PAPER No. 290.

Dr. A. G. ASGHAR — Studies in Lysimeters.

Part I.

Dr. A. G. Asghar :—Based on the experimental results achieved in the laboratory as well as in the field, reclamation procedure was decided upon by washing down harmful sodium salts by leaching and subsequent rice growing during Kharif season when enough water-supply is available in the Punjab Canal System. Research on basic problems with regard to the base exchange reaction was continued during the period 1932 to 1940. It was soon realized that the removal of the salts from soils depended on the rate of transmission of moisture through soils under the existing meteorological conditions of the province. It was thur decided to pay more attention to the study of movement of moisture on which would control the movement of salts.

According to the conclusions arrived at by E. Meckenzy Taylor, it was only necessary to depress the salts beyond the depth of 10′ from the natural surface. It was visualized that the salts would never rise to the surface again. The basis of this conclusion was the existence of three moisture zones in a soil profile in contact with water-table. Starting from sub-soil water reservoir the first moisture zone is capillary zone of high moisture content followed by second zone of field capacity above which lay the pellicular zone having a steep moisture gradient towards the natural surface. As the field capacity zone has moisture content which a soil could retain under gravatitional forces and a higher moisture than which could not be present in the soil material, the salts were visualized not to move from a lower depth, with the field capacity zone functioning as a buffer between pellicular and capillary zones.

The application of this fundamental study in the field, however brought to notice that once reclaimed areas became infested with thur after sometimes although the water-table was still below 10′. There was no doubt that such a distribution of moisture could be present in a soil profile but main conditions which would determine such a distribution were the cropping system of this province. It is well known that a major portion of the culturable land lies fallow in one season or the other and, therefore, the study of moisture distribution in an un-cultivated field was considered necessary.

The paper describes moisture studies in uncultivated field near Rakh Kot Lakhpat, about 7 miles from Lahore, where a space of 40′ × 40′ was marked out. Soil samples were taken by means of soil auguar upto the water-table within this area from time to time. The pellicular deffi-ciency of a soil profile calculated on the actual moisture contents from the top downwards would give us the total amount of water which that soil profile can hold withoht allowing any moisture to move towards the field capacity or capillary zones. The pellicular deficiencies are given on page 48 for the Period 1943-1945 and in detail in the tables which follow. It is concluded that the pellicular deficiency is at its maximum before

monsoon but is reduced by rain which may again increase after the subsequent dry period. Similarly the pellicular deficiency would be maximum before watering of a field. It is, therefore, self-evident that to estimate the portion of surface application which adds itself to sub-soil reservoir or its control, involved the study of the movement of moisture under the following conditions :-

(a) Un-irrigated land.

(b) Irrigated land under Principal crops of the province.

It is further suggestive that different meteorological conditions should also be taken notice of while making such a study.

The variables involved in the study of the problem and its importance, keeping in view the damage which has been done to our lands by harmful sodium salts, call for exhaustive experiments. As basic research was also needed as a preliminary to applied research, further work was taken up on the lines described in the subsequent parts of the paper.

PAPER No. 290.

Dr. A. G. ASGHAR, H. S. ZAIDI — Studies in Lysimeters.

Part II.

Dr. A. G. Asghar :—The initial studies on the movement of moisture in soil profile were started in small glass tubes, filled with soil and placed in troughs filled with water. There were a number of sources of error and, therefore, it was decided to carry out experiments on a bigger scale.

Glazed Pipes of 4" diameter were built up in segments of 2' length and erected vertically. Provision of water-table was made at the bottom Holes were made at regular intervals at a distance of each foot which were plugged with waxed bark corks. Artificial soil profiles were built up in these tubes and crown surface application was given at the top for various experiments. Soil samples were taken through the holes in the pipes and examined for moisture distribution from time to time as required. From these experiments conclusions were made for the surface application and the actual amount of moisture present in the soil profile. Mechaninal composition and dry bulk density were the two variables which were studied for various artificially prepared soil profiles.

On an examination of the results, the total surface application and the actual amount of moisture present in the soil gave evidence for an appreciable difference between two quantities. It was concluded from this study that moisture unaccounted for had reached the sub-soil water-table. This was an indirect way of proving that certain amount of surface application adds itself to the sub-soil reservoir. In the absence of direct results it was difficult to convince the Scientists regarding the understanding of the problems. It was felt that arrangements should be made for giving measured quantity of surface application, collecting the water which adds itself to the sub-soil reservoir and base our future programme on the direct observation rather than an indirect inference. In order to avoid the variable of rise and fall in the sub-soil water-level it was decided to keep the water-table constant in various experiments. This gave rise to the idea of building up of lysimeters.

The paper mainly describes the various draw-backs in the construction of lysimeter in various parts of the globe. Apart from the the size of the lysimeter studied by various workers the arrangement of soil material was an important factor which varied from place to place. In certain cases the building up of the soil profile in the lysimeter did not compare to the natural conditions in the field. It was also realized that that lysimeters being open at both the ends the moisture conditions in the field were not at all represented by these arrangements.

Both the above important factors were eliminated as far as possible by building up soil profiles in iron lysimeters of 36" diameter and 15' height, representing natural soil profiles as detailed on page 58. In order to keep moisture content as well as dry bulk density comparable to the natural condition, determination of both the soil constants was made during excavation of the soil material and during the building of the soil profiles. These lysimeters were placed in a double walled room in order to minimise the effect of temperature.

