The Journal of Animal & Plant Sciences, 21(2): 2011, Page: 215-219
ISSN: 1018-7081

SUBSURFACE DRAINAGE IMPACT ASSESSMENT ON CROP YIELD

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ABSTRACT

This study was conducted during 2001-04 in which four subsurface drainage projects viz; Mardan SCARP Project (MSP), Fourth Drainage Project, Faisalabad (FDP), Chashma Command Area Development Project (CCADP) and Mirpurkhas Tile Drainage Project (MTDP) were assessed for their impact on crop yield in irrigated areas of Pakistan. Quantitative comparison made on the change in pre- and post-project conditions revealed that crop yield significantly improved due to project implementation at all sites. The yield increased from 13 to 94% for most crops. The exception was rice, where it decreased by 23% at MTDP due to shortage of irrigation supplies. Maximum yield increase was observed in CCADP for cotton (80%), sugarcane (94%), wheat (67%); and at MSP for rice (46%). For chilli the maximum increase (147%) was observed at MTDP study site. Low increase in the yield was attributed to the shortage of irrigation supplies during the post-project periods. Limited sub-irrigation resulting from the operation of subsurface drainage systems was also observed to be another factor for low crop yields. Overall quantitative comparison indicated a positive impact of drainage system installation in terms of crop yield improvements.

Keywords: subsurface drainage, water logging, salinity, impact, crop yield.

INTRODUCTION

After the introduction of canal irrigation system, agricultural lands of Pakistan have suffered the menace of water logging and salinity. The Government of Pakistan (GOP) put a great emphasis to control this problem in early sixty's and a considerable part of the past investments (~ Rs.37 billions) has gone to remedy this situation (Azhar *et al*., 2004a). The subsurface drainage technology was introduced in Pakistan about three decades ago to control waterlogging and salinity; and up to the year 2000, eight drainage projects have been completed in various provinces of Pakistan. Different aspects of drainage systems have been investigated by various researchers in the past (e.g., Bhutta *et al*., 1995 and 1996; Iqbal *et al*., 1997; IWASRI, 1997; Azhar *et al*., 2004a). However, no systematic effort has been made to analyse the data of these systems in terms of "*improvement evaluation"*. The exception was a comprehensive study conducted by Kahlown *et al.*, (1998) regarding the waterlogging, salinity and crop yield relationships only for Fordwah Eastern Sadiqia, South (FESS) Project, Bahawalnagar of Punjab province. Keeping in view the huge investments incurred and the benefits attached with these projects, there is a great need to evaluate the performance of these systems and to suggest improvements for future drainage systems. As such, the reported study was conducted by the International Waterlogging and Salinity Research Institute (IWASRI) under National Drainage Programme (NDP) where four subsurface drainage projects were assessed for their impact on improvement of irrigated agriculture conditions. For this purpose, various performance indicators were investigated. Previous studies (Azhar, 2010; Azhar et. al., 2010 a; Azhar and Alam, 2010) presented other performance indicators; however, in this paper the analysis of performance indicator viz. *crop yield* has been discussed.

Study area: Four sites viz: MSP, CCADP (*KPK*), FDP (*Punjab*), and MTDP (*Sindh*) were selected for this study. These sites were selected based on their wide range of geohydrological and climatic conditions. In addition, these sites cover a range of old (i.e. MSP) as well as most recently installed (i.e. FDP and MTDP) subsurface drainage systems in different provinces of Pakistan. This range of selection would facilitate to evaluate the performance of subsurface drainage systems that were designed using old and new technology. The salient features of these four selected project sites are given in Table 1. For details of these sites, the reader is referred to Azhar *et al*. (2004b).

METHODOLOGY

In this study only one impact/performance indicator i.e. *crop yield* has been discussed. Crop yield is the function of many variables such as farm management, system of land tenure, soil potential, quality of irrigation water, provision and supply of farm inputs, credit facilities and extension efforts in disseminating modern technology etc. From the performance point of view of the drainage system operation, crop yields are generally expected to increase with the installation of subsurface drainage

system. For this analysis, relevant data were collected from various sources such as WAPDA, Provincial Irrigation and Power Department, Agricultural Department, and through forty farmers' interviews conducted by the IWASRI staff. The required data were collected for two stages i.e., *before* and *after* the installation of drainage system. The collected data were first screened for their integrity, and then analysed in various ways to assess the success of drainage project based on above stated performance indicator. In this study, for quantitative comparison between pre and post-project conditions, the pre-project value of crop yield was used as the *base value* for respective site.

