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USE AND LIMITATIONS OF SPRINKLAR AND DRIP IRRIGATION SYSTEMS IN PAKISTAN

Dr. Muhammad Mehboob Alam, Dr. Muhammad Nawaz Bhutta, Dr. Aftab H. Azhar

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ABSTRACT

Efficient use of water for agriculture production is highly emphasized by the Government of Pakistan due to limited available water resource to meet the growing need of ever increasing population. In Pakistan, the irrigators have been using traditional surface irrigation for more than a century which has caused not only waterlogging resulting from over-irrigation but also deprived the users of already short irrigation water. In Pakistan, yield per unit of water is the lowest in the world. Research in sprinkler and drip irrigation conducted so far in Pakistan, India and abroad has shown that these method lead not only to appreciable saving of water but also result in achieving higher crop yields as compared to surface irrigation methods. Although, these systems are characterized with high initial investment costs, these can be offset by saving in water and increase in production. There is a need to introduce these efficient irrigation systems in new water resources development projects, especially in those canals where surface water will be available for a couple of months. This will help to increase productivity of land and water. It will also alleviate poverty in those areas and reduce the ill effects of over irrigation.

The main objective of this paper is to highlight the scope of these systems in Pakistan due to limited available water resources and constraints of the adoptability of these systems.

Various research and development organizations in Pakistan have introduced and demonstrated the benefits of sprinkler and drip irrigation technologies, however, success is very limited with respect to adoptability of these systems by the farmers. The main reasons include low cost of canal water, lack of farmers' participation to build their confidence as they are not used to operate and maintain these systems, high initial cost, local availability of systems and back-up support and limited capacity of manufacturers with respect to quantity, quality and efficiency of these systems.

[1] Director, Director General and Junior Engineer, International Waterlogging and Salinity Research Institute (IWASRI), Near Village Muhammad Pura, Thokar Niaz Baig, Raiwind Road, Lahore, Pakistan. Phone: +92-42-5303390, FAX: +92-42-5303393, Email: drmehboobalam@hotmail.com

Use and limitations of sprinkler and drip systems have been demonstrated under an experimental project. Farmers response under various situations and lessons learnt have been highlighted. Promoting concept of 'more crop per drop' has been encouraged for enhancing water use efficiency and water productivity under National Water Policy. It has been recommended that areas under new and on-going irrigation development projects may be given high priority with respect to promoting the sprinkler and drip irrigation technologies through command area development with the help of Farmers Organizations. New areas have been identified. It is hoped that wide scale demonstrations of sprinkler and drip irrigation technologies, in the water scarcity area of Pakistan, will significantly enhance the water productivity and farmers' return.

INTRODUCTION

Land and water are the two essential factors required for agricultural development and economic advancement of a country. Nature has bestowed Pakistan with abundant water resources. However, due to limitations of topography, geology, physiology, dependability, quality & the present state of technology, only a part of available water resources can be utilized. The utilizable water for irrigation is further limited considering other competing demands for domestic & industrial uses.

The farmers have been using traditional surface irrigation for more than a century which has caused tremendous loss of not only the productive land due to waterlogging resulting from over-irrigation but also deprived the users of already short irrigation water. Further, yields per unit of water in Pakistan are the lowest in the world. There is a need to maximize the per unit production of water. This challenge can only be fulfilled by better & efficient use of these two natural resources. Adoption of advanced irrigation water saving methods like drip and/or sprinkler can help to achieve this goal.

Drip irrigation is a method in which water is supplied to crops at "specific point" usually at the base of the plant. This method uses a network of pipes ending with small emitters to give water to the plant roots. Whereas, sprinkler (or overhead) irrigation is a method of distributing water in pipes under pressure, and spraying it into the air so that it breaks up into small water droplets and falls to the ground like natural rainfall. As pressurized irrigation systems have better uniformity & higher application efficiency; higher crop yields can be obtained with these methods.

The drip/sprinkler systems are suitable where traditional surface irrigation methods do not work properly. For example in desert and hilly terrains pressurized systems can work quite satisfactorily (Bhutta & Azhar, 2005). The drip/sprinkler system can also be used with gravity flow where hydraulic head is available, reducing the initial cost. Such locations are available in northern areas, NWFP and Balochistan.

A comparison of pattern of moisture availability to crops under different irrigation methods is graphically shown in Figure 1. As can be observed, the soil moisture contents remained much closer to the *field capacity* (optimum growth) level in drip & sprinkler systems as compared to other traditional surface irrigation methods.

