Pak. J. Agri. Sci., Vol. 51(4), 867-873; 2014
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

PANCHO-IRRIGATION SYSTEM - A WASTEFUL PRACTICE OF IRRIGATING RICE FIELDS IN THE LOWER INDUS BASIN OF PAKISTAN

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In spite of water scarcity, farmers in the Lower Indus Basin of Pakistan are still using pancho-irrigation system, a system where standing water in the rice fields is drained after every 4-5 days and fresh canal water is applied to replace the drained water. Three systems: (i): pancho (ii) partial pancho that involves partial drainage of standing water occasionally and (iii) non-pancho where water is kept standing throughout the growing period, were tested and evaluated in selected fields. On an average, 408 mm (19%) and 785 mm (59%) excess gross water was applied under pancho irrigation as compared to partial pancho and non-pancho irrigation systems, respectively. The water drained out through rice fields under pancho and partial-pancho irrigation systems was 559 mm and 362 mm, respectively. The net water applied in pancho irrigation was 226 mm and 211 mm higher when compared to partial and non-pancho irrigation systems, respectively. The water table was found to be raised from 1-3 m to 10-20 cm during the rice growing season. The average rice yield was 12-16% higher under non-pancho when compared with pancho and partial-pancho systems. The water productivity of rice under non-pancho irrigation was 17-24% higher as compared to pancho and partial pancho-irrigations systems. The results revealed that by avoiding pancho irrigation, about four billion cubic meters (BCM) water can be saved in one season without compromising the rice yield. Moreover, avoiding pancho irrigation can also help control water logging and salinity in the area.
Keywords: Water-table depth, water logging and salinity, water productivity

INTRODUCTION

The cultivated area of Pakistan is about 30 million hectare (Mha), of which more than 16 Mha are irrigated (Qureshi, 2012). Rice (*Oryza sativa* L.) occupies about 25% of the cultivated area in summer season and 10% of Pakistan's cropping area (Khan *et al*. 2006). During 2006-2007, the overall rice cultivation in Pakistan was 2.58 Mha with 1.73 Mha in Punjab and 0.6 Mha in Sindh (MINFA, 2009). The Basmati rice which is one of the best varieties in the world was planted on 1.47 Mha in Punjab. In Sindh, the entire area was under IRRI-6 (an improved form of a variety developed by the International Rice Research Institute IRRI).
Rice crop is by far the largest user of water in Pakistan. It is usually cultivated by transplanting rice seedlings already grown in the nursery. The seedlings are transplanted in puddled fields, which are then submerged (10-15 cm) under water throughout the growing season. Land preparation consists of soaking, ploughing and puddling.
About 75% and 80% freshwater resources of the world and Asia are being used for rice production (Bouman *et al*., 2007). Freshwater resources of Pakistan, like many countries of the world, are under immense stress. Per capita water availability has reduced from 5300 m^3 to 1000 m^3 over the last fifty years, touching an alarming situation where a country experiences water-scarcity. Under present water-scarcity conditions, it becomes imperative to use water more efficiently and judiciously (Droogers *et al*., 2000; Bouman and Toung, 2001; Molden *et al*., 2010, Ashraf *et al*., 2010).
However, in spite of water scarcity, and disputes among the provinces over water availability and use, it is still being used lavishly. The cultivation of rice with pancho irrigations system in most of the rice growing areas of the Lower Indus Basin is an example of such misuse of water. This system involves draining of standing water from the field at regular intervals (4 to 5 days) to the adjoining low-lying areas and replacement with fresh water. This practice leads to water logging and salinity in the surrounding area (Aslam *et al*., 2002). The farmers use pancho irrigation with the concept that the standing water becomes hot during day time, and it can damage the crop. The farmers also presume that the standing water becomes saline after a couple of days, therefore this water need to be replaced with freshwater.
In some areas, partial pancho irrigation system is also in use. It involves draining of partial amount of standing water from the field occasionally and not at regular intervals as pancho system. A very small number of farmers use non-pancho irrigation in which the water is kept standing in the field throughout the growing period. However, no systematic study has been conducted to evaluate these systems. This study was therefore, conducted to evaluate the effect of these systems on rice production and to address some of the

apprehensions of the farmers in the Lower Indus Basin of Pakistan.

