On-Farm Rainwater Harvesting and Recycling Using Farm Ponds for Crop Productivity Enhancement in Marathwada Region of Maharashtra

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ABSTRACT: Marathwada region is traditionally a drought-prone region. The region receives annual rainfall in the range of 500 to 1100 mm and major area comes under assured rainfall zone. Rainfall is uncertain and erratic and sometimes this region suffers from severe droughts. The productivity of the crops decreases with deficiency of rainfall, its distribution or due to moisture stress during critical growth stages occurs in July and August. Thus, protective irrigation using water harvested in farm pond to rainfed crops particularly during dry spells is very important for assured crop production in drylands. Major crops grown in the region are soybean, cotton, pigeon pea, sorghum, greengram and blackgram during *kharif* season and gram, *rabi* sorghum and safflower in *rabi* season. Based on farmers need, technical interventions were taken up under NICRA (National Innovations in Climate Resilient Agriculture) research project through preparedness. Farmers constructed farm ponds through Government schemes on their field for harvesting of runoff water and farmers procured sprinkler set from the Government schemes. The farmers were advocated to apply farm pond water using sprinklers during dry spells in *kharif* and critical growth period in *rabi* season. Rainfall pattern indicated that every year 3 to 4 dry spells were occurred which had created moisture stress condition. Rainfall runoff relationship indicated that approximately 32.50 per cent runoff was produced from the crop seasonal rainfall. Protective irrigation from farm pond water during dryspell period to soybean and pigeonpea crop in *kharif* season resulted in an increase in yield to the tune of 43 to 49 per cent and one supplemental irrigation to gram crop during critical growth stage in *rabi* season from farm pond using sprinkler resulted in an enhancement of yield by 57 per cent.

Key words: Dry spell, farm pond, protective irrigation, sprinkler irrigation

Introduction

Rainfall is a basic resource for all the forms of water in semi-arid tropics. Several management options are available at farm level to increase the rainwater use efficiency. Marathwada region is traditionally a drought-prone region. The region receives mean annual rainfall of 880 mm and major area comes under assured rainfall zone. In Marathwada region, 49.60 lakh ha area is rainfed out of total cultivated area of 57.94 lakh ha. The impact of climate change and variability on agricultural production in the region is quite evident in recent years. Rainfall is the key variable influencing crop productivity of soybean under rainfed condition. Occurrence of frequent dry spells during critical crop growth period is common feature of the region which lowers the productivity of almost all the crops due to moisture stress. The south-west monsoon account for nearly 75% of the precipitation and exerts a strong influence on *kharif* food grain production and the economy in terms of agricultural output, farmers income and price stability. The onset of monsoon, the amount of rainfall and its distribution are crucial factors which influences the performance. The probability of erratic rainfall is about 40% and need to develop appropriate strategies to deal with it.

Major *kharif* crops of the region are soybean, cotton, pigeon pea, sorghum, greengram and blackgram. Based on the farmers need, technical interventions were taken up under NICRA (National Innovations in Climate Resilient Agriculture) research project through preparedness and real time contingency measures. Water harvesting is one of the key components for successful rainfed farming in semi-arid regions. (Suraj Bhan, 2009). Harvesting surplus runoff in farm pond and recycling the same for providing protective / supplemental irrigation to *kharif* crops or supplemental irrigation to *rabi* crop at critical growth stages has proved as successful technology adoption. Khan and Venkateswarlu (1993) mentioned that rainwater harvesting is necessary for increasing water availability in arid Rajasthan. Goyal *et al.* (1995) conducted a study on economic evaluation of water harvesting pond under arid condition. Vora *et al.* (2008) mentioned that farm pond technology is useful for enhancing crop productivity in Bhal area of Gujarat. Although the farm pond technology is well known in the country, its adoption has been low due to a number of constraints. Considering the need and current emphasis on on-farm rainwater harvesting for enhancing the water productivity in rainfed region, the present study on on-farm rain water harvesting and recycling through farm pond technology in Marathwada region was taken up in last 5 years under NICRA component and considering these issues,

farmers in the NICRA village were advocated and motivated for adoption of farm pond technology.

Material and Methods

Participatory trials were conducted on farmers' fields during 2016-17 to 2020-21 under the project "National Innovations in Climate Resilient Agriculture" (NICRA) which is in operation at village Babhulgoan in Parbhani District in Marathwada region of Maharashtra. Farmers had constructed farm ponds through Government schemes on their field for harvesting runoff water. Similarly, farmers procured sprinkler set from the Government schemes and were advocated to apply farm pond water using sprinkler set during dry spells at critical growth period. Demonstration fields were selected based on the willingness of the farmers to engage in participatory research to evaluate the science based strategy. Major soils in the research area are medium black (vertisol).