Research studies have indicated that the water saving is about 40-70% and the yield is increased by 10-100% for various crops, if the drip method is used (INCID, 1994). Drip irrigation is being used on a large scale for various crops such as: *Tree crops* - citrus, deciduous, avocado/mango, olives/nuts, nurseries & others; *Vines* - grapes & other; *Vegetables* - field, greenhouses; *Flowers* - nurseries, greenhouses; *Field crops* -cotton, sugarcane; Other & unspecified crops. The

worldwide coverage of different crops in terms of percentage of the total drip irrigation area is graphically shown in Figure 2.

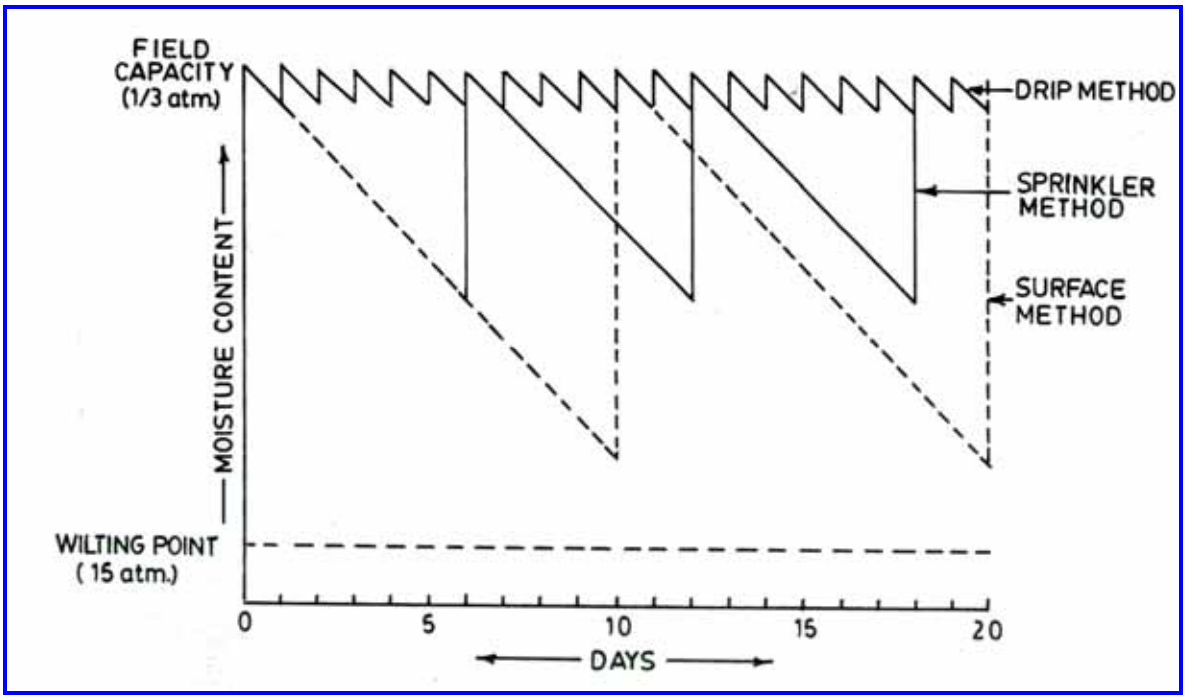

Figure 1: Soil Moisture Availability to Plants under Various Irrigation Methods (INCID, 1998)

