Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences
Volume 1 Number 1, 67-69, 2002

Improvement Potential of Rod Kohi Farming in Upland Balochistan

[1]Nadeem Sadiq, [2]Anwar Shah and [2]Ruhul Amin
[1]Arid Zone Research Centre, P.O. Box-63, Brewery Road, Quetta, Pakistan
[2]Water Resources Research Institute, NARC, Islamabad, Pakistan

Abstract: A series of studies were conducted in Barkhan area of Balochistan to determine the efficiency of various engineering structures (division, diversion and check dams) on the "Rod Kohi" runoff farming. Low cost engineering structures (wooden sheet, loose stone, barbed wire, 15 " pipe nacca) were constructed, the cost ranged from Rs. 1500 to 4000 per structure. Rod Kohi farming provides livelihood for the majority of the farmers in the area. Wheat and mix sorghum-mung are the crops generally grown in the area. Traditional practices were done in the target area for the utilization of runoff water involving dividing and diverting the runoff water with local shrubs, sticks and plant residues etc. These engineering structures constructed in this study improved the overall efficiency of the runoff farming system and conflict free environment among farmers by efficient water distribution and diversion. A reduction from 7 to 2% in gradient control of the earthen channels and maximum of 25% increase in wheat yield were recorded.

Key Words: Runoff, water harvesting, sailaba, rod kohi system, hill torrent

Introduction

Pakistan is an arid country, about 92% of the country's geographical area lies within semiarid and arid regions (WRRI, 1997). The total area of Pakistan is 79.61 million hectares out of which 8.91 million hectares is culturable waste (Agric. Stat. Pakistan, 1996). About 50 % of the rainwater is lost as surface runoff (Ahmad *et al.*, 1984) which also causes loss in soil fertility and reduced crop productivity. The runoff loss from the cultivable portion of Pakistan's rainfed areas is nearly 6 million acre-feet of water per year (Khan, 1985). Balochistan is the largest province, constitutes about 44% of the country's area (PARC and FAO, 1993). At present, 1.8 million hectares, which is less than 5 % of the total area has the potential for agricultural development. There are about 913,031 hectares in production and of this 90 % is irrigated and the remaining 10 % is on rainfed (AZRC annual report, 2000). Balochistan has continental arid and semi arid climate with mean annual rainfall ranging from 50 mm in the South to 400 mm in the North (Rafiq, 1976). Water is the most limiting factor in arid and semi-arid regions of Balochistan due to large spatial and temporal variability in rainfall. Rainfall occurrence and distribution is low and erratic. Cereal crops, in particular wheat is grown by the most dryland farmers as a dual purpose, crop grains being used for human consumption and the straw for animal feed (Buzdar *et al.*,1989).

The average intensity of cultivation in Balochistan is only 43% compared with 110 % in the irrigated lands and is low due to erratic rainfall (PARC and FAO, 1993). The meagre ground water resources are shrinking due to the mining of water for irrigated agriculture and over-flow of run-off water without infiltration. Therefore, the scope of water harvesting in Balochistan is considerable for raising of dry land crops (Shafiq *et al.*, 1994). Better water harvesting and management practices will not only enhance the productivity of the existing farming system but also tilt the balance towards the sustain ability of the existing ground water resources (Ahmad and Aslam, 1994).

Two types of dryland farming systems (Khuskhaba or direct rainfed and Sailaba or Rod kohi system) are common in Balochistan (AZRC Research Report, 2000). Rod Kohi is also called runoff water or hill torrent floodwater (Wahab, 1990). In this system flood water is collected from catchment areas and then diverted to the agricultural fields through earthen channels (Rod Kohi Annual Report, 1997-98). Series of studies have been conducted in highland Balochistan (> 1000 meters elevation), the objectives were to improve the runoff farming through innovative water convince, spreading and conservation techniques, to enhance the productivity and alleviate poverty of the rural communities.