Table 1. Salient Features of Selected Subsurface Drainage Projects

DESCRIPTION	MSP	FDP	CCADP	MTDP
Gross area (ha)	50,020	52,609.	63,509	36,165
Tile drainage area (ha)	29,542	30,351	60,936	24,281
Installation period	1983–92	1988–94	1984-94	1994–97
Mean annual rainfall (mm)	542	356	250	150
Design water table depth	140 cm	122 cm	140 cm	122 cm
No. of units/sumps	385	79	65	52
Type of outlet	Gravity	Pumped	Pumped	Pumped
Executive agency	WAPDA	WAPDA	WAPDA	WAPDA
Major crops (Kharif)	Maize, fodder sugarcane, vegetable, rice	Sugarcane, grains, cotton, fodder, rice	Sugarcane, vegetable and fodder.	Sugarcane, cotton, mango, rice, maize
Major crops (Rabi)	Sugar-beet, wheat, fodder, vegetable	Wheat, sugar-cane, fodder, oilseeds	Wheat, fodder	Wheat, fodder Sugarcane, mango
Consultancy	Harza NESPAK	USBR	Harza NESPAK	Mott. Macdonald
Total costs (PC-I)	Rs 673 million (1981)	Rs 1127 million (1987)	Rs 1127.800 million (1983)	Rs 2473 million (1993)

(After Azhar et al., 2004b)

RESULTS AND DISCUSSION

The impact on crop yields of various project sites is discussed below.

MSP Area: At MSP, following the installation and operation of drainage system crop yields were envisaged to increased. The pre-project (1982-83) and post-project (2003-04) average yields of major crops are graphically presented in Figure 1. The crop yields with prefix '*' symbol are shown at 1/10th reduced scale to fit in the figure. There was a significant increase in the yield as compared with the base year's conditions. The post-project change in crop yields for this site is shown in Figure 2. Increase in rice, sugarcane, kharif fodder, wheat, sugar-beet and tobacco yield was 46, 49, 50, 56, 43 and 23%, respectively.

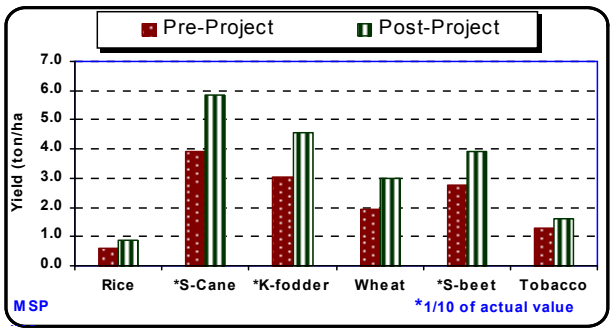

Fig. 1. Pre and post-project yields of major crops at MSP Area

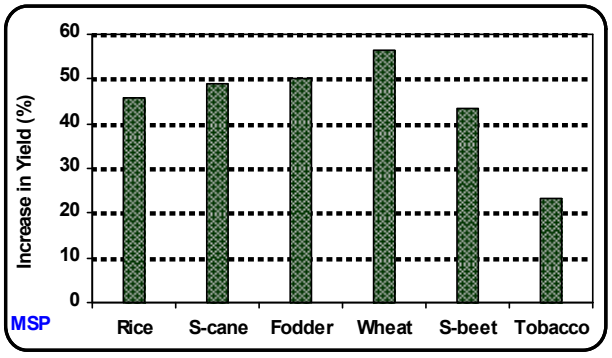

Fig. 2. Percentage increase in yields at MSP area

FDP Area: In FDP, during the first five years of the project operation, crop yields were planned to increase by 11 to 14% and expected almost similar trend all over the project (WAPDA, 2001). Based on the farmer's interviews, the base year's (1986-87) and 2003-04 yields of major crops at FDP area are graphically shown in Figure 3. During the post-project period an increase in the yields of almost all crops was achieved as compared with the base year's conditions. In Fig.3 the yields of crops with prefix '*' symbol are shown at 1/10th reduced scale just to fit in the figure. The post-project change in crop yields at this site is explicitly shown in Figure 4 which displayed a significant increase in the yields of rice

(26%), sugarcane (83%) and wheat (62%) crops, whereas the increase was relatively low for cotton (13%), kharif fodder (14%) and rabi fodder (13%). This shows the positive impact of drainage system on crop yields in this area. As was anticipated at FDP, almost all the crops achieved their planned yields.