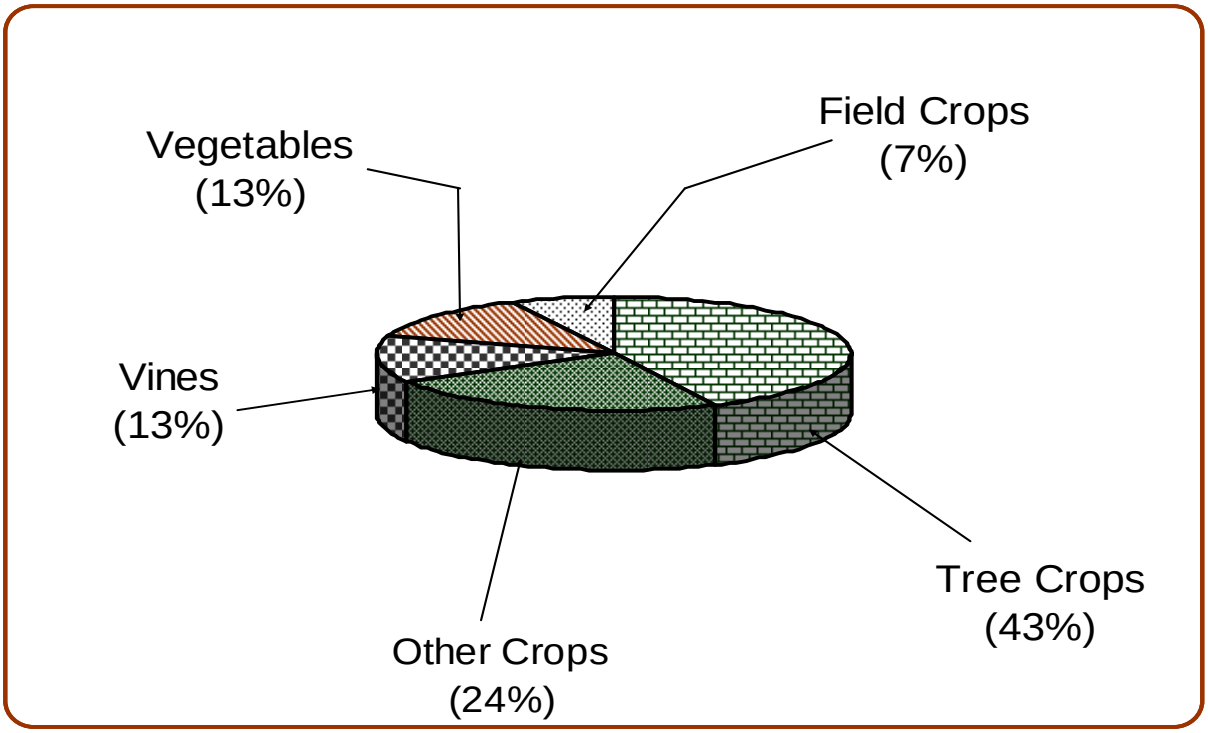

Figure 2: World-wide Crop Coverage by Drip/Trickle System (INCID, 1994)

As can be observed (Figure 2), drip system is practically best suited for tree-crops such as orchards and wide spaced high value crops. Field crops cover only 7% area. Based on this worldwide notion, it is justified to state that there is no denial of the fact that drip irrigation system is more remunerative to the farmers than the traditional/conventional irrigation methods.

OBJECTIVES

The objectives of this paper are to:

i) Review the state of use of drip and sprinkler irrigation systems in Pakistan,

ii) Identify the gaps in technical and social acceptability of these systems by farmers, and

iii) Identify the potential areas and recommendations for the use of drip and sprinkler irrigation technologies.

LITERATURE REVIEW

Drip Irrigation System

Now a day, drip irrigation technology in the world is under varying degrees of development and being practiced by over 60 countries, both developed & developing, throughout the world. The ICID Working Group on Micro Irrigation through their world-wide survey conducted for the leading countries of the World in 1991, arrived at a figure of 1.785 m.ha as the area under drip irrigation, with the highest figure of 0.606 m.ha in USA and the lowest figure of 20 ha in Ecuador, with India 0.071 m.ha (INCID, 1994). In Israel, the entire area is now irrigated through drip. In USA, large areas under citrus & deciduous grape, sugarcane cotton etc. are being irrigated through drip. Similar pattern is noticed in Australia, Southern Europe and other countries.

Water savings:

According to CWC (1991), irrigation efficiency in drip system was adjudged to be more than 90% as compared to about 65% in the case of sprinkler and about 30-50% in the case of lined distribution of conventional method of irrigation. Another experimental study in India reported by CWC (1991) showed that as compared to conventional method, the saving of water in the drip irrigation, varied from 27% for tomato to 59.8% for sugarcane. Ahmad and Ahmad (1993) reported a water saving of 80% with drip system in Pakistan. Other research studies conducted by various institutions in India as reported by INCID (1994) revealed that the water saving by drip irrigation was ranging from 40 to 70% over surface irrigation with a yield increase as high as 100% for some crops in specific locations. In addition, the saline water could, also be used in this system and the salt is accumulated only at the surface of the periphery of wetting zone and hence does not affect the growth of the crop. The experiments conducted by MREP-IWASRI showed

water savings of 85% for citrus crop using drip system as compared to farmer's traditional method. Therefore, the potential of this system was considerably high in the country (Rafiq and Alam, 2004).

Yield increase:

According to a survey (Padhye, 1990), the increase in crop yield as compared to flood irrigation was higher in drip irrigation than sprinkler irrigation. The percent increase in yields of coconut, coffee, sugarcane and vegetables using sprinkler method was 14%, 17%, 11% and 9-30%, whereas, using drip system was 29%, 39%, 20% and 20-80% respectively, as compared to traditional flood methods. It was also found that saving in power, water labor & annual cost of maintenance was higher in drip irrigation than sprinkler method. An experimental study in India (CWC, 1991) showed that in case of drip irrigation as compared to conventional method, the increase in crop yield varied from 5% for sugarcane to 27% for cotton depending upon the crop. The studies conducted in Pakistan indicated that water use efficiency (yield per unit of water) could be increased by 50% or more with the use of drip irrigation as compared to surface irrigation systems (Moshabbir et al., 1993). Also the research results in the USA as reported by the same authors indicated that trickle irrigation increased cotton yield by more than 8% while using 24% less water as compared to surface irrigation. Trickle irrigation was also effective in controlling the return flow volume and maintaining relatively low salinity levels in the soil adjacent to the emitters. The experiments conducted at MREP-IWASRI research fields using drip system in Bhalwal area has shown an increase in productivity per unit of water as 450% for citrus crop as compared to farmer's traditional method (Haque et al., 2005).