Materials and Methods

This study was carried out in Jhalwani, tehsil Barkhan, district Loralai, situated in the North-East of Balochistan. Runoff generated from the nearby mountainous catchment runs through the main water channels "Grabaccha" and "Khanki" and irrigate 550 hectares of cultivated land. The main crops grown under runoff irrigation are wheat in rabi and mix cropping (sorghum- and mung) in kharif. The long-term average annual rainfall of the area is 337 mm (WRRI, 1997) and the area comes under monsoon range. Most of the rainfall occurs in monsoon (July and August). Heavy showers also occur exceeding 40 to 60 mm in one time, damaging crops, water channels and bunds. Following studies for the efficient utilization of runoff water were carried out in the target area.

Division structures: Topographic surveys were conducted to know the complete topography and the slope gradient of the target area. Construction of division structures was done on the critical main points of the channels after calculating maximum discharge and the topography of the command area. Eleven division structures were constructed in the area using the locally available mountain stones. A main division structure was constructed at the first division of the channel "Grabaccha". The estimated maximum discharge was 335 cusecs. A part of surface runoff also adds to this discharge. The discharge is mainly dependent on the precipitation rate. The width of the weir was designed by the equation, $P = 4.75\ Q^{0.5}$ (Halcrow, 1988) Where P is the wetted perimeter of the channel in meters and Q is discharge in cusecs. The weirs constructed were masonry and it was of vertical drop type. The dividing wall of the division structure was stone patched on compacted soil and its height was designed according to the maximum discharge and the site conditions. The height and the length were designed with respect to width of the weir and design discharge. The wing walls were constructed on compacted soil with loose stone.

Diversion structures: Diversion structures were constructed on the point of water entrance of respective bunds for effective water utilization. The different diversion structures were:

a) Wood diversion structure: Wooden sheets were used for diverting runoff to the corresponding fields.
b) Pipe nacca diversion structure: Pipes of 15" dia were installed to divert floodwater from the channels in to the fields.
c) Loose stone masonry diversion structure: Loose stones were used to construct weir to raise the head of the water up to the highest point level of the respective bund to enter the flood water in the fields.
d) Pipe nacca outlet structure: 15" dia RCC pipes were installed in the bunds, in the down stream side of the fields, to drain the excessive water in order to save the bund from breaching.

These were installed at the maximum flood level capacity of the bund. These diversion structures were designed after complete topographic survey of the upstream and downstream area and in such a manner that the flood water entered the corresponding fields without any hindrance, after filling the bund to a desired level, excess water was drained out to the downstream side of bund without damaging that bund, which leads to another bund or waste land.

Check dams: Fifteen check dams were constructed to maintain the channel slope and to reduce the scouring of the channel. Check dams were constructed in the earthen channels that carry the floods due to gradient control and filling of the scouring of the channels. The main channels (Grabaccha and Khanki) were scoured due to steep slope and loose stone check dams were constructed on nominal rates. The average slope prior to check dams was around 4 to 5% and in some cases around 5 to 7% which was reduced to 2 to 2.5 %. The farmers leave their lands fallow for a period of 6 to 12 months due to moisture conservation and increase in soil fertility.

Sediment deposition: Study on the sedimentation was also conducted, twelve floods passed through the period and the silt deposition was recorded with engineer's level in the agricultural fields as well as in the channels. A permanent benchmark was established for this purpose.

Flow measurements: During five years, twelve floods were recorded. One high flood measured was 580 cusecs on the "Grabaccha" channel. Moisture conservation was possible for sowing of wheat crop and large number of farmers irrigated their fields. Continuity equation was used to determine the high floods:

$Q = AV$

Q is the quantity of flow in cusecs,

A is the cross sectional area of the water, and

V is the velocity in of flood ft/sec.

Results

Division structures: The average construction cost for a division structure ranged between Rs. 1500- 4000. Most of the structures were constructed with stone patching on compacted soil and the nose of some of them was cement grouted. Floods passed through these structures were of 412 -580 cusecs and silt depositions on the up stream side of the structure was recorded from 4.1 to 6.2 cm (Table 1). The number of bund erosion was decreased from 15 to 2 after the construction of division structures and resulted in more compactness. Area irrigated by these divisions were in the range of 5 to 30 hectares. Moreover, no conflicts were seen after the construction of these division structures because water was distributed precisely. Flow measurements were also recorded during heavy floods.