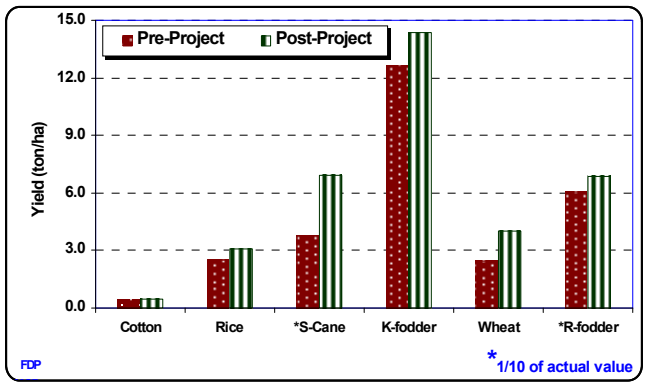

Fig. 3. Pre and post-project yields of major crops at FDP area

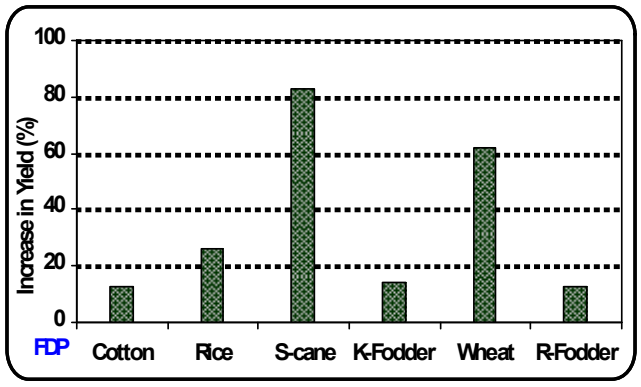

Fig. 4. Percentage increase in yields at FDP

CCADP Area: Like other project sites, following the installation of drainage system at CCADP crop yields were also envisaged to increase. The pre and post-project yields of major crops of this area are graphically presented in Figure 5. It can be observed from this figure, during the post-project period (2003-04), significant increase in the yields of almost all the crops was achieved as compared with the pre-project (1982-83) period. In Fig.5 the yields of crops with prefix '*' symbol are shown at $1/10^{th}$ reduced scale just to fit in the figure. The post-project change in yields of various crops at this site is shown in Figure 6 which depicted a significant increase in the yields of cotton (80%), rice (45%), sugarcane (94%), kharif-fodder (49%), wheat (67%) and rabi-fodder (37%) crops, whereas in case of oilseed crop the increase was relatively low (20%) indicating the positive impact of drainage system in terms of yield improvement in this area.

MTDP Area: The pre-project (1992-93) and post-project (2002-03) yields of major crops at MTDP as collected through farmer's interviews are graphically shown in Figure 7. During the post-project period, with the exception of rice crop significant increase in the yields of almost all crops was achieved as compared with the base year's conditions. In Fig.7 the yields of crops with prefix '*' symbol are shown at $1/10^{th}$ reduced scale just to fit in the figure. The post-project change in yields of various crops at this site (Figure 8) displayed a significant increase in the yields of cotton (77%), sugarcane (78%), chilli (147%), wheat (66%) oilseed (45%), onion (133%) and pulse (41%) crops, whereas in case of rice crop the yield was decreased by 23% mainly due to limited irrigation supplies as reported by the farmers. Overall, the yield trend of various crops depicted positive impact of drainage system installation in this area.

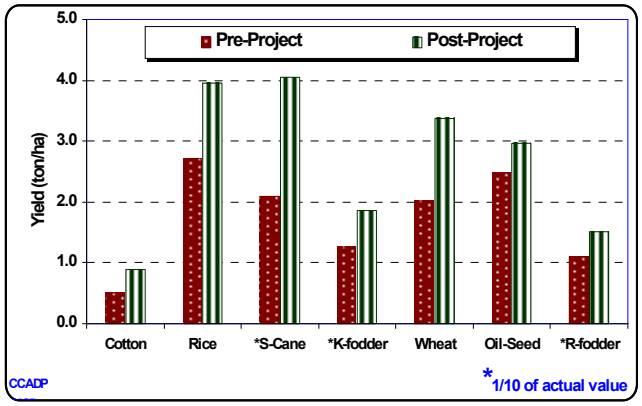

Fig. 5. Pre and post-project yields of major crops at CCADP

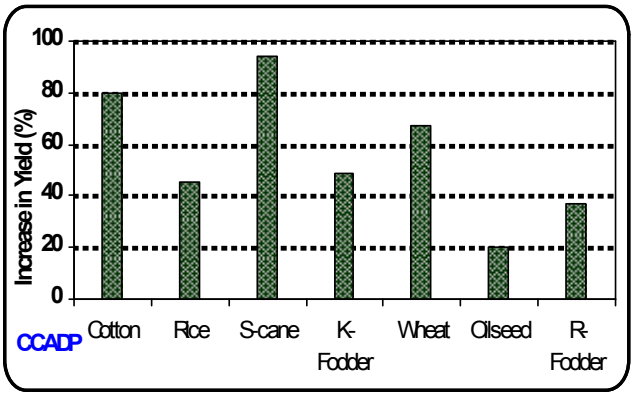

Fig. 6. Percentage increase in yields at CCADP

Overall Comparison: Based on the above quantitative analysis of crop yields at four project sites, it was revealed that there was significant increase in the yields of almost all crops due to project implementation at those sites. The analysis showed that maximum increase in the yields of Cotton (80%), Sugarcane (94%) and Wheat (67%) was at CCADP area. The maximum increase in