To further eliminate the size error two sets of water proof concrete lysimeters were constructed. Arrangements for taking watertable observation, adding water to the sub-soil reservoir and taking out a measured quantity of water without disturbing the soil profile itself were provided.

It may be mentioned that this Province has got the most uptodate and largest lysimeter ever-built any where. This fact has been brought to the notice of distinguished visitors from abroad from time to time. It is suggested that in order to appreciate the work being carried out on these lines officers of the Irrigation Department may kindly pay a visit to the Central Directorate of Land Reclamation whenever convenient.

PAPER No. 290.

DR. A. G. ASGHAR, H. S. ZAIDI, M.A. QAYYUM.

Studies in Lysimeters.

Part III

Dr. A. G. Asghar.—The results described in this paper are from the experiments carried out in two types of Lysimeters described in Part II. For the sake of reference various tanks have been given nomenclature of D, E, F and G.

The main conclusions drawn from this study are :—

(1) The cultivation of rice year after year increases the accretion to water-table in greater proportions than that of previous year.

(2) Cotton, wheat, gram, maize are exhaustive crops with respect to moisture and there is a depletion in the water-table during their growth.

Taking the mean temperature of soil as 27°C, and assuming that both sodium sulphate and sodium chloride were dissolved in equal proportions the average evaporation of 18.6" is capable of dissolving 650 tons of salts per acre annually. The salts are likely to be deposited at the surface if not washed down due to heavy irrigation or precipitation. It must be pointed out that light precipitation is entirely lost as evaporation losses.

(3) Heavy rains over a short period contribute greatly to accretion to water-table.

(4) The accretion to water-table during the growth of a particular crop is dependent to a great extent on the preceding crop.

(5) Sugarcane can be recommended as a crop for partially reclaimed fields as an appreciable portion of the surface application is added to the water-table and the trend of the moisture movement is from the soil surface towards the sub-soil water-table.

The results have been represented in the form of diagrams. The central lines show the sub soil water level and the verticlal coloured columns above this line show the surface application in the form of irrigation or rain or addition to water-table in order to keep it canstant. The accretion to water-table is represented by coloured columns below this line.

The observations plotted for tank G are the most important as these give the amount of moisture which is lost by evaporation under

the conditions of water-table which is beyond the limit of safety fixed by Dr. Taylor. It is evident that in a period of 3 years, comprising of 3 kharif and 3 rabi seasons, total evaporation of 55.8" has taken place. There is no reason to dis-believe that this much loss of water must have taken place from the other tanks also which were under crops, either due to evaporation or to evapo-transpiration and, therefore, an important conclusion is, that although evaporation is a very slow process yet it is steady and continuous and hence under favourable conditions the salts present in the soil profile would move up from a depth greater than 10 feet even.

The results reported in the case of Iron Lysimeters are of the same order as of bigger lysimeters with the difference that the length of the soil profile as well as the mechanical composition of the soil material have been observed to be controlling factors for the movements of moisture and the effect of surface evaporation on the sub-soil water-table.

Dr. Nazir Ahmad :—Studies in Lysimeter rather Punjab Lysimeter is a very interesting paper giving some insight of what happens in our irrigated lands.

There are one or two points which I feel need explanation. It is said that the effect of evaporation at surface reaches beyond 10 feet. There is a memoir in the Institute by Dr. Vaidianathan stating that the effect of evaporation was felt 22.0 feet below N. S. This effect on water-table should be distinguished from real evaporation snd its in-direct effect. May be this fluctuation is an indirect cause of pressure deficiency.

Perhaps experiments conducted by the avaluation of loss of weight from soil of different profile depth may clear this point.

In this connection I have some doubts whether the depletion and accretion of water from water table maintained in the soil is real or just an off shoot of the same changes in pressure deficiency aud capillary potential in soil. I would like to suggest that perhaps measurement of evaporation and transpiration of crops may give a true picture. I think that, in the future, if not already done these factors may also be measured along with estimation of soil moisture at different depths.

In the beginning of this paper the author has stated that in a soil at field capacity, if a given quantity of water is applied to the surface, an equal *quantity is immediately released*. Has this been experimentally verified.

On the whole paper is very finally written, very instructive and full of useful date for which I add my appreciations and congratulations.

Mr. I. A. Zafar :—According to the author the moisture distribution takes place in two zones with a point transition where the contents reach "Field capacity moisture". It is not clear to assume how two zones with 3 dimensions can have a transition stage in form of a point only. This needs clarification. Gradual transition from one zone to the other must be through a third zone and not a mere point.

After going through papers No. 290 parts I, II, III and 291 in which the name of Dr. Asghar manifests by permutations and combinations it will have to be admitted that he has successfully extended scope of his land reclamation on reclamation of the papers of Punjab Engineering Congress as well. He deserves the due credit.

It is a pity that some of very useful graphic studies made by me jointly with M/s. M. A. Rahim and S. M. Niaz for determining probability and exceedence studies could not be accepted and printed as accompaniment to our paper No. 292 on "Flood control investigations". On the other hand a host of tables, diagrams and photos are included to adorn the papers in which the name of Dr. Asghar appears. Idea of this "Imperial preference" is not sporting enough. It is hoped that these graphs which will be of immense value to engineers of all deparments confronted with flood problems will be now printed along with the discussions.