More than 15 farm ponds constructed in the NICRA village. Out of that, 3 farmers were selected to study the impact of application of farm pond water to soybean and pigeon pea in *kharif* and gram in *rabi* season. The farmers were advocated for application of farm pond water to the crops with respect to time of application and quantity of supplemental irrigation. Freebairn *et al.* (1986) studied the effect of catchment management on runoff, water quality and yield potential from vertisols. Similar procedure was adopted in the present study. The rainfall data was collected from the nearest weather station. The duration and number of dry spells were recorded every year. The runoff was estimated using SCS curve number method based on topography of the farmer's field, slope and land use for the year 2016 to 2020 (Satheeshkumar *et al.,* 2017). The numbers of filling of farm pond were observed each year due to surplus runoff water. The data on crop yield under both irrigated and non-irrigated treatments were recorded. Accordingly, the gross and net returns were worked out and thus the additional per cent increase in yield was analyzed.

Details of Farm Pond and micro irrigation on Farmers field

Size of Farm pond	:	20 m x 20 m x 3 m
Storage capacity	:	746 m^3
Water Lifting device	:	Diesel operated pumpset of 3.00 HP
Method of Irrigation	:	Sprinkler Irrigation
Depth of irrigation	:	5 cm
Quantity of irrigation	:	500 m^3 ha^{-1}
Time of irrigation	:	Soybean and pigeon pea- During dry spells of every year
Gram	:	During branching at every year in December

Results and Discussion

Rainfall and dry spells

The data on annual rainfall, crop seasonal rainfall, number and duration of dry spells during 2016-2020 is given in Table 1. The mean annual rainfall of the station is 880.9 mm.

Table 1: Seasonal rainfall and dry spells during 2016-2020

Year	Annual rainfall, mm	Crop seasonal rainfall, mm	Number of dry spells	Duration of dry spells, days	Dry spell period
2016	1159.5	1130.0	1	18	5 to 22 August 2016
2017	995.7	886.0	4	16	25 June to 10 July 2017
				13	26 July to 7 August 2017
				09	31 August to 8 Sept. 2017
				16	17 Sept. to 02 Oct. 2017
2018	812.1	802.4	2	25	22 July to 15 August 2018
				33	28 August to 30 Sept. 2018
2019	964.2	859.7	4	10	1 to 10 July 2019
				13	14 to 26 July 2019
				16	15 to 30 August 2019
				18	2 to 19 October 2019
2020	1098.7	1004.5	4	09	17 to 25 June 2020
				12	30 July to 10 August 2020
				10	28 August to 6 Sept. 2020
				09	02 to 10 October 2020

Out of 5 years, above normal rainfall occurred for 4 years and below normal rainfall was observed in one year. However, the distribution of rainfall was different in every year. Out of 5 years, 4 dry spells in every year were observed during 2017, 2019 and 2020, which has resulted in moisture stress during crop growth period which needs attention for providing protective/supplemental irrigation to crop.

Surplus runoff harvesting in farm pond

The data on annual rainfall, crop seasonal rainfall, number of rain storm produced runoff, surplus runoff harvested in pond and number of fillings of farm pond per year is presented in Table 2.

Table 2: Rainfall-runoff relationship related to water harvesting in farm pond

Year	Annual rainfall, mm	Crop seasonal rainfall, mm	Number of rain storm produced runoff	Runoff harvested in farm pond, mm	Number of fillings of farm pond
2016	1159.5	1130.0	10	330.1	4
2017	995.7	886.0	10	432.3	4
2018	812.1	802.4	08	265.4	3
2019	964.2	859.7	09	180.0	3
2020	1098.7	1004.5	08	314.4	4
Mean	1006.04	936.52	09	304.4	3.6
Per cent runoff				32.5	

Rainfall runoff relationship indicated that approximately 32.50 per cent runoff was produced from the crop seasonal rainfall. Every year, 8 to 10 storms resulted in generating runoff. On an average, 3 to 4 fillings of farm pond were observed in every year and sufficient quantity of harvested water was available to provide supplemental irrigation to *kharif* and *rabi* crops. Rainfall runoff relationship indicated that there is a good scope for rainwater harvesting and recycling. Narain and Goyal, (2005) reported that rain water harvesting is essential for improving crop productivity.

Crop productivity and its economics

The data on soybean crop productivity, gross monetary returns, net returns and B:C ratio due to application of farm pond water for soybean crop on farmer's field is presented in Table 3. The mean soybean seed yield was recorded as 1437 kg ha^{-1} due to application of farm pond water using sprinklers during dry spell period, as against the seed yield of 964 kg ha^{-1} with farmers practice.

