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Articles

Monitoring programs in drainage projects
Their importance, objectives, elements, and possible results*

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Introduction

The monitoring of drainage projects is not a common activity, neither in Pakistan, nor anywhere else in the world. Reports on monitoring activities are scarce, and publications on the subject are even fewer.

Found, Hill, and Spence (1976), monitoring the economic impact of drainage in Ontario, Canada, concluded that many of the drainage projects had cost-benefit ratios of less than 1 (Journal of Soil and Water Conservation, Volume 31, No. 1, pages 20-23). They also concluded that, despite the significance of drainage in Canada, drainage projects are seldom evaluated. The Canadian study illustrated that the timely monitoring of drainage projects might have led to better-defined drainage priorities and to better recommendations for improved design.

Nyland and El Guindy, monitoring crop yields, soil salinity, and watertable depths in drained and undrained areas in the Nile Delta of Egypt, arrived at a similar conclusion (ILRI Annual Report 1983). Despite scientific progress, the art of land drainage still appears to depend on experience gained locally and on the evaluation thereof. The scarcity of monitoring programs in drainage projects would seem to justify a plea to step up such programs.

The aim of monitoring

When an ailing patient is brought to a well-equipped hospital, his condition will be constantly monitored. A diagnosis will be made and treatment will be given, but it is the monitoring system that will tell the medical staff whether the procedure they are following is the correct one.
When the 'patient' is the irrigated agriculture of arid lands, and the 'il1ness' is waterlogging and salinity, a monitoring system is equally vital.
WAPDA and World Bank reviews have indicated that waterlogging and salinity in Pakistan have not substantially decreased, despite the massive efforts being put into reclamation projects. These disappointing results do not mean that the 'patient' should be taken off the monitor and left to his fate. On the contrary, he needs to be monitored under 'intensive care'.

*(Summary lecture of the Training Course on Scientific Monitoring of Tile Drainage Projects, held in Khairpur from 12 to 31 May 1984, and organized jointly by ILRI, the Water and Power Development Authority of Pakistan (WAPDA), and WAPDA's East Khairpur Tile Drainage Project).

The essence of project monitoring

The essence of a project monitoring program is twofold: it must assess the impact of the project, and, if necessary, it must find ways of improving the project. Drainage projects can be improved in two ways: by reducing the costs through the application of more efficient techniques, and by increasing the benefits through improvements in the project's production factors.

The effects of a drainage project's production factors can only be fully understood if realistic relationships are established between irrigation, drainage, groundwater flow, depth to watertable, soil salinity or alkalinity, crop response, and farming systems. The only way to establish such relationships is on the basis of surveys of actual field conditions, observations of actual developments after project implementation, and on comparisons with conditions before the project and outside it. One therefore needs to know the before/after situation, the with/without situation, and the inside/outside situation.

Book knowledge, theoretical conceptions, experience from elsewhere, and generalized methods can certainly be useful in the stages of a project feasibility study, initial design, and start of the project. During those stages, however, numerous assumptions have to be made, many of which may prove to be wrong. Reality has all too often proved to be altogether different from what one had expected, and no theory is able to beat the facts.

A monitoring program is a fact-finding program, and the facts to be found in drainage-project monitoring lie in the sciences of groundwater hydraulics, surface-water hydraulics, hydrology, engineering, soil/water chemistry, and agronomy. And then, because the natural conditions in agricultural lands vary - both in time and space - all the facts found must be subjected to a proper statistical analysis, which must include confidence statements about the estimates of magnitudes and relationships.

Questions to be answered

A monitoring program of drainage projects should answer such questions as:

~ Was the pre-project assessment correct?
~ Was the problem correctly quantified (in terms of depth of watertable, salinity, crop yield, farming practices, and the relationships between these factors)?
~ Were causes and effects properly analyzed?
~ Were the drainage criteria (e. g. required depth of watertable) correct?
~ Is the drain discharge as was expected?
~ Are the hydraulic properties of the soil as were expected?
~ Is the irrigation system functioning as was expected?
~ Was the project executed according to design, and was the design correct?
~ Do the drain spacings conform to the design, and are they adequate?
~ Do the drains have the correct depths and gradients, and are they adequate?
~ Are the drain diameters correct, and are they adequate?
~ Was the filter material applied properly, and is it adequate?
~ Were the structures, manholes, and sump pumps constructed properly, and do they function effectively?
~ Did any specific problems arise during execution? If so, did they affect the time schedule?
~ Are there any possible alternatives for the execution or design?

