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Research Needs for Aquatic Plant Management in Developing Countries

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ABSTRACT

Excessive growth of aquatic weeds limits the sustained performance of many tropical irrigation and drainage systems, with consequent reductions in food and fiber production. A priority theme for the International Program for Technology Research in Irrigation and Drainage (IPTRID) is to improve technologies for channel maintenance which includes aquatic plant management. Field research, technology transfer and training initiatives with emphasis upon the needs of developing countries are required to achieve effective and affordable weed control in irrigation systems. New techniques and adaptations of cost-effective technologies are considered necessary to sustain effective operation and maintenance. Practical solutions for use by developing country irrigation operators are likely to be enhanced by interdisciplinary networks and closer collaboration between scientists, engineers and managers, a primary role of IPTRID.

Key words: irrigation, drainage, maintenance, control, channels.

INTRODUCTION

Population growth and changing food habits pose a major challenge for agricultural production in the 21st Century. Annual yields in irrigated agriculture will have to increase by 3% to meet future demands for food and fiber (World Bank/UNDP 1990). At present a significant proportion of the total global output of wheat and rice is from irrigated agriculture. In 1986, 73% of the gross irrigated area of the world, 253 million ha, was in developing countries. Future yield growth will depend largely on the improvement in productivity of existing irrigation systems since there are limits to expansion of land for irrigation in many parts of the developing world. Moreover, competition from nonagricultural uses is increasingly limiting the quantity of water available for irrigation.

Concern about the poor performance of developing country irrigation systems has been growing for some time with calls for new initiatives and action on policy, management and technology to secure the promised benefits of irrigation (Sagardoy 1982, Le Moigne *et al.* 1989, 1992, ICID 1989). To give new focus to technology, the International Program for Technology Research in Irrigation and Drainage (IPTRID), cosponsored by the United Nations Development Program (UNDP), the World Bank and the International Commission on Irrigation and Drainage (ICID), was created in 1991. IPTRID is a cooperative venture of development agencies and professional bodies in developed and developing countries aimed at promoting and strengthening adaptive technology research in the developing world. While IPTRID does not undertake or finance research, it does assist organizations and developing countries in identifying research priorities and stimulating collaborative research and technology transfer by means of networking and human resource development. Attention is focused on three priority themes, modernizing irrigation and drainage systems, ensuring sustainable land and water use, and improving technologies for maintenance.

IMPACT OF AQUATIC PLANTS ON IRRIGATION

Worldwide, irrigation development has created several million kilometers of delivery canals and main drains (excluding farm channels). Unlined channels provide an excellent environment for aquatic plant growth, with stable water levels and flows, moderate depths (1 m to 3 m), clear water (usually), and a good supply of nutrients. Even in some lined systems it is not unusual to find aquatic plants growing through cracks in the lining or in sediment deposits. Aquatic plants can impede flow and reduce the capacity of the channels to convey water to or from an area. Vegetation growth can lead to water being lost from the reservoirs or channels through increased evapotranspiration and exacerbated seepage. Aquatic plants also pose problems to human health by providing habitats for the vectors of schistosomiasis and malaria.

Many irrigation designs have not taken adequate account of the potential for aquatic weed growth with the result that operational targets cannot be achieved and weed control becomes an excessive burden on already limited maintenance budgets. The control of excessive vegetation growth is now one of the major maintenance tasks facing irrigation and drainage engineers. In Egypt, 78% of the maintenance expenditure

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in 1983/84 was for the removal and control of aquatic plants. Expenditure in that year on excavation, which includes weed cutting and removal, and chemical treatments was equivalent to U.S.$1100/km/year for a combined length of 39,400 km of canals and drains. Data from the Egyptian Ministry of Public Works and Water Resources indicate that the total maintenance budget has increased by 20% per year since 1987/88. Expenditure on contracts for sediment and weed control has grown by 50% per year over the same period.

