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Agriculture is the most important industry of the Sudan,
and Gezira its major producing area.
Gezira cotton earns most of the country's foreign exchange and the need to produce still more
has led to intensification of production. The pressures created by this
are accentuating old and creating new problems, thus putting strain on the technically
good, but limited, resources of the Agricultural Research Corporation (ARC),
which is responsible for most of the research
on agricultural problems in the Sudan. The ARC therefore
requested technical assistance from the IAEA to help with these studies.

Radioisotopes in agriculture

The sentences which introduce this article are an almost direct quotation from the final report to the Government of the Democratic Republic of the Sudan prepared by an expert assigned by the IAEA to assist in the implementation of a project concerning the use of radioisotopes in agriculture, directed toward a study of water use by irrigated crops and the responses of soils to irrigation. This assistance was requested by the Government and approved as a part of the IAEA Regular Programme of Technical Assistance in 1969. The IAEA supplied a portable scaler/ratemeter with a neutron depth gauge for soil water measurement, a gamma depth gauge for soil density measurement, and a combined moisture/density surface gauge, plus safety equipment and various accessories. Later, two additional complete neutron meters for measuring soil moisture at depth were provided on the expert's recommendation. To assist in the work the IAEA appointed Dr. Frank Cope, of the Levington Research Station, in the United Kingdom, who prepared the final report.

Dr. Cope was assigned to the ARC and was based upon the Soil Science Section of the Gezira Research Station (GRS), the principal research station of the Corporation. This research station, which was established in about 1918, has a distinguished history of research into all aspects of the growing of irrigated cotton, although Dr. Cope noted that the need to expand and diversify production now directs attention increasingly to other crops – especially cash crops – as alternatives to cotton.

The Gezira soil has been found to have both advantages and disadvantages for irrigated agriculture, but important problems remain. Although some lie in pest and disease control, plant breeding, crop husbandry and so on, Dr. Cope found that some of the most urgent arise from the need to achieve more efficient irrigation; and that these problems apply equally to the Gezira scheme and to potential areas of irrigation development.

It is a truism that isotope methods, notably the use of neutron (soil moisture) and gamma (soil density) gauges, offer a new and effective means of research into plant-soil-water relationships. Dr. Cope's final report on the project in which he took part is adequate testimony that these methods can contribute effectively toward the solution of agricultural problems in the Sudan.

The neutron probe in use, in the course of soils investigation. Photo: Cope.

'Counterpart' scientists were appointed by the ARC, and all the work reported was carried out in cooperation with Sudanese scientists and technicians. The work done thus served as an effective means of training Sudanese technicians in nuclear methods: co-operation in staff training and research planning was extended beyond the ARC to members of the staff of the Soil Survey Division of the Ministry of Agriculture and others. The Soil Survey Division, strengthened by projects of the Food and Agriculture Organization of the UN (FAO), is now surveying the soils and the land use potential of new areas; Dr. Cope suggests in his report ways in which isotope methods can help in this work.

He writes: "It is true that the Sudan has resources of irrigation water in excess of its needs in the immediate future, but these do not remove the need to conserve water in existing schemes. The capacities of the canal systems are often restrictive, whilst over-watering can markedly reduce crop yield and profit as well as causing problems for the future. Basic information on crop water needs is a first requirement for efficient planning of new irrigation schemes. A most accurate way of collecting such information is to measure changes in soil water storage as the crops is irrigated and as it uses water from the soil. The neutron meter is now generally admitted to be the best available tool for this type of work. Without this

Preparatory work in progress; one of the projects with which Dr. Cope was concerned was a study of soil amelioration by cultivation and the application of gypsum. Photo: Cope.

information, water might be allocated in wrong amounts or at the wrong time for a particular crop, affecting development of that crop and (in cases of over-allocation) the development of other crops at the same time."

The introduction to Dr. Cope's report presents the Sudan as a country heavily dependent on agricultural production for its well-being and poised on the brink of further development in the same direction. "The country has a well-established organization for agricultural research but one which has to meet many challenging problems. Capital for development is very limited and the economy cannot afford many mistakes, so development plans must be based on the best information possible. Several of the problems facing irrigated and rain-fed agriculture are susceptible to attack by new techniques, of which isotope methods, the particular subject of this report, are amongst the most useful. Their value is brought out in this report."

Dr. Cope enters one important caveat which should be noted by any group considering the introduction of fairly sophisticated isotope methods to assist them in their work, especially in a developing country: the equipment must be put to work intensively and effectively in order to justify its high capital cost; and proper arrangements must be made for servicing the equipment and for importing spare parts when required. In a project such as that with which Dr. Cope was associated the first limb of this condition is the responsibility of the scientists doing the work, and of the expert who may be assisting them; the second is that of the Government, which alone can ensure that the local scientists receive proper support and that essential spares are made available.