Benefit/cost ratio:

The B/C ratio for drip system in India as reported by INCID (1994) excluding the proportion of water saving was ranging from 1.31 to 2.60 for various crops excluding grapes. In case of grapes, it is about 13.35. If water saving was also taken in to account, the ratio went up from 2.78 to 11.05 for various crops and 30.00 for grapes. This fact accounted for the economic logic of entrepreneurial grape farmers to go/decide for the drip system on an extensive scale.

Saline water use:

INCID (1994) has reported that highly saline water could be used in drip method of irrigation and the salt accumulation at the surface of the periphery of wetting zone would prevent the development of osmotic stress in the root zone. With regard to salinity, drip irrigation had an advantage as it kept the soil moisture continuously high at-least in the root zone. Therefore, a low salt concentration level was maintained in the root zone due to daily irrigation, which leached away the salts to the outer periphery. Asghar et al., 2004 has

reported that timing of the irrigation is the most important factor when irrigation management includes salinity consideration.

Sprinkler System:

A total area under sprinkler irrigation in the world was about 21 58 m.ha. by 1990 (INCID, 1998) having the USA the largest user of sprinkler irrigation technology with area of 8.57 m.ha. A good example of sprinkler is the Saudi Arabia where extensive centre-pivot sprinkler irrigation development has made the desert blossoming. There are 25,000 centre–pivot irrigation systems irrigating over 1.2 million hectares of desert lands where crop yields have been reported to be comparable to those obtained in developed countries (Latif, 1990; Keller, 1990). In India, the area irrigated by sprinkler irrigation is 2,50,000 ha. Similar beginning is already made in the Potohwar plateau of Pakistan to provide supplemental irrigation to Barani lands (Yasin et al., 2004). The sprinkler/drip system can be used with gravity flow where hydraulic head is available, reducing the initial cost. Such locations are available in northern areas, NWFP and Balochistan.

Water Savings:

With regard to water savings, previous studies have reported the savings in irrigation water ranging from 46 to 65% (average 59%) in Pakistan by Latif (1990); and in India 29 to 56% (average 51%) by Malhotra (1984) for various crops. An average saving of 50% means that irrigated area could be increased to 1.5 times of the existing area without any increase in water allocation. On saline soils, sprinklers are recommended for better leaching and crop germination. As reported by Yasin et al. (2004) the water required for reclamation was reduced to one-third with sprinkler irrigation compared to the traditional surface irrigation. The local experiments conducted at MREP-IWASRI research fields using sprinkler irrigation system in Bhalwal area has shown water savings of 56% for wheat crop and 59% for maize crop compared with farmer's traditional method (Rafiq and Alam, 2004).

Yield increase:

In many cases, sprinklers have shown increase in yield, such as in the fresh vegetables & fruits where color & quality is very important (Kay, 1988). With sprinkler, an increase in yield up to 20% was reported in Pakistan by Latif (1990), and 11 to 30% for India (INCID, 1994 & 1998). It is reported by many researchers that quality of produce has also improved using sprinkler irrigation with some exception. A timely irrigation with sprinkler system applying only a few centimeters of water at a critical crop growth stage can offer more than double yield. Thus economics of sprinkler irrigation is very attractive (Ahmad et al., 2004). MREP-IWASRI installed sprinkler irrigation system in Bhalwal area, which has shown the increase in productivity per unit of water as 103% for wheat and 130% for maize crop as compared to farmer's traditional method (Rafiq and Alam, 2004).

INCID, 1998 has reported that benefit cost ratio ranged from 2.0 to 2.5 for maize-wheat crop rotation using sprinkler irrigation system.