~ What were the costs of execution, and could they be reduced?
~ Could any of the specifications be advantageously modified?
~ Have conditions for agriculture improved?
~ Have the watertables in the area been sufficiently lowered? If not, what remedy can be suggested?
~ Have the salinity levels of the soils been sufficiently reduced? If not, what remedy can be suggested?
~ Is sufficient leaching taking place? If not, what remedy can be suggested?
~ Are the farmers willing and able to make full use of the improved conditions?
~ Are their irrigation practices adequate?
~ Are they making good use of the drainage system?
~ Have crops responded to the lowered watertables or to the reduced salinity levels? If so, to what extent? If not, what explanation can be offered?
~ Have cropping intensities increased or have cropping patterns changed as a result of the project? If so, due to which factors?
~ Are there any noticeable negative side effects from the project?
~ What are the average costs of the project (investment, operation, maintenance) per ha of cultivated land, and what is the financial/ production benefit?

This list of questions is not exhaustive, and many of the questions exert an influence on others, but any comprehensive monitoring program ought to be able to provide clear-cut answers to the questions that are posed.

Methods of monitoring cannot be uniquely defined. A certain ingenuity is required to find methods that suit the prevailing conditions. Much depends on the analytical abilities of the monitoring staff. During the WAPDA/ILRI Monitoring Course, a variety of methods were demonstrated.

Pilot areas, experimental plots

If a large drainage project is being planned, much valuable information can be obtained by monitoring pilot areas in advance of the project. If these areas contain experimental plots in which various drainage designs, techniques, and materials are applied, they can provide the planners, designers, and executors of the large project with guidelines that may lead to a less costly and more effective project.

Staffing of monitoring programs

The staff required for a monitoring program will, of course, depend on the size of the area that is to be monitored and on the complexity and number of questions that are to be answered. These factors will also decide the duration of the program.

As monitoring is a multidisciplinary exercise, the staff selected to work in such programs should preferably be persons with a wide range of experience, rather than specialists in narrow fields. If necessary, staff should be trained to recognise the basic relationships that exist.

It speaks for itself that they should be provided with the necessary equipment and transport facilities, and be backed up by competent office staff for data processing and report writing.

Conclusion

Monitoring programs are not a popular activity anywhere in the world. One reason for this, perhaps, is that they can produce embarrassing results. Another possible reason is that people tend to regard them as too expensive, or that they 'waste' expertise that could be better employed elsewhere. But the cost of a monitoring program is negligibly small compared with the cost of a project, whereas the results produced by the program can yield immense benefits in terms of cost reduction or the discovery of alternative solutions to problems. Moreover, monitoring programs can provide excellent opportunities to train staff in the many facets of agricultural engineering that are inherent in irrigation and drainage.
In fact, experienced monitoring officers may ultimately become qualified to assume responsibility for policy-making and planning.

On the next pages there are examples of results of monitoring crop yields versus soil salinity to find the tolerance thresholds.

From H.J. Nijland and S. El Guindy, Crop yields, watertable depth, and soil salinity in the Nile Delta, Egypt. In: Annual Report 1983, International Institute for Land Reclamation and Improvement (ILRI), Wageningen, The Netherlands.

(one feddan is approximately 0.4 ha)

