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in the case of oil. This is so much that the Bombay oil miller finds it costlier to import copra than to import oil. For every ton of oil that he obtains from the imported copra he stands to lose Rs. 1-12-0. In addition to the lower freights for oil the lower import duty on oil reacts detrimentally in the oil milling industry. Roughly the price of the cake covers the cost of crushing. The price of copra therefore should be purely based on its oil value i. e., the price of copra should be 60 per cent of the price of oil. Or in other words the price of oil should be 166 per cent of the price of copra. The duty on oil therefore should be 166 per cent of the duty on copra. But this has not been the case up to 1933, and up to that period the imports of oil into India were very large as compared to the imports of copra. Even at present when the low freights are taken into consideration it is cheaper to import oil from Ceylon than to import copra. The freight for a ton of oil from Ceylon to Bombay is only Rs. 7-8-0 while from Cochin to Bombay a shorter distance it is as much as Rs. 12 i.e., a difference of Rs. 4-8-0. The effect of these freights has been to close down our markets particularly in Calcutta and Rangoon.

We have seen that the price of copra depends upon the price of coconut oil and cake. It has also been mentioned (1) the establishment of oil mills in the centres of consumption namely Bombay and Karachi, (2) the preferential export duty on oil from Travancore and (3) the low freights from Ceylon as compared with the Coastal freights are the factors which adversely affect the coconut industry and therefore the producer.

Ultimately the Bombay price for the coconut oil is the price in Ceylon plus the import duty, plus the freight and incidentals. The price on the West Coast should therefore be the Bombay price minus the freight and incidentals. It is evident that the price of the coconut oil on the West Coast will be affected by a change in any of these four factors viz., the price in Ceylon, the import duty, the freight from Ceylon to India and the freight from West Coast to other Indian ports.

THE DRAINAGE ASPECT OF IRRIGATION.

By B. VISWANATH, F. I. C, F. C. S.

It is very kind of the Secretary of the Union to have invited me for the College Day and Conference and to take part in the symposium on irrigation this morning. I regret to have to deny myself the pleasure of attending the functions, but I am glad of the opportunity to associate myself once again—though from a long distance—with this function and to give a paper for the symposium.

I have been asked to contribute a paper on any aspect of irrigation. In recent years, I have had occasions to participate, as Agricultural

Chemist to the Government of Madras, in discussions on soils and irrigation in connection with the new irrigation projects in the Presidency and to lay down a scheme of soil survey and irrigation research. The discussions on the importance of drainage in an irrigation system as a preventive and curative measure against soil deterioration being still fresh in my mind, I have chosen the drainage aspect of irrigation for my theme.

Drainage is an aspect of irrigation which, unfortunately, did not receive the attention it deserved in the execution, in the past, of the irrigation projects in several parts of the country. As a result of this neglect, the public and the Government are becoming more and more alive to the troubles involved and are anxiously striving to at least mitigate the evil effects of irrigation.

The Evil consequences of irrigation systems with inadequate and inefficient drainage provision are well known to those who have experience with the working of the old irrigation projects in the Godavari, Krishna, Guntur, Tanjore and Madura districts in the Madras Presidency, and of those in Bombay and the Punjab. When I was working in Mesopotamia, I could realise the extent to which damage by irrigation could go. In that ancient land, whose praises were sung as the Garden of Eden, the barren and desolate country of the present day, stands vividly in contrast to its ancient richness and prosperity, as witness to the fact of man's inability to use wisely the advantages which nature has conferred.

In bringing under irrigation an area that has been cultivated under rainfed conditions, we are upsetting the equilibrium between the soil, climate and crop. This equilibrium is the result of natural adjustment of the several agencies through a long series of years. Compare for example the low rainfall area of the Ceded districts and the high rainfall region in the West coast of the Presidency. In the one case baking heat alternated with low rainfall has developed a state of soil and sub-soil with good retentive capacity for water, while in the other the soil is porous with poorer retentive properties. When irrigation is super-imposed over conditions as in the former, a steady accumulation of underground water occurs, ultimately leading to waterlogging and the formation of saline and alkaline soils.

A soil under irrigation is not a simple existence of the two components, water and inert solid matter lying side by side. The two components are subject to a series of very complicated interactions brought about by frequent irrigations and intensive cropping. The intensity and the result of these reactions depend on the relative amounts of the interacting compounds and on their chemical composition. Sooner or later the result will be the development of saline and alkaline conditions in the soil, slowly but steadily followed by a rise in the sub-soil water level. The behaviour of the salt laden soil depends on whether the soil is put under continuous or intermittent irrigations in a given season or year. Under continued irrigation conditions alkalinity will be more in evidence and salinity is diminished owing to dilution and hydrolysis. Under intermittent irrigations alkalinity is diminished, but salinity may attain highly injurious concentrations. If the soils and waters are rich in sodium salts, coupled with low calcium concentrations, there occur a series of base-exchange reactions by which the composition of the soil clay is altered and the soil is rendered impervious. Uuder such conditions soil management would be difficult and the result would be that in course of time the soil would deteriorate even to the extent of becoming infertile.