MATERIALS AND METHODS

State of the Art of Pressurised Irrigation in Pakistan

Drip Irrigation System

During the 1980s many research and development (R&D) organizations exerted efforts to introduce drip/trickle irrigation system in the country. All those efforts were based on the use of imported materials, higher installation costs, lack of services and skills. Later on those R&D organizations were entrusted to promote indigenization of drip irrigation system in the country using local skills, technology & materials. Consequently, in collaboration with the Plastic Technology Centre (PTC), Karachi and GRIFFON Industrial Corporation, Lahore, the indigenization process has successfully been completed, and commercial production has been initiated. Similarly, high-pressure centrifugal pumps of 2 lps, 4 lps, 6 lps and 8 lps capacity were designed & indigenized in collaboration with MECO Pvt., Lahore. This company now manufactures pumping systems for any configuration of pressure and discharge. The pumping systems are available with electric motor or diesel engine (Moshabbir et al., 1993). Drip irrigation installations include the FAO supported Deciduous Fruit Development Centre, Quetta, demo plots by ADBP, coconut farms Uthal, demo plots by PARC and PCRWR and demo plots by MREP-IWASRI WAPDA at Bhalwal and Ghazi Bharotha Hydropower Project. According to an estimate over 500 ha area is under drip irrigation in Pakistan. Recently, Government of Balochistan has started Area Development Program with the assistance of the UNDP to provide technical support in collaboration with farmers for sprinkler/drip systems. At present, the appropriate technology, skills & services are available to install standard trickle/drip irrigation systems, which will be used in the future for large-scale adoption of trickle irrigation in the country. The farmers are convinced about the usefulness of the system, but the adoption is rather slow due to the high investment costs of the system with recurring O&M costs that include energy charges a well.

Sprinkler Irrigation System

In Pakistan, sprinkler irrigation is being introduced, and the locally developed sprinkler systems have been tested & demonstrated at various places in the country. The results achieved are quite encouraging (Asghar et al., 2004). Furthermore, progressive farmers are importing sophisticated systems such as centre pivots and linear move sprinkler machines (Figure 3). Farmers, particularly those of water scarcity areas, have shown keen interest in this technology. It is hoped that introduction of this technology, particularly in the water scarcity areas of Pakistan will significantly enhance farmers return and will shorten the gap between demand and supply.

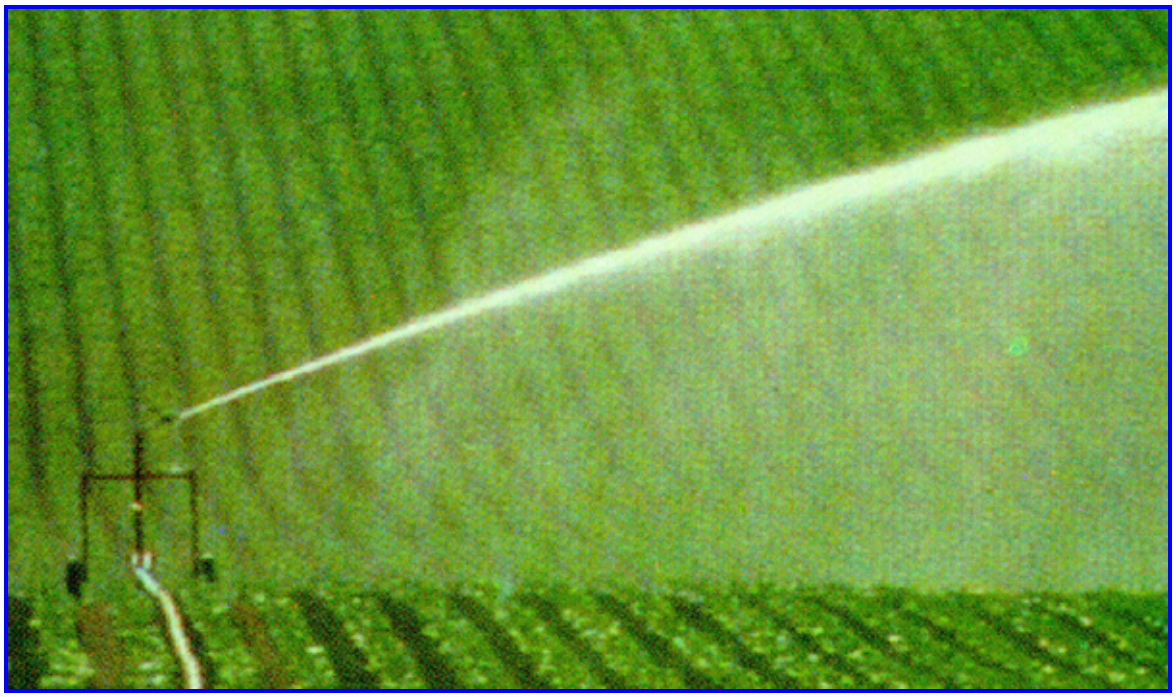

Figure 3: Portable Raingun Sprinkler System Irrigating the Row-Crops

Most of the system components of sprinklers have been successfully manufactured in Pakistan. MECO Pvt. Ltd., Lahore developed a complete range of Raingun sprinkler systems using locally available materials and technology. The high-pressure low-density (HPLD) polyethylene pipes with black carbon and UV stabilizers are being produced in Pakistan. These are available in different diameter sizes, which can be used for pressures up to 120 psi (Asghar et al., 2004). In the near future, other low-pressure systems will also be developed (Ahmad et al., 2004). Many big companies e.g. DADEX Eternit, Engro Asahi and Popular Pipes etc. have been entered in this business. So far, the R&D institutions at a limited scale have promoted sprinkler and drip irrigation technologies, however, involvement of big companies may help in promoting these technologies at a commercial scale for adoption by the farmers.