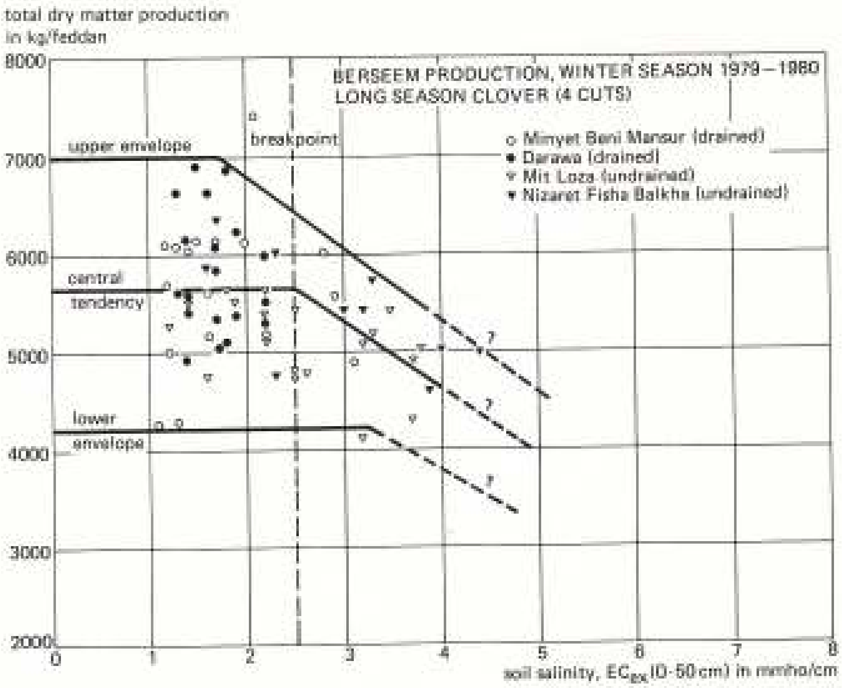
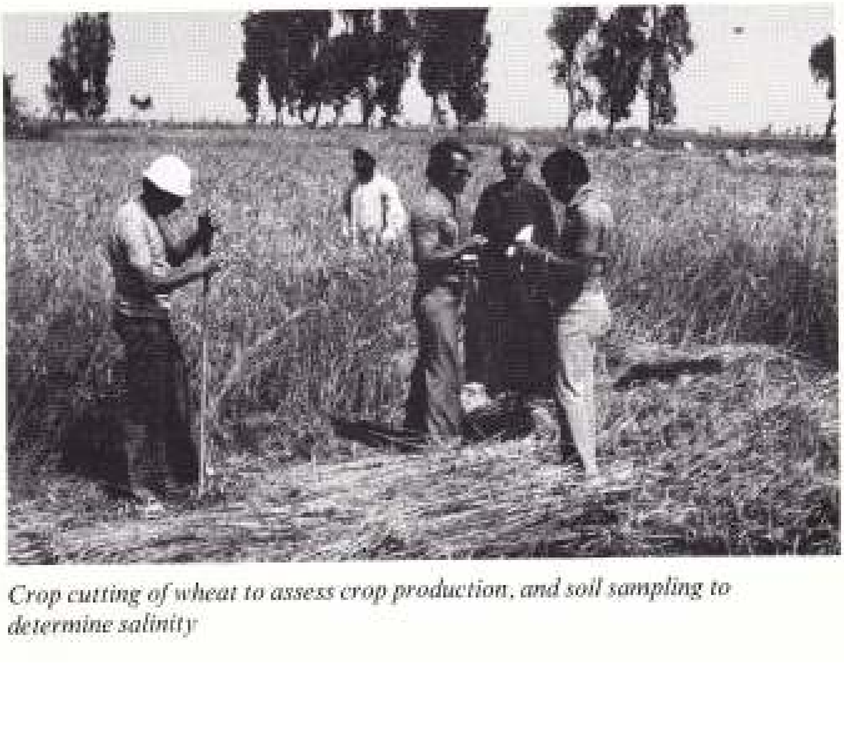


Figure 4. Relation between berseem yield and soil salinity during the growing season



Crop cutting of wheat to assess crop production, and soil sampling to determine salinity