When the soils are rich in calcium salts, there is no marked change in the composition of the soil clay and the trouble is chiefly due to excessive salt concentration in the soil water. In such soils, at the time when water is applied evaporation is high. Percolation will also be rapid, but very soon the soil is left containing an amount of water equivalent to the saturation capacity of the soil. The phase that follows is one of decreased evaporation and diminished percolation, both going on at a steadily diminishing rate until the water content is reduced to the neighbourhood of minimum capillary capacity. The position now is that the soil particles are surrounded by films of water containing the salts in solution. The power of the root-hair to take water from this film depends on the difference in the osmotic pressure between the cell sap and the water film and on the force with which the water is held to the soil particle, which force depends on the surface tension of the soil solution. Unless the salts are taken away from the sphere of activity, the surface tension increases. The loss of soil water decreases as the concentration of dissolved salts increases, and the effect of this is to increase the water holding capacity of the soil and at the same time to decrease the availability of the water to the plant. To prevent this condition arising, more and more irrigations will have to be given and with each irrigation and rainfall the sub-soil water level continues to rise rapidly. Nearly a third of the irrigation water applied finds its way to the underground water table. With the rise in the level of the underground water, the salts are carried to the surface and the problem then is to lower the sub-soil water level to such a depth that goes beyond the root zone of the crops. This can be done by drainage only.

It is, therefore, seen that water, the only vehicle by which nourishment can be conveyed to the plant, is capable of doing immense harm when it is redundant and stagnant. It is then unfavourable to vigorous and healthy plant growth, makes the surrounding atmosphere damp and humid and unhealthy to human beings, live stock and plant growth.

When once salts are allowed to accumulate in the soil and the damage is done, it is a difficult and tedious and expensive process to effect improvements and bring the soil back to its original state by means of drainage. Drainage as curative process is many times more difficult than drainage as a preventive method. Because, by then, the general rise in the water table would have taken place and an equilibrium would have been established in the system, and the flow of the ground water as relieved by drainage and evaporation from the soil will be equal to the volume of water continually added by irrigation and rainfall. Besides, the base-exchange reactions occuring in the soil would have made the soil practically impermeable to water.

The provision of a system of drainage, simultaneously with the execution of an irrigation project, will render the transition from stagnant saturation to drainage saturation simple and easy and will constitute an efficient protective measure against deterioration. To produce efficient drainage both underground and surface water must be dealt with. It is not possible to wash off surface accumulations of salts by a sudden rush of water over the land into an open drain. Although this has been practised with fairly good results, the effect is only temporary. An examination of the soil always showed that the salts were merely washed down into an insignificant depth only to rise again as soon as the soil is left to dry. Drainage of percolation water is necessary for the removal of the salts outside the sphere of activity. The truth of the fact in hydraulics that the velocity of a stream of flowing water is decreased in proportion as the area of the channel in which it flows is increased, is likely to prove useful in adjusting the shape of the drains with due regard to the slope of the land in designing an effective drainage system. Any method of field drainage requires in the long run a main drainage system over the entire area under the irrigation project. This can only be provided as a Government undertaking.

An efficient system of drainage keeps the soil sufficiently permeable to air and prevents its being saturated with water. The soil is thus in a fit state to be worked on the surface into a fine tilth. In this condition it is fit to take moisture, other than rain, from the atmosphere, which is a constant and inexhaustible vehicle for water vapour. The process of deposition of dew, is dependent on the relative temperatures and on the degrees of aqueous repletion of the air and soil at a given time. This kind of moisture absorption is more in evidence with the soils of Hagari, which may be considered as representing the type of soils of the Tungabhadra project area. In this area the temperature of the soil during the day is moderated, by the evaporation of a large amount of water vapour, whilst the humidity lost is replaced by the dew deposited during nights. The amount of dew deposited can be judged by an inspection of the fields early in the morning and before sunrise. The relative powers of soils to absorb water from the atmosphere have been ascertained to vary from 26 tons to 36 tons of water per acre of soil.

It is obvious that well pulverised and cultivated soils attract much more dew than those which are compact and close. If under irrigation there are facilities for the rapid removal of surplus water by surface and percolation drainage, the soil would soon be fit for working and being brought into a condition to absorb the dew, thus indirectly contributing to the economic use of irrigation water.

Drainage, therefore, is a good protective measure and a doubtful curative agent for the evils that necessarily arise from irrigation. The provision of a sound drainage system should be done with due regard to the depth, composition and distribution of the deposits of soil and subsoil. Much has yet to be done by soil scientists and drainage engineers before land drainage in this country can be put on a scientific basis, affording data by which the various classes of soils can be drained with the maximum efficiency and minimum expenditure. In this then, as in other departments of Agricultural Science, we see that though much has been done, more yet remains to be done. We have as yet taken a few onward steps and the direction of further advance—dictated at once by policy and business exigencies—should be by painstaking research coupled with sound reasoning based on mature experience and judgment.

SOIL SURVEY OF THE LOWER BHAVANI PROJECT AREA

By T. LAKSHMANA RAO, B.A., D.I.C. & M. R. BALAKRISHNAN, B.A., B.Sc. (*Ag.*)

The object of this paper is to give in a succinct form the work of an Agricultural Chemist and the necessity for consulting him in launching any new irrigation project. With this purpose a descriptive account is given of the work done by the Chemistry Section here in connection with the Lower Bhavani Project.

This project aims at constructing a dam across the river Bhavani at a place 9 miles west of Satyamangalam and taking a channel from there across the country in a south-easterly direction to join the river Cauvery somewhere near Kodumudi. The strip of land which thus lies between this channel on one side and the rivers Bhavani and the Cauvery on the other is about 60 to 70 miles long and of an average breadth of 4 to 5 miles. The total area which will thus get to be under irrigation when the channel becomes a *fait accompli* will be about 200,000 acres, the main crops being millets, nadam cotton and occasionally groundnut. There is no doubt that when the area comes under irrigation we will be greatly adding to the prosperity of the whole tract by enabling ryots to go in for more paying crops which for want of water they are unable to raise now.