over one square foot of area took 20 hours to reach a depth of 5 feet with a maximum lateral moisture spread of 7.5 feet during that time. The moisture outline began to disappear from about the 14th to 16th day after the application.

Citrus is known to be shallow-rooted so that a moisture penetration below root regions is not to be aimed at by an irrigation if water is to be used economically. The maximum depth from which citrus gets its supply of moisture is between 4 to 5 feet. In practice a sufficient depth of irrigation is given to bring the soil to field capacity within a depth of 5 feet for that particular soil. Results illustrated in Fig. II give the desired data completely.

Expressing the above figures in the more familiar way to us we get 0.82 in. to 1.49 in. depth per ft. depth of soil. For a 24-hour irrigation for Minneriya medium soil this figure is reduced to between 0.75 in. and 1.25 in. depth per ft. depth of soil. In medium soils this head may be applied for the full depth and retained in it till the next irrigation. On this basis full depth of irrigation required per application is from 3.5 in. to 6 in. depth.

In Fig. III are given the average monthly rainfalls over 35 years at Minneriya. It will be seen that the rains commence

in October and end in January. February and March rains are meagre. April has a fair amount and from May onwards starts the dry period till the second week of September. During February and March irrigations are not required, for the storage during the wet season immediately preceding will supply the moisture requirements during these two months. Also it is a good practice to give the soil a rest for aeration after the heavy rains. Then irrigations will be required only from about the middle of May and thereafter till the second week of September. In Minneriya it was found that as explained earlier a fortnightly irrigation of the above amount was sufficient.

But during July and August it would be advisable to give the heavier irrigation at 10 days interval as day temperatures are high with dry winds as shown in Fig. IV. Though there is not much fluctuation in monthly temperatures July and August are bad due to the dry winds. During these months a 5-inch irrigation at 10 days interval may be tried.

Then confining the irrigation period to 4 months at intervals of two weeks between irrigations, on an average 8 irrigations will be required during the dry season. Allowing a 4-inch application per irrigation total water requirement for the season will be 32 acre inches per acre. Making an allowance of 4 inches for distribution losses and bad handling gross requirement will be 36 acre inches per acre for the whole irrigation period or converting these into approximate cusec as expressed for the design of channels we get $\frac{24 \times 14}{4} = 84$ acres per cusec—say 90 acres per cusec. This is the duty of water for citrus in Minneriya or in the dry zone with similar conditions as in Minneriya. On account of the method of culture in orchards an economic use of water is practicable which may increase this figure to about 110 acres per cusec.

Those who are handling the water in farm distribution must remember that citrus is shallow-rooted and that light individual irrigations with a uniform distribution of moisture in the soil are the best suited. A young orchard will require about $\frac{2}{3}$ of the amount required for that of a mature orchard in full bearing.

Method of field applications.—Two methods are used in general for irrigating orchards with variations to suit the topographic conditions of the field. One is called basin irrigation and the other furrow irrigation. In the former water is ponded on an area around the tree for a period of time and in the latter water is run in furrows between trees,