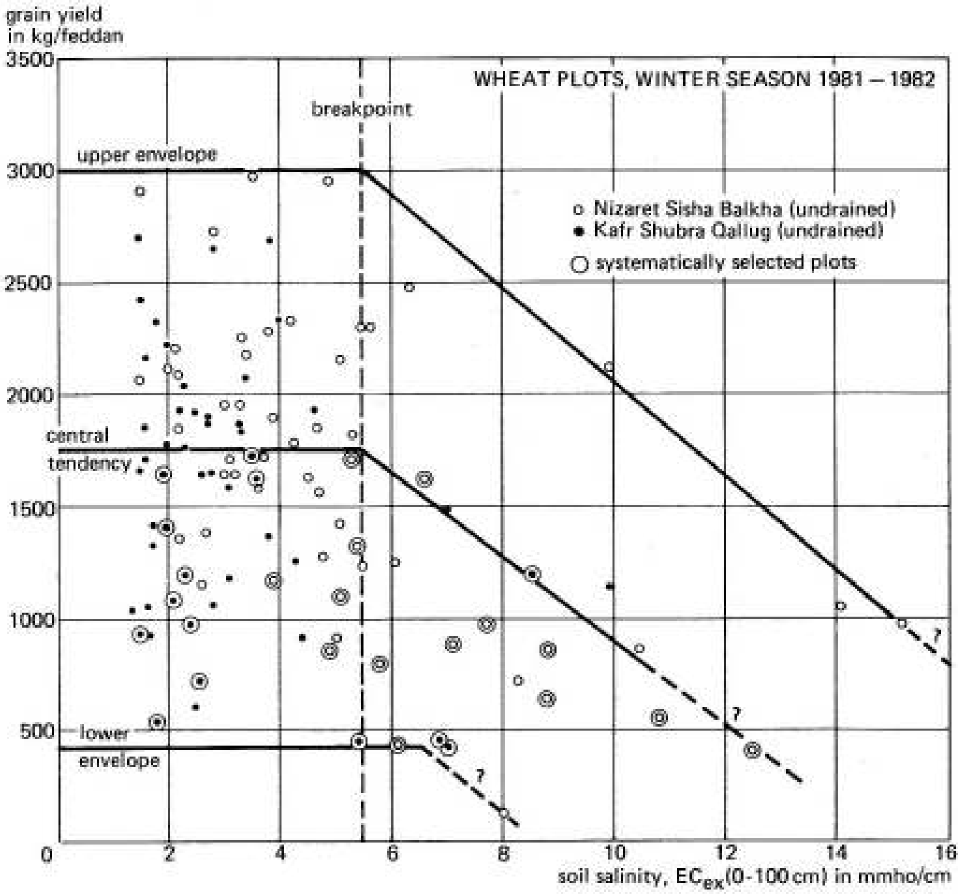


Figure 5. Relation between wheat yield and soil salinity at harvest date

Rice

The farmers grow the short-grain or Japonica type of rice, the predominant variety being Nahda. Rice nurseries are prepared in May and the rice is transplanted in June. The harvest starts mid-October.

Figure 6 shows the relation between the rice yield in the village Mit Loza and the top soil salinity. As in the earlier figures, a clear breakpoint is found: this time at a salinity level of EC_{ex} = 3.5 to 4.0 mmho/cm. Up to this level an average grain yield of 2,400 kg/feddan can be obtained. If the top soil salinity increases, yields decrease sharply. From EC_{ex} = 3.5 to 7.5 mmho/cm, the grain yield decreases about 1,000 kg/feddan. This means that, if the soil salinity increases one unit in this range, yields decline about 250 kg/feddan. The samples were taken at random, and if we look at the number of observation points, we can conclude that in Mit Loza the rice fields of about 40% of the area could be improved by salinity control.

Maize

Maize is the major coarse grain in Egypt and it is used extensively in bread for human consumption, especially in rural areas. It is planted from the end of May to mid-June and is harvested from mid-September to mid-October. The relation between the grain yields of maize in three villages – Kafr Shubra Qallug, Darawa, and Minyet Tukh – and the soil salinity is presented in Figure 7.