MATERIALS AND METHODS

Nine farmers in Tando Muhammad Khan were selected for this study (Fig. 1). Pancho, partial-pancho and non-pancho irrigation systems were evaluated on three farms each with an area of one hectare. Therefore, three treatments with three replications were studied. The soil at experimental sites was clayey in nature. The rice variety locally known Guard was cultivated. Mostly the nursery was transferred in June and the crop was harvested in October. Fertilizer applications were kept constant on these fields. Phosphorous (P) and potassium (K) and half of nitrogen (N) fertilizer were applied before transplanting and remaining half of N was applied at tillering stage. After 20-30 days of transplanting, zinc sulphate was applied at the rate of 22 kg/ha. As preventive measures against insect attack, Padan granular (the mention of trade name does not imply endorsement by the authors) was applied at a rate of 20 kg/ha. Weeding was done manually twice to maintain weed free plots. Except water, all the other cultural practices and inputs were kept constant in all the treatments. Canal water was used for irrigation and the water applied and drained out was measured by installing cutthroat flumes in the fields. A piezometer was installed in each field to measure the water-table depth before and after rice season. A water-level indicator was used to measure the water-table depth before and after rice season. The electrical conductivity (EC) of the standing and drained water was also measured using an EC meter. Temperature of the standing water was measured at noon with a thermometer. Soil samples were collected up to 60 cm depth at 15 cm interval before sowing and after harvesting. The salient features of the experimental fields are given in Table 1. The average rainfall and pan evaporation

Table 1. Salient features of the study area

Treatments	Farmers name	Farm area (ha)	Source of irrigation	Crop after rice
Pancho	Chaudhri Ghulam Rabbani (R_1)	18	Bukhari minor*	Mustard
	Chaudhri Ghulam Jilani (R_2)	18	-do-	Mustard
	Abdul Malik Talpur (R_3)	40	-do-	Fallow land
Partial Pancho	Mir Muhammad Nawaz (R_1)	5	Dhandhi minor	Sugarcane + mustard
	Mir Ghulam Rasool (R_2)	5	-do-	-do-
	Abdul Hameed Halepoto (R_3)	1	Gaga minor	Fallow land
Non Pancho	Mir Muhammad Khan (R_1)	24	-do-	Sugarcane
	Ghulan Hussain Girano (R_2)	2	-do-	Wheat
	Allah Bux Mirbahar (R_3)	2	-do-	Mustard

* Minor: a distributing channel

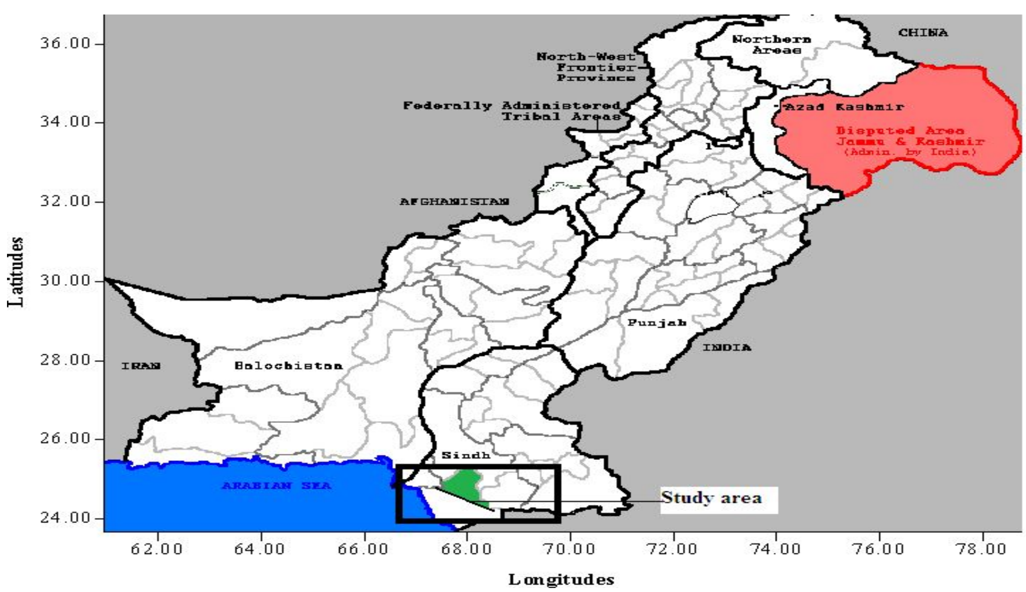

Figure 1. Map of the country showing the study area

Table 2. Average rainfall and pan evaporation during the study period

Month	Rainfall (mm)			ETo (mm/day)		
	2006	2007	2008	2006	2007	2008
June	24	68	3	11	9	9
July	52	18	26	9	7	8
August	158	83	65	4	7	7
September	175	2	0	6	8	8
October	0	0	0	6	6	6
November	0	0	0	4	0	4

during the study period (2006-8) are given in Table 2. The total rainfall during the cropping seasons of 2006, 2007 and 2008 was 409 mm, 170 mm and 93 mm, respectively. However, pan evaporation ranged from 1226-1272 mm during the cropping season.