FIG. 3

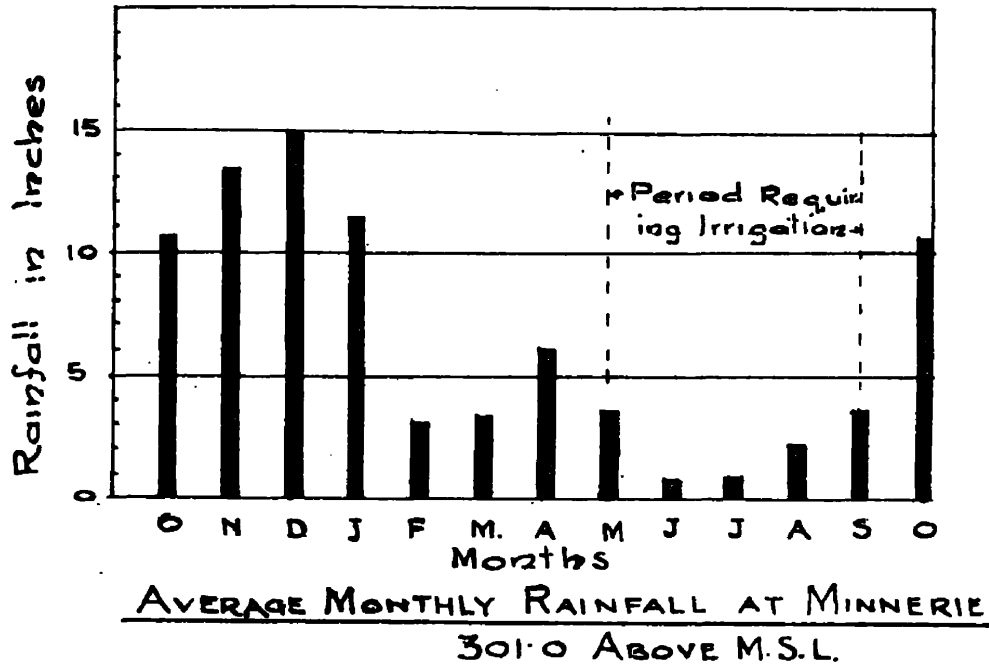