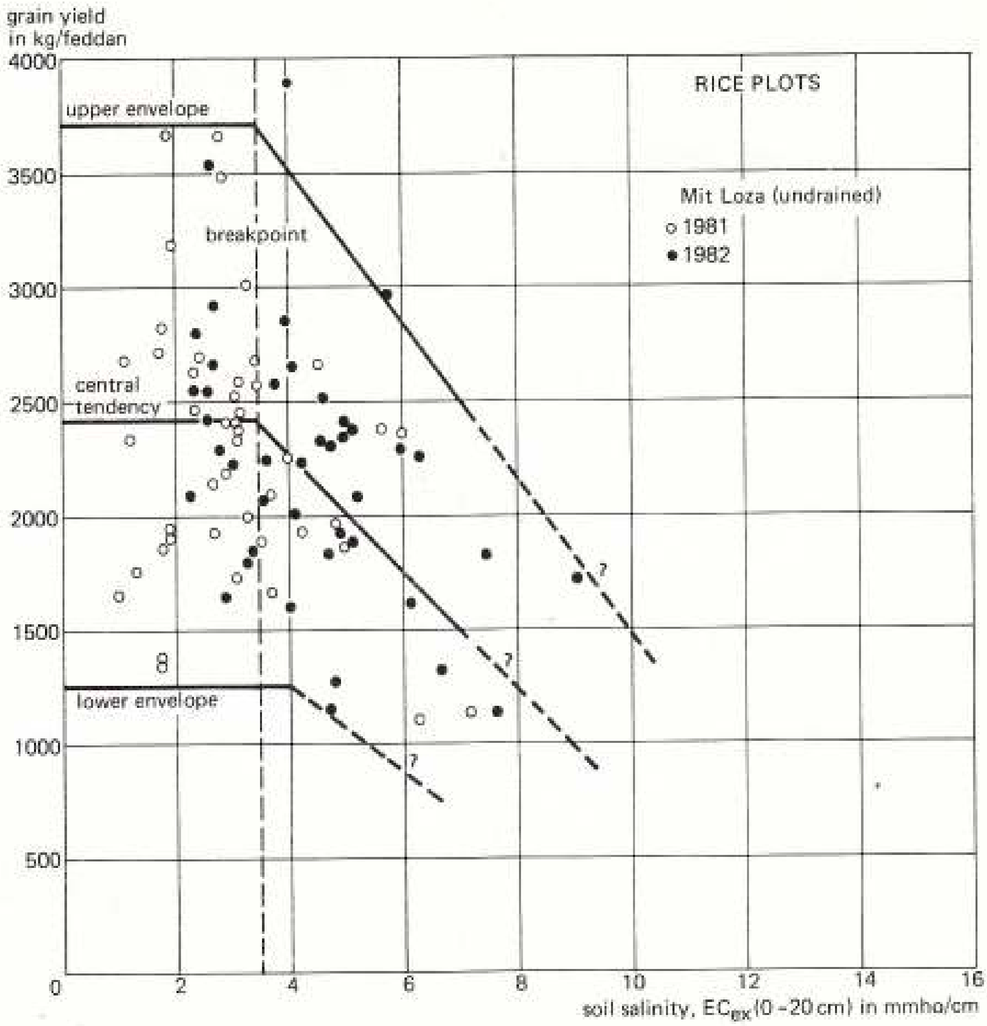
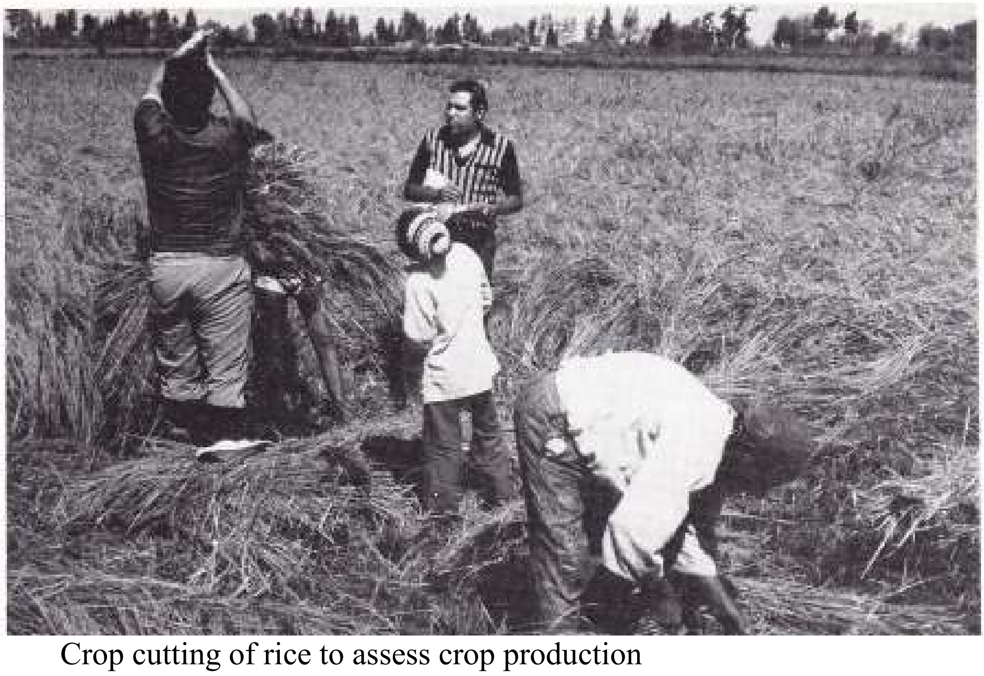