Maintenance budgets in developing countries still appear to be inadequate for aquatic plant control. For example, in Pakistan, McLoughlin (1988) calculates that the operation and maintenance (O&M) expenditure for irrigation in 1985 probably needed to be four times the amount actually spent to achieve effective control. In Thailand, Plusquellec and Wickham (1985) found that equipment, manpower and budget were all insufficient to carry out maintenance work to the required standard. In many countries inefficient and inappropriate technologies, such as heavy construction equipment and the misapplication of herbicides (Brabben 1988), continue to be used resulting in the need for remedial work which in turn jeopardizes the performance of the irrigation systems and reduces crop yields.

There is little economic analysis and no effective literature about operations and maintenance (McLoughlin 1988). The economic, environmental and social impact of the lack of maintenance or ill-timed, inadequate weed control on irrigation efficiency, equity of water distribution and reliability of supply is not clearly quantified. Quantification of the benefits of maintenance and the costs when it is inadequate is an important step toward planning and managing maintenance activities. Maintenance activities can be more effective if technological improvements with better managerial and institutional arrangements are researched and applied (ICID 1989).

RESEARCH NEEDS

Irrigation and drainage maintenance often receives attention only when construction is complete. Without some operational experience of the system in question there is a tendency to be too optimistic about future system performance. More attention to the establishment and revision of the maintenance plan over the first few years of operation is required. In this way siltation and weed growth can be recognized and their impact gauged with timely identification of the need for further investigation of cost-effective control solutions.

A key factor in implementation of an irrigation maintenance plan is to know how the irrigation or drainage system is functioning. Technical information is needed to determine the hydraulic performance of the system, for which simple and reliable diagnostic methods are required. Background knowledge of how channel systems deteriorate is also relevant so that the correct or optimum level of resources for maintenance can be planned and allocated before deterioration increases beyond repair. For aquatic plants, the aim is to anticipate problems by implementing regular control programs. To be effective irrigation agencies require information or guidance on the effectiveness of particular control actions.

However, in most irrigation communities managers do not always have the information and guidance to make decisions based upon the latest practical technological research. Up-to-date information on machines and herbicides has to be more fully disseminated. The research community has to explain clearly the impacts of different weed control activities and provide policy makers with practical, widely applicable, longer term, biological methods.

Maintenance can involve specialized tasks but may not be carried out properly due to a lack of skilled personnel in existing operational organizations. Large irrigation and drainage undertakings should be able to afford technologically advanced hardware and invest in staff training. However the growing desire to pass the operation and maintenance to farmer groups or water users associations means that it is unlikely that these groups can make such operational investments. Sophisticated maintenance requirements will be beyond the reach of most farmer groups or individual farmers unless high technology solutions can be made manageable.

With adequate training and equipment, the use of herbicides can be safe and effective in most irrigation and drainage channels. However, in many developing countries, these conditions cannot be assumed. Suitable alternative methods integrating a variety of approaches, but offering a flexible response, are probably best for such situations. Egypt, due to environmental concerns over the use of herbicides by unskilled labor, banned herbicides for use in, on or around water channels in 1991. To deal with the aquatic plant problems in the future, existing mechanical and biological methods have to be either extended by the Egyptian engineers or other techniques have to replace what was previously done with herbicides. In the Sudan Gezira, aquatic plants constitute a major constraint to the irrigation system. Sudan's policy has been to emphasize chemical control. However, there is no concrete evidence in Sudan to show that chemical control is superior to any other method either theoretically, economically or environmentally. Other techniques which are more sustainable need to be reviewed for use in Sudan (Ahmed and Abdulla 1992).

Considerable high quality research on the botany of particular aquatic plant species and on ways to control their spread has been undertaken worldwide. There is still a need, though, to develop, adapt and integrate these research results into techniques that can be applied and sustained on developing country irrigation and drainage systems given the constraints commonly experienced in these locations, limited access to foreign exchange, inadequate supervision and poorly functioning equipment.

If plant control is to be sustained, one approach could be to make canals and drains less suitable environments for aquatic vegetation. A principle of seeking to mimic nature may be appropriate like discouraging the growth of plants in sensitive areas by constructing deeper channels and providing shade (Brookes 1988 and Gardiner 1991). These "soft engineering" techniques, now being used by some river engineers in the USA and northern Europe, can potentially minimize weed control requirements. The construction and management of "environmentally acceptable channels" can provide hydraulically acceptable channels with reduced maintenance costs and a positive environmental impact (HR Wallingford 1988 and Fisher 1992). To be successful these methods will require a better understanding of the plant's growing cycle. "Professionals should recognize the characteristics of physical and biological systems which enhance sustainability" (Gardiner, in press). Guidance on the various techniques and their costs will have to be researched and developed if they are to be adopted by maintenance engineers in developing countries.