RESULTS AND DISCUSSIONS

***Irrigation water applied*:** Table 3 shows that on average 785 mm (59%) and 408 mm (19%) more water was applied under pancho irrigation as compared to non-pancho and partial pancho irrigation systems, respectively. This excess water application in pancho was due to draining of water from the fields which indicates that the farmers who practice pancho irrigation waste over 50% of water as compared to non-pancho irrigation system. In partial-pancho irrigation system, about 377 mm (22%) more water was applied when compared to non-pancho irrigation system. The water drained out from the rice fields under pancho and partial-pancho irrigation systems to surrounding low lying areas was 559 and 362 mm, respectively. The net water applied under pancho was 226 and 211 mm higher as compared to partial and non-pancho irrigation systems, respectively (Table 2). Figure 2 shows that 93-409 mm of rainfall occurred during the cropping season. However, the farmers kept on applying and draining water and therefore, there was no use of rainfall. Moreover, as the soil is already saturated, the rainfall further aggravates the problems of water logging and salinity. Theoretically, the water requirement for land preparation is 150-200 mm but it can be as high as 650-900 mm when its duration is long, i.e. 24-48 days (DeDatta 1981; Bhuiyan *et al*., 1995). Field water input during growing season may vary from 500 to 800 mm (De Datta *et al*. 1973). However, under pancho and non-pancho systems, almost double amount of water was applied. The net water applied through partial pancho and non-pancho irrigation was non significant at 5% probability level. However, it was significantly different as compared to pancho-irrigation system. Therefore, only avoiding pancho-irrigation system, more than 50% of irrigation applied to rice crop can be saved. Moreover, as there is high evaporation in the area (Fig. 2), the practice of standing water either in the fields or the surrounding areas leads to increased concentration of salts at the soil surface.

The rice is cultivated on about 0.54 Mha in Sindh. Therefore, by avoiding pancho irrigation, over 4.0 billion cubic meter (BCM) water can be saved in one season. This is huge amount of water which can help overcome water shortage in the province and would also help control water logging and salinity.

There are innovative management practices that could help reduce rice water consumption (Toung *et al*., 2005; Won *et al*., 2005; Humpherys *et al*., 2005). Various options are now being evaluated to save water in rice fields such as bed and furrow, sprinkler irrigation (Kahlown *et al*., 2007; Spanu et el., 1996), direct seedling (Aslam *et al*., 2002; Dawe, 2005), reducing ponded depth to soil saturation or by alternate wetting/drying (Bouman and Tuong, 2001; Li and Barker, 2004; Hafeez *et al*., 2007).

***Crop yield and water productivity*:** In Sindh, mostly coarse varieties of rice are planted and their average yield is relatively higher than Basmati rice. During 2007-2008, the average yield of IRRI in Pakistan was 3058 kg/ha whereas average yield of Basmati was only 1801 kg/ha (MINFA,

Table 3. Gross irrigation water applied, water drained and net water applied

Year	Gross irrigation water applied (mm)			Water drained (mm)			Net water applied (mm)		
	Pancho	Partial Pancho	Non Pancho	Pancho	Partial Pancho	Non Pancho	Pancho	Partial Pancho	Non Pancho
2006	2135a	1574b	1338c	535a	224b	0	1600a	1350b	1338b
2007	2273a	1856b	1371c	676a	483a	0	1597a	1373b	1371b
2008	1957a	1712b	1252c	465a	379a	0	1498a	1333ab	1252b
Ave	2122a	1714b	1337c	559a	362b	0	1563a	1352b	1337b
LSD		81			68			68	

Means with the same letters are not significantly different at P = 0.05

Table 4. Yield, water productivity and standing water temperature under three treatments

Year	Yield (kg/ha)			Water productivity (kg/m^3)			Maximum temperature (°C)		
	Pancho	Partial Pancho	Non Pancho	Pancho	Partial Pancho	Non Pancho	Pancho	Partial Pancho	Non Pancho
2006	5060b	4405b	7080a	0.32b	0.33b	0.51a	29.3a	29.6a	28.6a
2007	5499a	5682a	6488a	0.34a	0.42a	0.48a	30.3a	29.6a	29.3a
2008	8925a	8562a	8562a	0.60a	0.65a	0.68a	29.0a	29.0a	29.0a
Ave	6495a	6216 a	7377a	0.42b	0.46 a	0.56a	29.5a	29.4a	29.0a
LSD		1515			0.11			1.03	