Figure 6. Relation between rice yield and soil salinity at harvest date



Crop cutting of rice to assess crop production

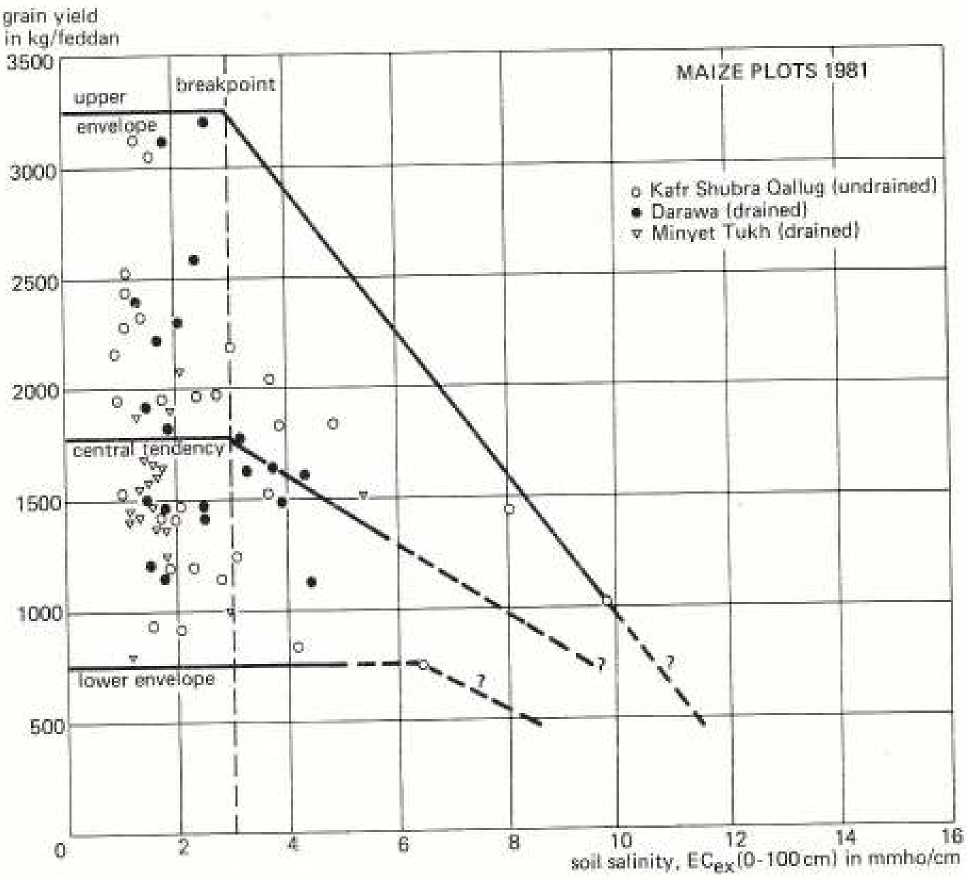
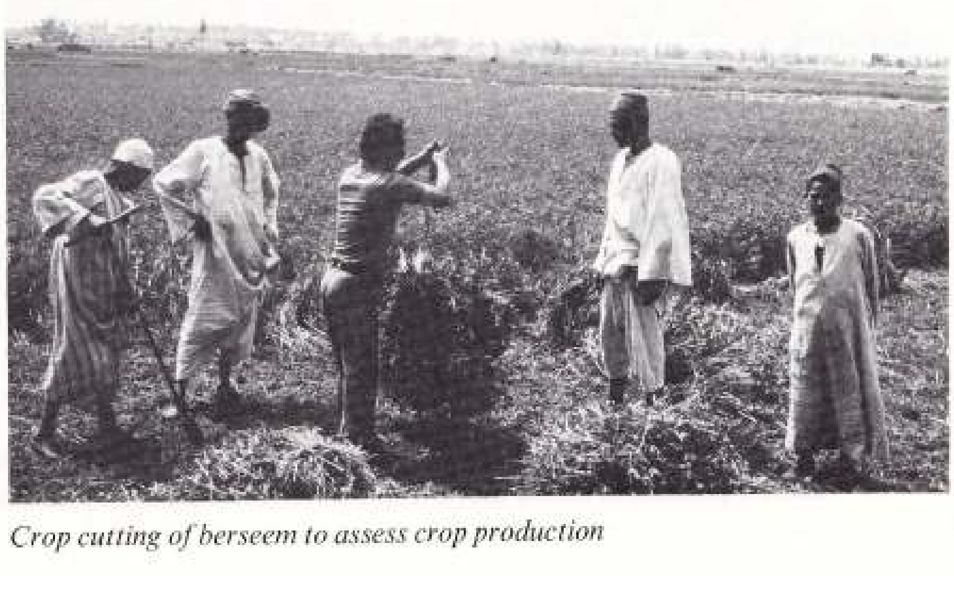