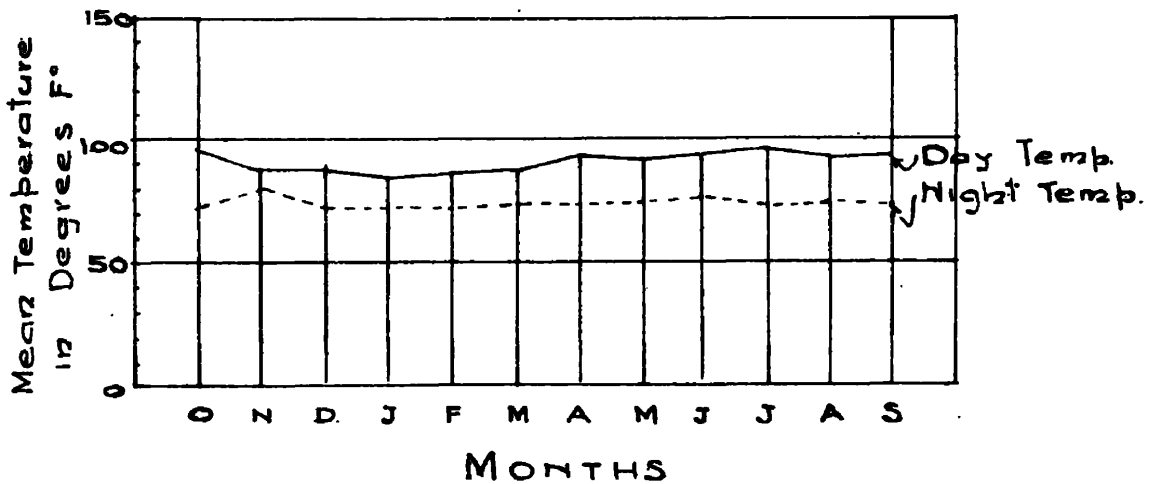
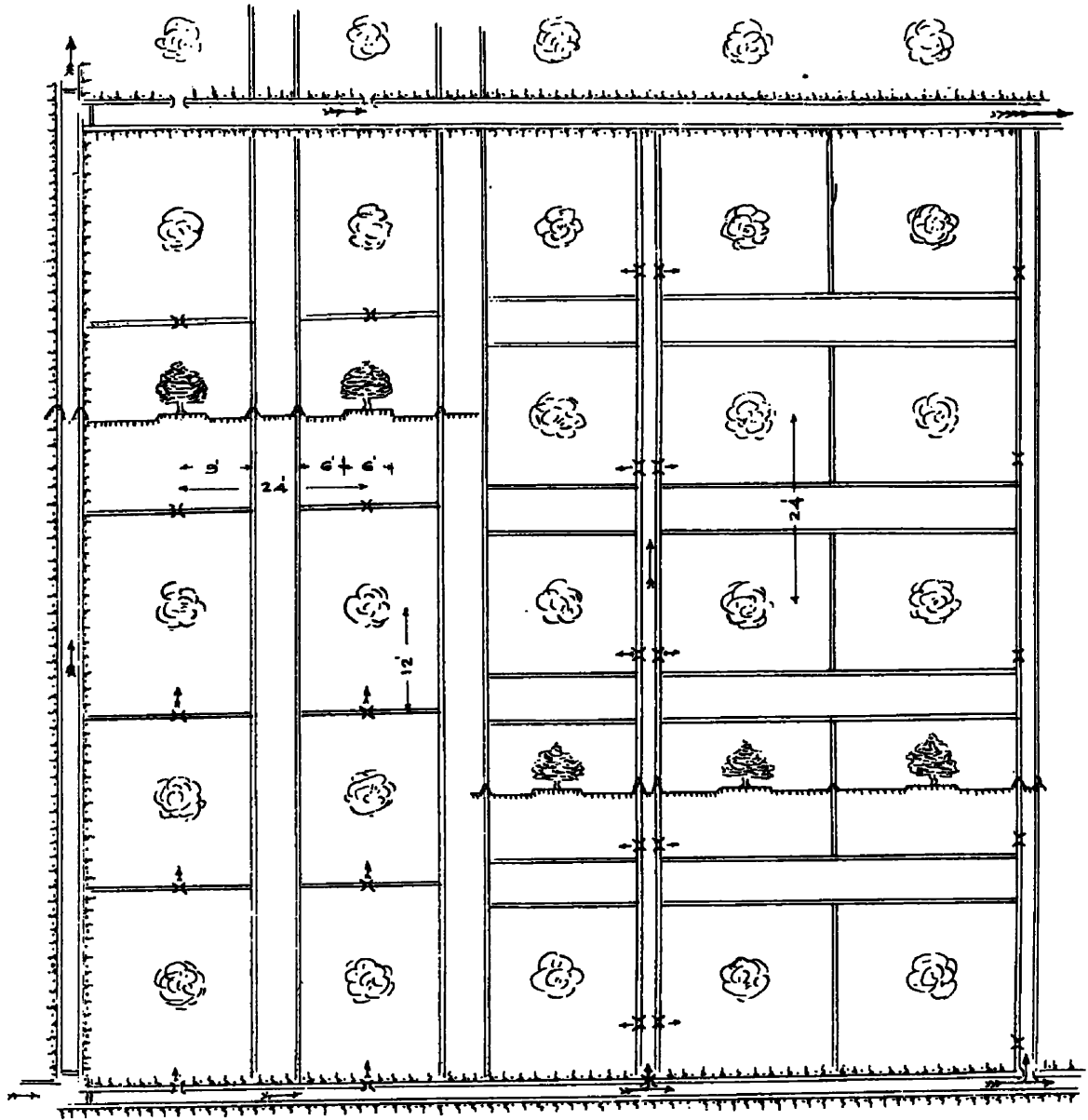