yield of Rice (46%) was observed at MSP, whereas for chilli the maximum increase of 147% was observed at MTDP study site. However, some crops showed low increase in the yields. As explained by the farmers, the main reason for low yields was the shortage of irrigation supplies during the post-construction period at those sites. Limited sub-irrigation supplies due to subsurface drainage systems' operation was observed to be another factor responsible for low yields of crops in the study areas. However, the overall quantitative comparison indicated the positive impact of subsurface drainage systems for improving the crop yields at all four study sites. Therefore, it is justified to say that the objectives have been achieved by these projects in terms of increase in crop yields. Nevertheless, the benefits of these projects can further be increased by reviewing the post-project irrigation requirements in those areas.

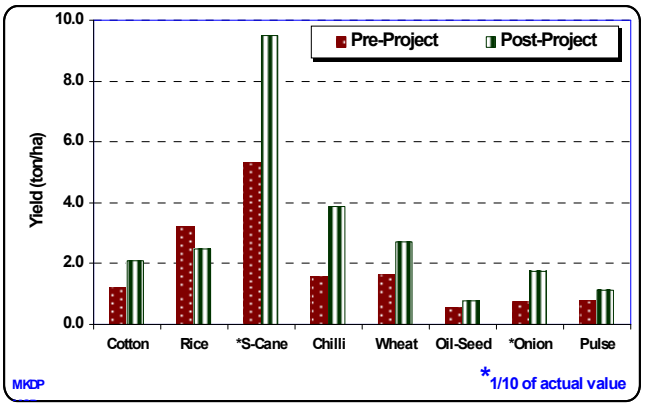

Figure 7.Pre and Post-Project Yields of Major Crops at MTDP

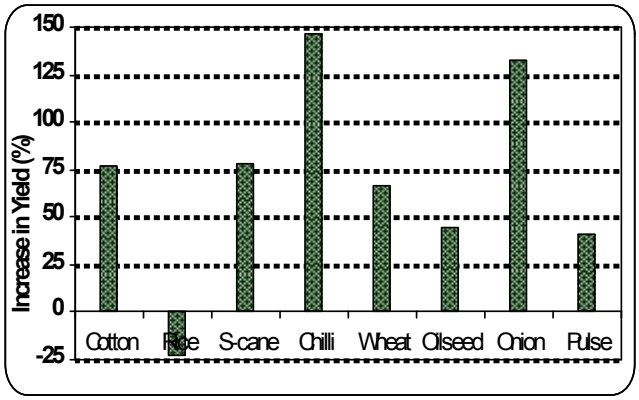

Fig. 8. Post-project change in yields at MTDP

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

i) The crop yield data analysis revealed that the objectives of drainage systems installation have been achieved in terms of improving the crop yields at all four study sites.

ii) At MSP, there was an increase of 46, 49, 56, 43 and 23% in the yields of rice, sugarcane, wheat, sugar beet and tobacco crops respectively, thus showing a positive impact of drainage system on crop yields in this area.

iii) At FDP, during the first five years of the project operation, crop yields were planned to increase by 11 to 14% and expected almost similar trend all over the project. The analysis revealed that this target was not only achieved but it showed an extra upward trend up to 83% for sugarcane crop. At CCADP, during the post-project year, significant increase in the yields of almost all crops was achieved with a maximum trend of 94% for sugarcane crop. Similarly, at MTDP an upward trend of 147% was achieved for the chilli crop.

iv) The yield of cotton crop was relatively low, mainly being plagued with the ever-increasing pest/insect attack.

v) The main reason for low yields of crops was the shortage of irrigation supplies during the post-construction period at those sites. Limited sub-irrigation supplies due to subsurface drainage systems' operation was also another factor for low yields of crops in the areas.

Recommendations

- Subsurface drainage water quality of different drainage projects should also be investigated because shallow water quality plays an important role in crop production and physio-chemical properties of the soils.
- As a result of drainage system operation, irrigation demands of crops are significantly increased due to reduced sub-irrigation supplies. Hence, the post-construction total water availability as well as shortage of irrigation water for the crops grown in different project areas should also be investigated, quantified and carefully reviewed accordingly.

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