Table 3: Effect of supplemental irrigation from harvested rainwater to soybean

Intervention	Seed yield (kg ha^{-1})					Mean seed yield (kg ha^{-1})	Gross monetary Returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
	2016-17	2017-18	2018-19	2019-20	2020-21				
Farm pond water	1370	1545	1410	1395	1465	1437	48844	28344	2.38
Farmers' practice	972	1140	842	832	1032	964	32766	14266	1.77

Further, it was observed that due to this intervention, additional 49 per cent soybean seed yield was recorded as against farmers traditional practice. The net returns in soybean crop was Rs. 28344/h due to application of farm pond water during dry spell was recorded as against of Rs. 14266 ha^{-1} under farmers practice. The B:C ratio of 2.38 was recorded under application of farm pond water as against 1.77 under farmers practice. Narayanan *et al.* (1987) evaluated the impact of supplemental irrigation through farm pond on drylands, similarly, Rathore *et al.* (1996) conducted study on on-farm rainwater and crop management for improving productivity of rainfed areas. The results of this study confirm with the results of previous researchers. The data on crop productivity, gross monetary returns, net returns and B:C ratio due to application of farm pond water and without irrigation for pigeon pea crop on farmers field is presented in Table 4.

Table 4: Effect of supplemental irrigation from harvested rainwater to pigeonpea

Intervention	Seed yield (kg ha^{-1})					Mean seed yield, kg ha^{-1}	Gross monetary Returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
	2016-17	2017-18	2018-19	2019-20	2020-21				
Farm pond water	1172	1095	890	1180	1565	1180	66965	34965	2.09
Farmers' practice	725	765	700	875	1052	823	46705	16705	1.55

Data on economics of pigeonpea crop productivity indicated that due to application of farm pond water using sprinklers during dry spell period, the mean crop yield was 1180 kg ha^{-1} as against 823 kg ha^{-1} under farmers practice. The mean gross monetary returns (GMR) of Rs. 66965 ha^{-1} was recorded as against Rs. 46705 ha^{-1} under farmers practice. Further, it was observed that due to this intervention, additional 43 per cent GMR was recorded over farmers traditional practice. The net returns in soybean crop due to application of farm pond water during dryspell was recorded as Rs. 34965 ha^{-1} as against Rs. 16705 ha^{-1} under farmers practice. The B:C ratio of 2.09 was recorded under application of farm pond water as against 1.55 under farmers practice. Narayanan *et al*. (1987) conducted a study on effect of supplemental irrigation through farm pond to enhance crop productivity and found yield enhancement. The results of this study confirms with the previous results. The data on crop productivity, gross monetary returns, net returns and B:C ratio due to application of farm pond water and without irrigation for gram in *rabi* season on farmers field is presented in Table 5.

Table 5: Effect of supplemental irrigation from harvested rainwater to gram *(rabi)*

Interventions	Seed yield (kg ha^{-1})					Mean seed yield, kg ha^{-1}	Gross monetary Returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
	2016-17	2017-18	2018-19	2019-20	2020-21				
Farm pond water	895	765	640	842	869	802	37052	18552	2.00
Farmers' practice	492	486	430	590	545	509	23516	7016	1.42

Data on gram crop productivity and its economics indicated that with application of farm pond water using sprinkler irrigation during branching stage, the mean yield was 802 kg ha^{-1} against 509 kg ha^{-1} under farmers practice and the mean gross monetary returns (GMR) was Rs. 37052 ha^{-1} as against Rs. 23516 ha^{-1} under farmers practice. Further, it was observed that due to this intervention, additional 57 per cent GMR was obtained over farmer's traditional practice. The net returns were Rs. 18552 ha^{-1} in gram crop was due to application of farm pond water during branching stage as against Rs. 7016 ha^{-1} under farmers practice. The B:C ratio of 2.0 was recorded under application of farm pond water as against 1.42 under farmers practice. Singh *et al*. (2006) conducted an experiment on economics of rainwater harvesting and recycling for winter vegetable production in mid hills of Meghalaya and found yield increase similar to this study.

Conclusions

Rainfall pattern indicated that every year 3 to 4 dry spells were occurred which had created moisture stress condition. Rainfall runoff relationship indicated that approximately 32.50 per cent runoff was produced from the crop seasonal rainfall. Protective irrigation from farm pond water during dry spell period to soybean and pigeonpea crop in *kharif* season resulted in an increase in yield in the tune of 43 to 49 per cent and one supplemental irrigation to gram crop during critical growth stage in *rabi* season from farm pond using sprinkler resulted in yield enhancement of 57 per cent.

Acknowledgment

The authors are thankful to the Director, ICAR- CRIDA, Hyderabad and Authorities of Indian Council of Agricultural Research New Delhi for sanction, providing facilities and financial support under NICRA Project.

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