Diversion structures: Seven types of diversion structures were constructed (Table 2). The cost ranged from Rs. 500 to 2500. Percent increase in area after the constructions of structures varies from 11% (traditional type) to 41% (Wooden sheet). The most effective structure was wooden sheet due to its easiness to operate and maximum efficiency of water diversion. Prior to these structures on average 3- 5 persons were required to divert and irrigate one bund of 2-5 acres. Whereas, after the diversion structures on average 1- 2 persons were needed to divert the flood water for the same area (Table 2).

Check dams: The channels filled with only five floods and proper slope was maintained. Silt deposition was seen as the floods came and silt was deposited in the up stream side of the check dams in the channels which worked as small weirs. The original slopes were 5.2 to 7.2 % which was brought to 2 to 3% (Table 3). A total of 13 full floods were recorded during the project period of five years. Discharge measurement was recorded from 318 to 510 cusecs .

Impact of structures on crop productivity: The engineering structures increased cropped area, deposited silt, reduced bund breaching, labor cost and damage to crops (Table 4). 15 -24 % increase in crop yield was recorded during the study period. The percent increase in command area is the result of efficient division, diversion and better utilization of the floodwater. Silt deposited was also a factor for the increase in yield. Also fallowing the lands for 6 months saw increase in 15-20 % of wheat yield.

Discussion

Collection of runoff water, spreading, division and diversion structures have increased the utilization efficiency of runoff water, increased crop production and soil fertility, increased cultivable area, gradient control

Table 1. Effects of division structures on silt deposition

Name of Structure	Flood Passed (ft^3/Sec)	Area Irrigated(hectare)	Silt Deposition (cm)	Conflicts among farmers
Grabaccha main	412	21	6.2	Nil
Grabaccha Sub	143	11	4.2	Nil
Khanki main	510	30	4.1	Nil

Table 2. Effects of Diversion structures on command area.

Type of Structure	Command area irrigated (hectares)		% age increase in command area	Reduction in labor %
	Before	After		
Wooden sheet	3.58	6.07	41	75
15" pipe nacca	3.30	4.85	32	45
Loose stone weir	3.89	5.06	23	68
Loose stone weir	4.23	5.26	20	45
Barbed wire	2.87	3.68	21	75
Traditional type	4.73	5.34	11	

Table 3. Gradient control of the channels

Name of Channels	Length meter	Original Slope %	Controlled slope	Max. Measured Discharge (Ft^{-3} Sec)
Grabaccha sub1	1161	5.2	2.5	413
Grabaccha sub2	720	4.9	2.6	325
Khanki sub 1	1255	7.2	2.3	510
Khanki sub 2	929	6.1	2.2	318

Table 4: Results of the structures constructed

% increase in cropped area with different structures	No of floods passed	Soil fertility due to silt deposition in the fields (cm)	Wheat yield (Kg/ha)		% reduction in bund breaching	% reduction in damage to crops
			Before	After		
41 (wooden)	3	2.1	1570	1936	30	32
32 (pipe nacca)	2	1.6	1282	1778	25	26
23 (loose stone)	2	0.6	1333	1763	19	22
20 (loose stone)	3	2.3	1254	1521	26	23
21 (barbed wire)	2	2.9	1212	1578	27	12
14 (Traditional type)	3	0.4	1032	1032	-	-