Dr. Cope adopted a wide-ranging approach, in order to involve as many as possible Sudanese research workers who were likely to find isotope methods useful. Co-operative investigations were begun with a number of scientists, enabling valuable training and creating widespread interest in the new methods. The equipment had a thorough 'work-out' and its performance was felt to have fully justified its choice. But these initial investigations had a more direct objective: that of making a worthwhile contribution towards the solution of some of the cropping and soils problems outlined earlier.

In all, nine specific investigations were made during the year Dr. Cope was in the Sudan; many are on-going, and he has offered to continue to take an interest in the work and to co-operate in various ways. Some of the work in which he took part may be discussed briefly here.

First, a study of pre-watering and the use of nitrogen fertilizer, in relation to the growth of cotton at a GRS farm. It was necessary to know by how much, and for how long, each pre-watering would increase water storage in the soil at various depths – this information being relevant to other studies on soil nitrogen, weed growth and the response of the cotton crop – and how this affected the soil conditions for the growth of the crop, for example by aggravating waterlogging or by supplying the crop with water accumulated in the subsoil.

Previously, the difficulties of augur sampling had prevented the making of a comprehensive soil moisture record. In 1971 it was therefore decided to make a series of measurements with the neutron meter. Dr. Cope notes that although pre-watering may be practised for reasons other than crop water supply – for example, for weed control, nitrogen release, conditioning of the seed bed and so on – the value of the water itself should not be disregarded. The view often expressed in the Gezira, that most of the pre-irrigation water was lost from the soil before the cotton was sown, was shown to be true only for the topsoil; from a single April, May or July pre-irrigation, 41, 49 and 89% of the water stored in the soil remained at sowing time; from triple pre-irrigation (in April, May and July), 58% remained. Most of this water was stored below 30 cm and above 80 cm depth. Prewatering in May, three times, somewhat increased soil water below 1 m depth – and cotton is known to exploit water which lies even deeper. During this study water use by nitrogen-fertilized and unfertilized crops was compared: among the results was a finding that fertilized plants exploited water rather deeper in the soil profile than unfertilized. An expected observation was that the immediate topsoil dried out more quickly under the open canopy of unfertilized plants than under the closed canopy of fertilized plants, which could have a bearing on microclimate and disease incidence. A practical implication of a finding such as this is that the more vigorous stands of cotton now being produced by improvements in fertilizer practice (and probably other improved practices also) can have a greater leaf area than previous crops, and hence a higher consumptive use of water. Irrigation intervals which sufficed for crops of lesser leaf area may result in undue water stress in these more vigorous crops; and Dr. Cope recommended more work on this point.

A second study concerned the use of water by sugar cane under various irrigation régimes, at Guneid. The sugarcane crop here and at Kashm El Girba "seems to be on the threshold of development, at least to the extent of supplying the home market to save hard currency," writes Dr. Cope; whereas cotton has been closely studied in the Sudan, this is not true of sugar cane, and there is a total lack of water use data. Trials using neutron moisture gauges, in co-operation with the staff of the Guneid Sub-station, showed that the soil itself placed restrictions on water intake and even the lowest rate of water application was usually sufficient to charge the soil fully to the depth exploited by cane – 70 to 80 cm – so that excess water was largely wasted by remaining on the surface until lost by run-off or evaporation. Earlier studies had in fact shown good response of cane to short irrigation intervals but no response to

rate of application, so the result was not unexpected. The detailed results obtained in the neutron studies indicated a pattern of water use by cane which was lower than might be predicted without reference to 'crop factors'. "More seasons' work are needed before general recommendations can be offered," Dr. Cope writes, "but there seems every likelihood that the amount of water allocated for cane at times of lower crop water use could be reduced and this water made available instead for concurrent development of other crops in cane areas."

Other studies in which he took part concerned soil amelioration by cultivation and the application of gypsum, for various crops and in various areas; irrigation rate and interval for maize; the effect of cracking on moisture penetration in Gezira clay soil under permanent fallow; and the like.

Dr. Cope ends his report with detailed recommendations relating to future studies across a broad spectrum; the use of isotope techniques to aid the Soil Survey; long-term effects of irrigation on Gezira soil; a summary of his conclusions; and no less than 11 appendices presenting data. His first conclusion seems amply borne out by the detail of his report: "Isotope methods have great value in solving agricultural problems in the Sudan, as is shown by the extent of productive work in one year of the present assignment." He ends: "All projects in this report involve research applied to problems of economic importance; some will be more productive than others. The development of the country would benefit" – as may that of other countries at a similar stage in their development – "if all such applied research were to be assessed by an experienced, independent panel, and those projects given high priority, then given adequate support.

"Money allocated for research tends to be frittered away when spread too thinly over too many projects, no matter how worthy these may be."