Means with the same letters are not significantly different at P = 0.05

Table 5. Water-table depth (cm) before sowing (BS) and after harvesting (AH)

Treatments	Replications	2006		2007		2008	
		BS	AH	BS	AH	BS	AH
Pancho	R1	122	15	300	18	231	16
	R2	122	12	310	19	266	17
	R3	244	11	300	16	231	15
Partial Pancho	R1	122	8	220	16	236	15
	R2	122	10	340	16	240	16
	R3	122	7	290	14	189	15
Non Pancho	R1	122	7	120	8	230	8
	R2	122	9	270	8	242	10
	R3	122	7	255	10	208	10

2009). The average rice yield under non-pancho was 12-16% higher than under pancho and partial pancho irrigation systems (Table 4). However, this difference was non significant at 5% probability level. The rice yield under all the treatments was more than double than the average rice yield in Sindh during 2007-2008. As pancho irrigation did not indicate any improvement in rice yield, therefore this practice is wasteful and needs to be stopped or replaced with non-pancho irrigation.

Water productivity is an estimate to measure how accurately irrigation water has been used for crop production. Any effort that tends to increase crop yield or reduce the amount of water needed without affecting the crop yield, can result in improving the water productivity (Molden *et al*., 2010). The water productivity of rice under non pancho was 17-24% higher as compared to pancho and partial-pancho irrigations systems suggesting that the applied water was utilized efficiently with significant increase in crop yield. The water productivity of rice under pancho irrigation system was significantly different at 5% probability level. These results indicated that the water productivity increases with decrease in water input.

***Standing water temperature*:** Farmers normally use pancho irrigation system with the concept that temperature in the standing water increases that damages the crop. The results suggested that there is no significant difference between the temperatures of the standing water under different irrigation system (Table 4). These results emphasize the need to extend this knowledge to the farmer to rectify their logic in using pancho and partial-pancho irrigations systems to avoid wastage of water.

***Water-table depth and quality of water*:** In Sindh province, out of the gross command area of 5.74 Mha, 1.35 Mha (23.6%) has water table less than 1.5 m (Sufi *et al*., 2004) whereas about 54% area is saline. The extent of salinization keeps on changing due to the dynamic nature of the problem. The main reason for higher soil salinity in the lower part is low rainfall, high evaporation rates, and shallow and saline groundwater (Qureshi *et al*., 2008).

Before sowing, the water-table depth ranged between 1 to 3 m depth. Since there was no drainage system, the standing water recharged the groundwater and moved it close to the surface (10-20 cm) after the crop harvesting. The rise in water table under non-pancho system was more pronounced that might be due to continuous standing water (Table 5). Therefore, such a high water table brings water to the surface through capillary rise. At the surface, this water is evaporated to the atmosphere leaving the salts at the surface. This is one of the most important reasons for saline soils in the Lower Indus Basin.

The groundwater level in the Indus basin fluctuates seasonally. In general, groundwater levels are the deepest at the end of the dry season (May–June) and shallowest immediately after the wet season of monsoon rainfall (September). Estimates show that after the monsoon season, about 4.7 Mha (30% of the irrigated area) have groundwater levels within 1.5 m of the soil surface. Prior to the monsoon period, this area is reduced to 2 Mha, which is 13% of the irrigated area (Tarar, 1995). The Punjab Province has about 25% of its irrigated area severely waterlogged and Sindh has about 60% in the same category (Qureshi *et al*., 2008). Since canal water was applied, its quality was very good (<1 dS/m). However, the electrical conductivity (EC) of the standing water and the drained water increased significantly (Table 6).

Table 6. Average EC (dS m^{-1}) of the water applied, standing and drained water

Water source	2006	2007	2008
Canal water	0.33	0.66	0.41
Standing water	2.09	1.68	1.88
Drained water	2.60	2.89	1.95

This could be due to the rise of water table that brings the salts closer to the surface, hence, increasing the EC of the standing water. Table 7 shows that before sowing the EC of the groundwater was higher at the sites where pancho and partial-pancho irrigation was practiced as compared to those sites where non pancho irrigation was practiced. However, the quality of the groundwater improved at all sites after rice season due to recharge from the canal water. It is interesting to note that the farmers keep on applying the fresh water, resulting into waterlogging, salinity and to wash the salts that had accumulated at the surface at the cost of freshwater which is becoming a scare resource in the region. Until and unless there is no proper drainage system, the salts will remain within the system and will keep on increasing.