TECHNICAL AND SOCIAL PARADIGM

Advantages & Limitations of Drip System

Like any other irrigation method, drip system also has its own advantages & limitations with specific reference to socio-economical, technical and crop production factors as described below:

Advantages

Water Savings: In drip system, due to partial wetting of the soil volume, reduced surface evaporation, decreased run-off & controlled deep percolation losses, the water use efficiency is as high as 90 to 95% compared to only 40 to 50% in the conventional furrow or flood irrigation

Improved Plant Growth & Yield: Slow & frequent watering eliminates wide fluctuations in soil moisture content resulting in better growth and yield. It has been reported that drip irrigation increases the yield from 10 to 230% depending upon soils and crops over conventional methods of irrigation (INCID, 1994).

Labor & Energy Savings: There is considerable saving in labor, as the well-designed system needs labor only to start or stop the system. Because of high irrigation efficiency much time is not required to supply the desired quantity of water, thus, it also saves energy.

Suitability to Poor Soils: Very light soils are difficult to irrigate by conventional methods due to deep percolation of water. Like-wise, very heavy soils with low infiltration rates are difficult to irrigate even by sprinkler method. However, drip irrigation has been found successful in both types of soils.

Weed Control: In drip method, due to partial wetting of soil, weed infestation is very less in comparison to other methods of irrigation.

Economy in Cultural Practices & Operations: Besides achieving effective control of weeds, it also increases the efficiency of other operations like spraying, weeding, harvesting etc. There by reducing the operational costs even up to the extent of 50%.

Use of Brackish/Saline Water: High soil moisture content due to frequent irrigation and lesser water requirement up to even 60% than surface method keeps saline concentration below the detrimental level.

Enhanced Fertilizer Application Efficiency: In drip system, because of reduced loss of nutrients through leaching & run-off water and also due to localized placement, the fertilizer use efficiency can be improved considerably.

No Soil Erosion: There is no soil erosion due to drip irrigation.

No Land Preparation: For drip system, preparation of leveled bed, bund and channels is not necessary, only land smoothening will suffice.

Minimum Diseases & Pest Problems: In drip system, because of less atmospheric humidity minimum diseases and pest problems are observed.

Limitations

Notwithstanding the observed advantages, there are certain limitations inherent with the drip systems that have been observed for some soils, water qualities and environmental conditions. These are described as below:

Extensive maintenance requirement: Emitter clogging is considered as the most serious problem in drip irrigation unless preventive measures are taken, which could be expensive. Apart from this, slat & chemical deposits can accumulate plugging the discharge openings. Clogging can adversely affect the rate & uniformity of water application, increased maintenance costs (as it becomes necessary to check, replace or reclaim the clogged emitters), and result in crop

damage & decreased yield, if not detected early & corrected timely. Other maintenance problems may include pipeline leaks and cracking of the tubes. Rodents, rabbits, dogs, etc. can chew & damage drip line; and ants & other insects have occasionally enlarged opening in drip tubing. Drip lines can be cut or dug-up accidentally when weeding, when replacing or repairing other pipelines or utilities in nearby areas. Filters, chemical injectors, pressure regulators, water meters and pumps are also subjected to malfunctioning and liable to theft.

Salinity hazards: Although drip system can be used under saline conditions, it must be managed properly. Otherwise reverse pressure gradients in the soil will cause flow of salts towards plant root with the resulting detrimental effects.

Economic and/or technical limitations: As equipment requirements are extensive in drip irrigation, initial investment & annual costs can be high when compared with surface or portable sprinkler irrigation systems. The actual costs will vary considerably depending on the type of crop, grades of pipelines, filtration equipments, fertilization equipments etc. The high initial cost of drip system is not unfortunately within the easy reach of small and marginal farmers.

High skill requirements: High skill is required for designing the installation and subsequent operation. The technical improvement in the designs of emitters, fittings, filters, etc. has been necessary. The development procedures for preventing or correcting emitter clogging & equipment failure have been difficult; and the development of the proper methods for injection of fertilizers & other chemicals has sometimes been a problem. A higher level of design, management & maintenance is required with drip than other irrigation methods.