FIG. 4

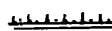

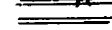
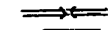


BASIN METHOD OF IRRIGATION
FOR CITRUS
 FIG. 5



BASIN TO BASIN DISTRIBUTION ← CENTRAL CHANNEL DISTRIBUTION

LEGEND

-  SUPPLY CHANNELS
-  DISTRIBUTORY CHANNELS
-  RIDGES
-  REGULATOR GATES

also for a period of time. For both these methods extensive levelling is not required but as seasonal cultivation of the soil is necessary basins or furrows should not form a permanent feature of the lay-out of the orchard. They should be formed just before the irrigation period starts.

Basins are formed by ridges to contain one or more trees according to the head of water handled. If the area enclosed in a basin is small, levelling may not be necessary except what is required for forming ridges. While preparing ridges and basins the earth must be worked towards the stem of the tree so that it forms a raised platform of about 3 ft. radius round the tree, which should be about 3 inches above the level of water ponded. This will prevent any injury to the tree being caused by the stem coming in direct contact with water. Fig. V illustrates diagrammatically an orchard prepared for this method of irrigation.

Water can be delivered to the basins in two ways, either from basin to basin much in the same way as in paddy fields or by running the water in a distribution channel between rows of trees and delivering direct to each basin individually as shown in the right hand side of Fig. V. The former method with some variations to suit the then existing conditions of the citrus area at Minneriya was tried by Mr. Guneratne. In basin to basin distribution there will be an excess of application to trees in the basin at the head to which water is admitted. With this method uniform application will be difficult even with careful attention. On account of the larger area water has to travel over, a large head of water is required which limits the number of trees that can be handled from one basin head to about 6 trees. In the other method water is let into each basin and turned off when the required depth has been let in. This is quicker and advantageous as a uniform soakage of soil and better control of water can be secured.

Basin method is suitable to localities where individual irrigations are desired on account of the heaviness of soil or where excessive percolation occurs by other methods. It is not favoured for orchards as a large area of the surface is wetted and baked alternately.

It may be interesting to note that a type of basin irrigation is practised by the tobacco cultivators along the banks of Mahaweli-ganga in Tamankaduwa District, North-Central Province.

The lay-out of an orchard for basin irrigation is straightforward and requires no special attention. All the details are shown diagrammatically in Fig. V.

The method most commonly used in orchards is furrow irrigation. This method is adopted equally to flat as well as steep country. Furrows which are really small channels are run between rows of trees into which water is delivered from the supply channel. The number of furrows required per tree row depends on the tree spacing, age of trees and the lateral movement of moisture in the soil during the period water is run in the furrows. If a more intensive irrigation is required then cross furrows can be made, into which water is led from main furrows and held till soaked into the soil. For Minneriya soils cross furrows are not necessary. Fig. VI shows the arrangement of a block for furrow irrigation.

With the usual heads available from the supply channel and the time available to irrigate a set, the length of a furrow is limited to about 600 feet. The grade of the furrow depends on the amount of percolation losses expected at the head of furrow and the time required to get the necessary depth of water. For Minneriya soils grades varying from 0.002 to 0.004 can be used with satisfactory results.

There are distinct advantages to favour the adoption of a furrow system in an orchard ; it can be used on any contouring of the land without extra cost in preparation ; a uniform distribution of moisture is given to the soil ; and desired depth can be obtained without wetting the entire surface and subsequent baking as happens in the basin method.