of irrigation channels, conflict free atmosphere and reduction in labor. Similar division and diversion structures in various part of the world have shown efficient utilization of runoff water and increased crop productivity (ILEA, 1986). The thresh hold value of a catchment basin under natural conditions may require rainfall of about 10 mm before runoff would occur (Perrier, 1988). This amount increases with the compactness of the catchment area. The results showed that runoff generation occurred after 15 mm of rainfall but 30 to 50 mm of high intensity rainfall events brought enough flood water to irrigate the fields. According to Legget (1959) at least 100 mm of rainfall is required for the winter wheat crop for its vegetative growth, there after an average of 16 Kg/ha grains are produced for each millimeter of rainfall. The average rainfall in the target area is around 337 mm which is good for enough runoff generation and crop production. Runoff water capture schemes are usually employed in areas of 50 mm to more or less 300 mm rainfall (Perrier, 1988). The target area is suitable for run off irrigation as the evaporation of the target area (Barkhan) does not exceed 1.21 mm/day and the mean relative humidity is between 60 - 70% throughout the year with average maximum and minimum temperatures of 29 and 17°C (Rod Kohi Annual report, 1996-97). Evaporation generally accounts for the largest water loss in dry land areas and may account to 50 to 70% of the annual precipitation (Pependick and Campbell, 1998). The agricultural fields are remained fallow (approximately 50%) in both Rabi and kharif seasons due to the shortage of runoff water. Fallowing the land increases the soil fertility, available nutrients and water conservation for the next crop. (Greb *et al.,* 1979) reported that fallowing the land resulted in high soil nutrients and increase in moisture for the next crop. Our results showed 15-20 % increase in wheat yield by fallowing the land for 6 months. Papendick (1988) concluded that in great plains, 6 months fallow with continues wheat had an average fallow efficiency of 32 % which is in accordance with our study.

Eleven division structures divided the runoff water precisely without any conflict, they also controlled the erosive flood speed and silt up the upstream area of the structure. Erosion increases if there are slope variation and irregular paths. The results of this study showed that the weirs constructed filled the dumps and un-levelled paths and behaved like levelled fields as compared to the previous position. No sediment loss was observed from the channels and fields after the silt deposition in the channels and reduction in flood speed. According to Rose and Dalal (1988) the crop decrease by 1 mm soil loss was 20%. Here in our case the soil got deposited (2 -5 cm) and the yield increased up to 25%. Although it is not accordingly that 1 mm soil loss resulted in 20% decrease in crop yield, but soil deposition has increased crop yield. ILEA (1986) studied the effects of soil accumulation and found that nutrients, carried by the runoff water increased the crop yields. The check dams and the division structures also gave the same results as 2 - 2.5 % slope gradient reduced the amount of erosion from the irrigation channels. The check dams constructed reduced the slope of the long earthen channels from 4-7 to 2 -2.5 %. This reduction was achieved in five floods. Silt was deposited in the channels to obtain the desired slope so that the channels can act like a properly maintained channel. Flow energy increases by increasing slope gradient and the stability of material on the slope decreases with the increasing slope gradient (Mou Jin-ze, 1988). He also concluded that the check dams resulted in strengthening erosion points thus preventing vertical erosion. The function of silt erosters is to retain sediments and floods coming from upstream and change the waste slope into fertile lands, thus retaining sediment and increase the output.

Diversion structures diverted the high speed flood water in the corresponding fields without any obstruction. Loose stones, sticks and wooden sheet were used for the structures. They were built in the water channels, with the wing walls, apron and toe walls to strengthening them against high speed floods. Maximum water use efficiency was seen which resulted in save of time, labor, money and hence increase in outputs. The basic component of flood irrigation is precise diversion with least labor and efficiency. ILEIA (1986) studied effect of division structures and found that runoff water diverted to the agricultural fields gave maximum efficiency with spreading techniques i.e., low permeable bunds made of stones, sticks, etc., constructed along the contours were used to facilitate infiltration. The diverted water infiltrated and hence used for crop production. The fertile top soil and runoff water are limiting sources in the semiarid and arid regions. Thus water and fertile top soil should be used in the best combination for maximum crop production. The studies improved the distribution and utilization of Rod Kohi irrigation system and increased the productivity.