The partial cutting of aquatic plants from boats is now practiced as routine in some north European countries (Pitlo 1986). This has the advantage of speed, achieves an adequate conveyance, maintains a diverse aquatic environment and gives savings in cost by reducing staff, machine hours and material handling. Cutting vegetation from the bed of the channel gives the same hydraulic performance as a complete cut of the whole channel and does not involve as much material handling. The maintenance engineer needs guidance to decide on how much plant material to remove from a channel cross-section to achieve desired hydraulic objectives at minimal cost.

Cutting or herbicide applications to pre-empt the growth in the next season may also offer the potential for reducing costs (Westlake and Dawson 1986, 1988). Savings of between 30% and 50% in the annual cost of aquatic plant cutting may be possible. Adaptation of such techniques on irrigation and drainage channels offers the potential to make more effective use of manpower and machines. The research input of aquatic plant specialists in collaboration with irrigation engineers is needed to make this part of a routine maintenance plan.

Research is also needed to identify the most appropriate machinery for aquatic plant cutting and adapt it for use by farmers/farmer groups (IPTRID 1991a, 1991b). Pilot studies in Mexico and Egypt could be envisaged that make practical use of aquatic plant managers from developed countries in twinning arrangements to provide guidelines on how to choose and adapt off-the-shelf machines and herbicide techniques.

Biological control of submerged aquatic vegetation using grass carp (*Ctenopharyngodon idella* Val.) and the use of insects (*Neochtina bruchi* Hustache, *N. eichhorniae* Warner, etc.) to control floating plants have been shown to be effective in many locations (Pieterse and Murphy 1990). However, these methods do not give instantaneous results, unlike cutting or dredging, and engineers and farmers are reluctant to use them for this reason. Under favorable conditions 90% of water hyacinth plants (*Eichhornia crassipes* (Mart.) Solms.) can be controlled by insects within 3 yr (Harley 1990). Clear demonstrations of the benefits, in financial and environmental cost terms, are still required to convince skeptical users. How such methods can be more widely used and incorporated into maintenance activities will require an interdisciplinary approach.

With the increased interest in environmental management the use of West Indian Manatees (*Trichechus manatus* Linnaeus) to control vegetation has been proposed in Surinam where they occur naturally. Reports from Guyana (Haigh 1991) indicate success in keeping channels clear; in general though, little information appears to be available on how to keep and use manatees without endangering them. However in Florida, Etheridge *et al.* (1985) found that manatees were inefficient as control agents. More pilot studies, building on the experience from Guyana and Florida will be needed to develop management guidelines for concurrent plant control and manatee conservation.

Aquatic plants can be harvested and used for fiber and building materials or as food for farm animals or directly for human consumption (National Academy of Sciences 1976). In particular, the removal of water hyacinth plants has yielded source material for compost, fodder, fiber and biogas. In some pilot studies sale of plant material products has helped allay the costs of control and removal, with varying results. Techniques to ease handling and drying require continued research and application if maintenance costs are to be recovered in part.

Information about the susceptibility of particular plants to variations in environment, light, velocity of water, temperature of water and competition from nearby species is not well known by irrigation and drainage engineers (Dawson and Brabben 1991). Application of this knowledge for different approaches to aquatic plant control is worth considering in some circumstances. There is scope for existing networks, such as the Aquatic Plant Management Society, and the

European Weed Research Society to involve more engineers and increase the dissemination of relevant research to the developing world perhaps by working more closely with the ICID and other non-governmental organizations. The establishment and strengthening of networks bringing practicing maintenance professionals together with researchers from the hydraulic, biological and engineering professions, to provide the necessary transfer of knowledge and experience, is vital if irrigation and drainage systems in developing countries are to be sustained.

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