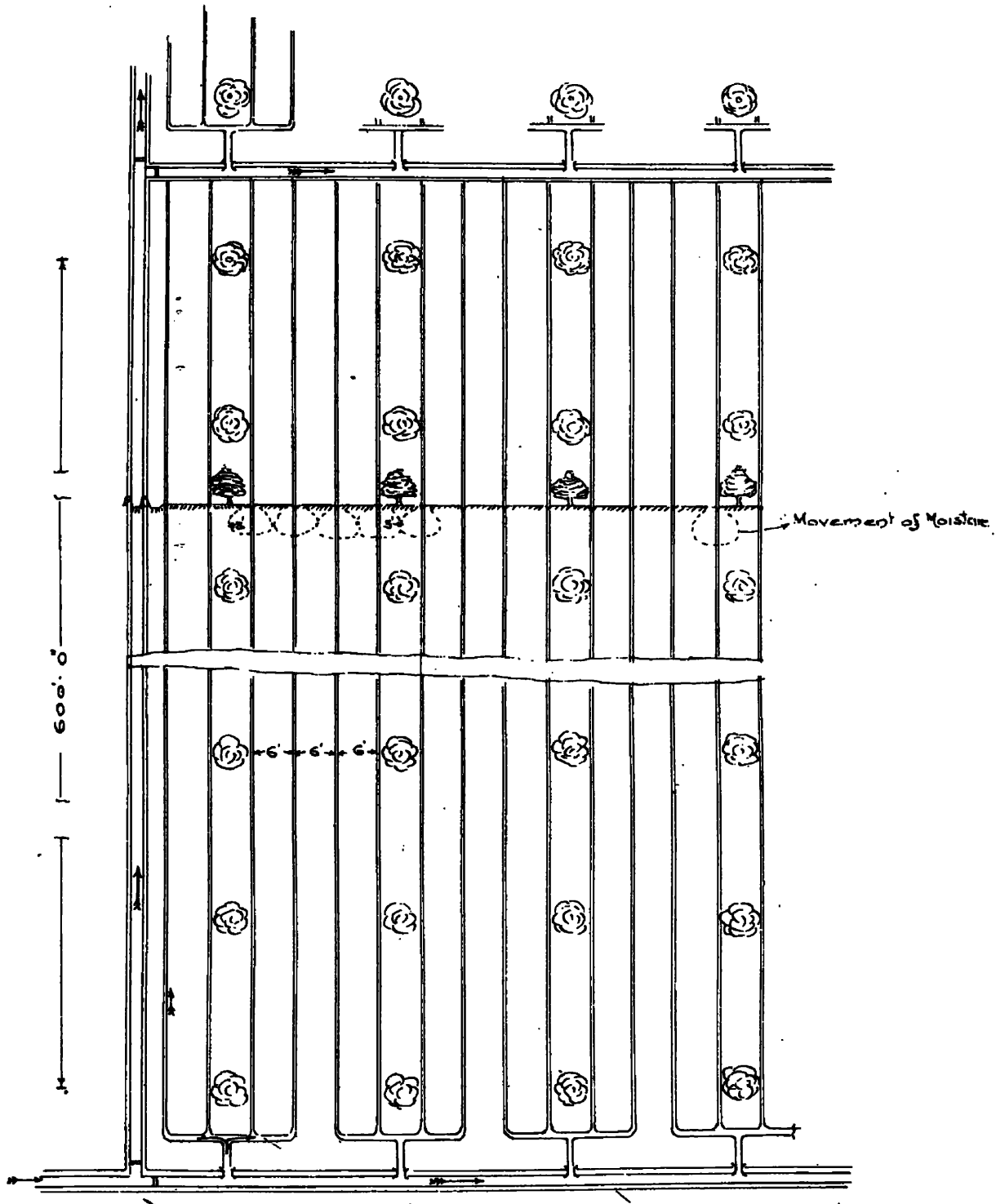
Distribution to the furrows requires a little more care and attention than in the basin method. The main channel should run at the head of the furrows so as to command all the furrows without any checking of flow.

To give complete information for the preparation of an orchard for furrow irrigation details for a 600 ft. length of furrow using the data obtained from Fig. II are worked out below.





At the rate of 80 trees per acre spacing of citrus is at about 24 ft. square. For a lateral moisture movement of $7\frac{1}{2}$ feet, 4 furrows spaced at 3'—6'—6'—3' per tree row will be used. With a duty of 90 acres per cusec on a 14-day basis, the area irrigated per diem is 6.5 acres. Effective lateral moisture penetration of a furrow is taken as 6 feet. The area irrigated by each furrow is 600 by 6=3,600 sq. ft.=1/12th acre. One cusec for 24 hours gives approximately 24 acre inches. Hence

for a 4-inch irrigation to 1/12th acre in a day $\frac{4}{24 \times 12}$
 $=0.015$ cusecs must be discharged to each furrow from the distribution channel and run for 24 hours. This will give a

FURROW IRRIGATION
FOR CITRUS
FIG. 6



LEGEND

-  Supply Channels
-  Furrows
-  Regulator Gates
-  Distribution Gates

4-inch irrigation. One cusec will irrigate 20 tree rows 600 ft. long. Details of the lay-out of the orchard is shown in Fig. VI. This is the duty of water and method of irrigation recommended for Minneriya and similar places in the dry zone.

I expect to follow this article with a description and construction of cheap structures and implements necessary for field distribution of water and preparation of land for above method of irrigation.