Figure 7. Relation between maize yield and soil salinity at harvest date



Crop cutting of berseem to assess crop production

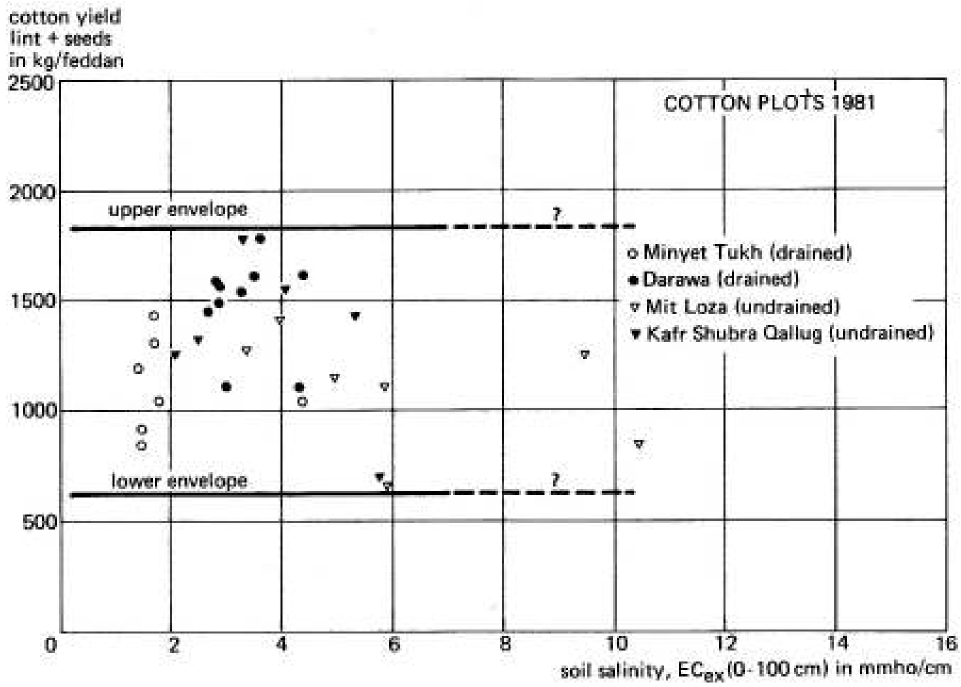


Figure 8. Relation between cotton yield and soil salinity

The breakpoint is found at an EC_{ex} = 3.0 to 4.0 mmho/cm, the average grain yield being approximately 1,800 kg/feddan in the range EC_{ex} = 0.3 mmho/cm. In the range EC_{ex} = 3 to 5.5 mmho/cm, yields decline from 1,800 to 1,350 kg/feddan. If the EC_{ex} value in this range decreases 1 mmho/cm, the grain yields of maize increase by 180 kg/feddan.

Cotton

Figure 8 presents the relation between soil salinity and cotton yield in the summer season of 1981. From this figure it can be seen that soil salinity exerts no influence on the yields in the range EC_{ex} = 0 to 7 mmho/cm. Lack of data beyond EC_{ex} = 7 mmho/cm makes it impossible to indicate the breakpoint.

Conclusions

The data collected under the Crash Program have allowed various conclusions to be drawn. For example, the data on the relation between watertable depth and crop yields show that cotton is more sensitive to high watertables than wheat; with average watertable depths of less than 90 cm during the growing season, cotton yields decline. Although no data on maize and berseem are available yet, literature data would seem to indicate that these crops are less sensitive to high watertables. It is therefore justified to conclude that the design criteria presently used by the Egyptian Public Authority for Drainage Projects (EPADP) – i.e. that field drains be installed to lower the watertable to at least 1.0 m – provide an adequate watertable level for all crops grown.

For four of the five main crops grown in the Nile Delta, the Crash Program made it possible to derive the yield decreases at soil salinity levels exceeding the threshold value. This information is presented in Table 2, which shows