Sodium Adsorption Ratio (SAR) of the groundwater before planting and after harvesting of rice is shown in Table 8. Contrary to the EC, the SAR increased after cropping season during the study period at all sites. However, this increase was more pronounced at the sites where pancho and partial pancho irrigation was practiced. This might be due to reason that EC shows only the soluble salts that can be diluted with freshwater. However, SAR shows insoluble salts that cannot decrease with the addition of fresh water. High SAR in the water reduces the permeability of the soils making them unproductive. Such soils are difficult to reclaim and need special treatments either with gypsum or some acids such as sulphuric/nitric acid (Azhar *et al*., 2001) to keep SAR at recommended levels.

Soil salinity: The soil EC and SAR at most of the depths decreased, most probably due to flushing of soluble salts with the freshwater. However, Exchangeable Sodium Percentage (ESP) slightly increased at most of the depths under pancho and partial-pancho systems whereas decreased under non-pancho systems (Table 9). The soil salinity does not show any systemic trend. This might be due to frequent lowering and rise of water table that mixed the salts.

Table 7. EC (dS m^{-1}) of groundwater before sowing (BS) and after harvesting (AH)

Treatments	Replications	2006		2007		2008	
		BS	AH	BS	AH	BS	AH
Pancho	R1	3.40	2.28	3.50	2.20	3.60	2.21
	R2	2.26	2.15	2.35	2.23	2.32	2.13
	R3	2.78	1.86	2.88	2.04	2.83	2.05
Partial Pancho	R1	3.82	2.84	3.75	2.97	3.83	2.95
	R2	2.87	2.25	2.85	2.35	2.78	2.21
	R3	3.85	2.35	3.92	2.42	3.93	2.41
Non Pancho	R1	2.30	1.46	2.19	1.38	2.20	1.40
	R2	1.00	1.47	1.02	1.49	1.10	1.39
	R3	2.65	2.65	2.73	2.70	2.75	2.75

Table 8. SAR of groundwater before sowing (BS) and after harvesting (AH)

Treatments	Replications	2006		2007		2008	
		BS	AH	BS	AH	BS	AH
Pancho	R1	4.50	11.28	4.66	11.20	4.67	11.30
	R2	15.40	19.60	15.64	19.72	15.58	19.75
	R3	5.80	10.52	5.97	10.66	5.96	10.68
Partial Pancho	R1	8.05	14.90	8.03	15.03	8.07	15.01
	R2	7.90	11.50	7.97	11.57	7.98	11.58
	R3	8.15	11.53	8.19	11.61	8.20	11.63
Non Pancho	R1	3.50	5.65	3.64	5.48	3.63	5.97
	R2	3.98	5.23	3.90	5.39	3.94	5.38
	R3	4.70	8.90	4.80	9.00	4.81	9.04

Table 9. Analysis of soil samples collected before sowing and after harvesting (2006-2008)

Irrigation system	Sampling depth (cm)	EC (dS/m)		SAR		ESP	
		BS	AH	BS	AH	BS	AH
Pancho	0-15	5.02	3.80	5.70	5.13	5.46	5.34
	15-30	3.88	3.38	5.02	4.29	4.61	4.97
	30-60	3.89	3.79	4.91	4.04	4.30	5.03
Partial Pancho	0-15	4.99	5.62	4.61	5.19	5.52	5.58
	15-30	4.86	4.89	4.45	4.42	5.27	5.67
	30-60	3.67	4.26	4.21	4.45	4.77	5.64
Non Pancho	0-15	5.16	4.22	4.71	4.26	5.47	4.39
	15-30	4.74	3.94	4.29	4.07	5.02	4.65
	30-60	4.75	4.02	4.33	4.31	5.02	4.68

Nevertheless, the SAR and ESP were within the permissible limits (Ashraf *et al*., 2012) whereas EC exceeded the limit at all depths.

***Conclusions*:** Under pancho irrigation, on an average 785 mm (59%) more water was applied as compared to non-pancho irrigation systems. Moreover, 559 mm of water was drained out of the rice fields under pancho-irrigation systems. The average rice yield under non-pancho was 12-16% higher than pancho and partial pancho irrigation systems. However, there was no significant difference in yield between the three treatments suggesting that with non-pancho irrigation system significant amount of water can be saved without compromising the yield. As the pancho-irrigation system results in wastage of significant amount of precious water and leads to waterlogging and salinity, it should be stopped.

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