Advantages and Limitations of Sprinkler Irrigation System

One of the major advantages of sprinkler irrigation is that this system is suitable where traditional surface irrigation methods do not work. For example in desert and hilly areas sprinkler system can work quite satisfactorily (Bhutta and Azhar, 2005). A good example of this is the Saudi Arabia where extensive sprinkler irrigation development has made the desert blossoming. Sprinklers are especially desirable where soils have a high permeability and/or low water holding capacity. Sprinklers can offer distinct advantages over other irrigation methods in dense soils with low permeability. On saline soils, sprinklers are recommended for better leaching and crop germination. In areas where labor & water costs are high, sprinklers can be the most economical way to apply water. The drip/sprinkler system can also be used with gravity flow where hydraulic head is available, reducing the initial cost. Such locations are available in northern areas, NWFP and Balochistan.

Sprinklers often have multiple uses. The same equipment can be used for irrigation, crop cooling, frost control, and the application of pesticides, herbicides and fertilizers. MREP-IWASRI installed sprinkler irrigation system in Bhalwal area which has shown water savings of 57% & an increase in productivity per unit of water as 125% for wheat crop, and 57% saving of water & 131% increase in

productivity per unit of water for maize crop as compared to farmer's traditional method.

The sprinkler irrigation systems have high initial cost in addition to its operation and maintenance expenditure.

Comparison of Drip / Sprinkler Systems with Traditional Methods

Water Savings

In this regard, previous studies have reported the savings in irrigation water with sprinkler system ranging from 46 to 65% in Pakistan, and in abroad 29 to 65% for various crops. Similarly with drip system, irrigation water savings of 83% in Pakistan and in abroad ranging from 27% to more than 90% have been reported. Experiments at MREP showed water saving of 36% with Zero Tillage and 43% with Bed and Furrow Method. These methods are less cost intensive with least maintenance as compared to sprinkler and drip irrigation systems. As such these methods are more attractive to the farmers.

Crop Yield Improvements

In sprinkler/drip systems, fertilizers & pesticides can be mixed with water and applied, and hence the efficiency of these inputs for crop production is more when compared to the gravity irrigation method. In this regard, previous studies have reported the increase in the yields with sprinkler system up to 20% and in abroad ranging from 9 to 30%. The increase in water use efficiency (i.e. yield per unit of water) with sprinkler ranging from 125 to 131% in Pakistan has also been reported. Similarly with drip irrigation system, the increase in yield ranging from 5 to 80% in abroad has been reported, whereas, in Pakistan with drip system, an increase in water use efficiency for citrus fruit up to 450% has been reported as compared to traditional methods. Zero Tillage and Bed and Furrow Methods can help in yield improvement within 8%.

Social Acceptibility of Sprinkler/Drip Systems by Farmers

Farmers in the country are tune to the traditional flood irrigation system. The innovations such as bed and furrow irrigation and zero tillage have gained popularity recently. however, sprinkler and drip irrigation systems are not gaining popularity due to various factors such as high initial cost of the system, non-availability of parts and technicalities involved in the operation and maintenance of the system. The situation can be improved by providing the training and technical support to the farmers, local maintenance and repair facilities and cheaper availability of systems and spare parts can help in improving the large scale use of sprinkler and drip system.

Farmers Training

Since the farmers are not tuned to the sprinkler and drip systems, therefore, their training to use and maintenance the system is necessary to enhance the water saving and crop yield. Agriculture extension departments can provide these services

to organize such training at local level. The regular training sessions can help the farmers to adopt these systems.

Technical Support

Indigenous capacity building at local level is essential to provide cheaper maintenance and repair facilities. Initially the support can be provided by the Agricultural Extension Department. However, roadside mechanics and mechanical workshops should be established and strengthened for easy excess of the farmers.

Manufacturing and Local Availability of Parts/Systems

Presently very limited companies and manufacturer are available in the country for providing sprinkler and drip systems and their spare parts. Mostly, the systems and their parts are also imported that make the systems very costly. To cut down the initial cost of the systems, their manufacturing in the country and availability at the local level may be ensured.

Dissemination of Results

For wider acceptability, it is essential that the dissemination of advantages and use of new technologies may be made properly. Unless the beneficiary (i.e. farmer) is properly educated about the merits and limitations of an innovation, the adoption process becomes not only difficult but also quite often the innovation is actively resisted. Hence, to harvest the real benefits of sprinkler and drip irrigation technologies, the community involvement must be ensured.