Acknowledgment

In the name of Allah, the most merciful, the most beneficent. For the completion of this paper, the guidance provided by Dr. Shahid Ahmed (Director WRRI, NARC) and the co-operation extended by Mr. Ahmed Samiullah, Dr. Sarfraz Ahmed and Dr. Muhammad Islam of AZRC is thankfully acknowledged. It was with their sincere help and guidance, authors were motivated for generation of the paper.

References

Agriculture Statistics of Pakistan, 1996. Statistical wing, Ministry of food, agriculture and livestock, Pakistan.

Ahmad, S., M. Shafique and M. Z. Ikram, 1984. Rainfall intensity-runoff relationship for small catchments in Potohar plateau. Journal of Engineering and Applied Sciences, 3: 37-44.

Ahmad, S. and M. Aslam, 1994. Development of resource management strategies to raise productivity of eroded areas and watersheds. WRRI, NARC, Islamabad, (Document Pak-SS-PB-11).

AZRC Research Report No. 22, 2000. Agronomy at Arid Zone Research Centre (1995-1999)

Buzdar, N., J. D. H. Keatinge. J. G. Nagy, G. F. Sabir and K. Mahmood, 1989. Rainfed Agriculture in Highland Balochistan: Farming Systems prospective. MART/ AZRC Project. Research Report No 54. ICARDA, Quetta, Pakistan. FAO. 195. Initial Participatory Rural Appraisal and Planning. Mithawan Watershed Management Project. GCP/PAK/083/JPM, Part 1 and 11, Islamabad, Pakistan.

Greb, B. W., D. E. Smika and J. R. Welsh, 1979. Technology and wheat yield in the central great plains. Journal of soil and water conservation, 34: 264-268.

Halcrow, U.L.G., 1988. Wier design mannual, Balochistan minor irrigation and agricultural project, Government of Balochistan.

ILEIA, (Information Centre for Low External- Input Agriculture) 1986. Water harvesting, a review of different techniques. Leusden, The Netherlands.

Khan, S. R. A., 1985. Water harvesting and runoff farming in barani tracts. Pakistan Agricultural Research council, Islamabad. (Unpublished).

Legget, G. E., 1959. Relationships between wheat yield, available moisture and available nitrogen in Eastern Washington dryland areas. Bulletin609. Washington agricultural experiment station. Pullman: Washington State University.

Mou Jin-ze, 1988. Prediction and control of soil erosion in the yellow river basin, China. Proceedings of the International Conference in Dryland Farming, USA. pp: 111-114.

PARC and FAO, 1993. Participatory rural appraisal of Loralai district. Integrated Agriculture Production and Resource Management System. Pak/92/T01, Islamabad, Pakistan.

Papendick, R. I. and G. S. Campbell, 1988. Concepts and management strategies for water conservation in dryland farming. Proceedings of the International conference in Dryland Farming, USA.

Perrier. E. R., 1988. Water capture schemes for dryland farming. Proceedings of the International Conference on Dryland Farming, p 235-238.

Rafiq , M., 1976. Crop ecological zones of nine countries of the near east region. Publ. by Food and Agricultural Organization of the United Nations, Rome.

Rod Kohi Annual Report, 1995-96, 1996-97, 1997-98 and 1998-99. Water Resources Research Institute, NARC, Islamabad, Pakistan.

Rose, C. W. and R. C. Dalal, 1988. Erosion and runoff of nitrogen. In J. R. Wilson (ed). Advances in nitrogen cycling in agricultural ecosystems. Commonwealth Agricultural Bureau. (CAB International).

Shafiq, M., S. Ahmad, M. Z. Ikram and M. Aslam, 1994. Potential for water harvesting under medium rainfall zone of Potohar, Pakistan, Science, Technology and Development, 13, pp: 45-49.

Wahab, A, K., 1990. Water management in the Rod Kohi system of irrigation and potential for future development. Symposium on problems and prospects of Rod Kohi Agriculture. BARD project. D. I Khan, pp: 38-45.

WRRI (Water Resources Research Institute), PARC, Annual Report, 1997. Water Harvesting and Conjunctive use of water for Sustainable Agriculture in Dry Areas of Balochistan, Pakistan.