Institutionalized Efforts of Government of Pakistan

The Govt. of Pakistan has put concerted efforts toward development and management of water resources. For this purpose the government has approved the National Water Policy under Mid Term Development Framework 2005-10 (GOP, 2005). The fresh water conservation has been accorded the highest national priority. In the choice of conservation technology diligent care shall be exercised to select the technology that; has a proven record of performance, is the least cost option, has the potential to generate multi-benefits and is environment friendly. The National Water Policy prescribes an Integrated Water Resources Management Regime having one of the objectives with respect to conserving and optimizing water use efficiency. Irrigation and land reclamation is one of the priority areas of the policy. The key elements of the policy with respect to irrigated agriculture are;

i) Strategies and Action Plans shell be prepared to ensure Food Security for the people of Pakistan, and these shell be vigorously and diligently pursued.

ii) The concept of “More Crop per drop” shell be pursued by, among others, the following;

   a) A national plan to enforce improved irrigation methods and practices;

b) Extensive research in developing crops with high yields and lower water consumption and water saving techniques.

iii) The concept of participatory management of irrigation system shall be promoted in the shape of Farmers' Organizations (FOs) to enable the irrigation stakeholders to participate effectively in the decision-making processes.

iv) Ground watertable shall be so managed that it does not impede crop growth or causes land salinity or underground salt-water intrusion.

v) Private investment shall be promoted in irrigation and drainage sectors.

The National Water Policy adequately supports the use of water conservation technologies in the area of irrigated agriculture.

Identification of Potential Areas

Switching over to the sprinkler and drip irrigation on the existing agricultural areas may be intricate and time consuming as it requires not only convincing the farmers to install the systems but also have implications with respect to full grown orchards and laying of the systems on existing agricultural crops.

Implementation of sprinkler and drip irrigation systems may be easier if institutionalized and made mandatory in the new areas being developed for agriculture under the new and on-going water resources and irrigation projects. Many such projects are identified under WAPDA Vision 2025 (WAPDA, 2002) are listed in Table 1. Under these projects an area of 3.493million acres will be developed for agriculture. The government may enforce such policies, which make the installation of sprinkler and drip systems mandatory under command area development of on-going and new irrigation projects.

Table 1: Irrigation Development Projects Under WAPDA Vision 2025

Sr. No.	Name of the Project	Location	Agricultural Area (Million Acres)
	ON-GOING PROJECTS		
1	Gomal Zam Dam	NWFP	0.163
2	Mirani dam	Balochistan	0.033
3	Greater Thal Canal	Punjab	1.560
4	Rainee Canal	Sindh	0.304
5	Kachhi Canal	Balochistan	0.713
6	Satpara Dam	Baltistan(Skardu)	0.020

7	Kurram Tangi Dam	NWFP	0.085
8	Sabakzai Dam	Balochistan	0.025
9	Raising Mangla Dam	AJK	0.000
		Total	2.903
	NEW PROJECTS		
	Small and Medium Storage Sites	Balochistan	0.067
	Small and Medium Storage Sites	Sindh	0.044
	Small and Medium Storage Sites	Punjab	0.119
	Small and Medium Storage Sites	NWFP	0.360
		Total	0.590
		Grand Total	3.493

CONCLUSIONS AND RECOMMENDATIONS

Sprinkler and Drip irrigation technologies are relatively new in Pakistan. There is a lot of potential in these technologies because of the water scarcity in the foreseeable future. The following conclusions have been drawn based on the analysis given in the paper.

CONCLUSIONS

i) Sprinkler and drip systems are costly and beyond the affordability of small medium farmers.

ii) The systems and their spare parts are not readily available from the local markets.

iii) Only a limited number of manufacturers, suppliers and technicians are available in the big cities.

iv) There is a lack of indigenous capacity and technical support to the farmers for installation and O&M of the sprinkler and drip systems.

v) The Govt. of Pakistan has provided the environment and policy for the water conservation and management.

RECOMMENDATIONS

The following recommendations have been made.

i) The government should build the local capacity keeping in view the National Water Policy with respect to irrigated agriculture.

ii) Technical and financial support systems may be promoted through the Action Plans with respect to manufacturing of cost effective systems,

their installation, O&M, availability of spare parts and training of farmers etc.

iii) The key players with respect to providing the technical support are OFWM and Agriculture Extension Dept., manufacturing agencies, research institutions and farmers organizations/NGOs.

iv) Farmers Organizations being institutional/representative body of farmers can play a vital role in coordination and interaction among the farmers and technical support services organizations for provision of the needed support services.

v) Areas under new and on-going irrigation development projects may be given high priority with respect to promoting the sprinkler and drip irrigation technologies. It should be made mandatory to install these systems under the command area development.

vi) Farmers in the others areas may also be encouraged and motivated for installation of sprinkler and drip systems.

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