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Feasibility of *Rabi* crops using harvested Rain Water through farm pond under semi-arid conditions of North Gujarat

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Abstract

The ponds prevailing in the history give ample evidence about the knowledge of man regarding harvesting and utilization of runoff water in rainfed areas. The farm ponds are one of the best alternative methods for collecting and storing rainwater for future use. The farm ponds are supports to sustain agricultural activities and improve the standard of living of people, especially in the rural area. A field experiment was conducted to study the effect of treatments consists of three *Rabi* crops with low water requirement grown using harvested rainwater. The CC lined farm pond of 1100 m³ capacity was used to harvest runoff water and results of crop performance obtained during 2019-20, 2020-21 and 2021-22 are presented. The harvested water was used for growing popular regional crops such as cumin, mustard and dillseed. Year wise cumin seed yield was obtained highest 410 kg/ha in the 2021-22 with mean seed yield of 377 kg/ha. The net profit of cumin cultivation (mean) was obtained ₹11917/ha with 1.28 BCR. Year wise mustard seed yield was obtained highest 1248 kg/ha in 2019-20 and mean seed yield of three years was obtained 1202 kg/ha. The net profit (mean) of mustard cultivation was obtained ₹20562/ha with 1.49 BCR. The mean seed yield of dillseed for three years was obtained 1265 kg/ha. The net profit of dillseed cultivation (mean) was obtained ₹ 40259 / ha with 2.03 BCR. The comparative performance of dillseed crop was found better over cumin and mustard in terms of water productivity and net return.

Keywords: Feasibility, *Rabi*, rain water, pond, semi-arid

Introduction

Rainwater harvesting and recycling is an age-old practice in India, especially in the semi-arid regions. Unfortunately, modern techniques of groundwater utilization (tube wells) have over the years encouraged individualistic approach and the community participation in rainwater harvesting disappeared slowly. Increased population pressure and increasing demand from domestic and industrial sectors coupled with erratic monsoon has forced re-invention of old techniques. Water is becoming scarce in the rural livelihood. Farm ponds have a significant role in rain fed regions where annual rainfall is more than or equal to 500 mm. If average annual rainfall (AAR) varies between 500 to 750 mm, the farm ponds with capacity of 250 to 500 m³ can be constructed. If AAR is more than 750 mm the farm ponds with capacity more than 500m³ can be constructed particularly in black soil regions without lining. It was observed from field experience that at least two to three rainfall events can occur, making the ponds highly beneficial to farmers [Reddy *et al.* 2012] ^[1]. Normally, the farm ponds are constructed for rainwater harvesting from the rainfall with high intensity and used for life saving or supplemental irrigation. In semi arid region, two to five events are available in semi arid region having rainfall 500 mm to 750 mm. Besides, life saving and supplemental

irrigation, the water harvested from delayed monsoon can be used for seedbed preparation or sowing of *Rabi* crops also. In Northern part of Gujarat, crops like cumin, dillseed and Isabgul are some of the crops which require low water to grow and grown in conserved moisture depending upon availability of rainfall at later part of the monsoon season. In the situation, the harvested water in farm pond is a good source for assured cultivation of such crops. The study was undertaken to know feasibility of harvested water for cultivation of *Rabi* crops.

Materials and Methods

The harvested water from 8 ha catchment area was stored in CC lined farm pond of 1100 m³ storage capacity was used to grow low water requiring *Rabi* crops such as cumin, mustard and dillseed. The irrigations were applied through sprinkler system at the rate 0.5 IW/CPE ratio in cumin and dillseed where as in mustard at the rate 0.6 IW/CPE ratio. The fertilizers were applied as per recommended dose. The volume of water harvested, evaporation losses and seepage losses were worked out year wise. The cost of farm pond construction was considered for deriving the economics. Based on the comparative performance of the crops on water use, net profit and BCR was derived to determine most economical *Rabi* crop using harvested water.

Results and Discussion

Out of total harvested rainwater, 434.9 m³ (39.5% of storage) of water was used for irrigation using sprinkler irrigation system (Table 1). Average evaporation and

seepage losses were found to be 20 percent and 2.2 percent, respectively. Mahalle, *et al.*, 2014^[5] estimated the similar rate of evaporation from farm pond for semi-arid region.

Table 1: Year wise details of rain water harvested and water balance of farm pond

Rainfall and details of harvested water in farm pond	Year			
	2019	2020	2021	Mean
Rainfall, mm	830.3	1173.3	524	842.5
Water harvested, m ³	1432.5	3835.0	1329.0	2198.8
Used for irrigation, m ³	486.0	384.0	434.7	434.9
Evaporation, m ³	198.0	228.0	235.2	220.4
Seepage, m ³	25.0	20.9	26.1	24.0
Other losses (overflow/ leakage), m ³	342.5	3003.0	568.2	1304.6
Storage at the end of the season, m ³	381.0	220.0	64.8	221.9

The performance of different crops is described as under

Cumin

Cumin is one of the popular spices crops of the region. The

crop growth and yield attributes are presented in Table 2.

Table 2: Year wise results of growth and yield attributes, yield, and water use efficiency and economics for cumin cultivation (2019-20 to 2021-22)

Parameter/Character	2019-20	2020-21	2021-22	Mean
Plant height, cm	28.3	30.5	34.9	31.2
Number of umbels/plant	43	40.2	36.5	39.9
Number of branches/plants	11	9	8.3	9.4
Seed weight, kg/ha	384	336	410	377
Stalk weight, kg/ha	984	712	1265	987.0
Water applied, mm @ 0.5 IW/CPE	280	220	240	247
WUE, kg/ha mm	1.37	1.53	1.70	1.5
Cost of cultivation ₹/ha	22100	22680	23430	22737
Annual capital cost of farm pond, ₹	12400	12400	12400	12400
Annual capital cost of pump unit and MIS, ₹/ha	6667	6667	6667	6667
Total cost, ₹/ha	41167	41747	42497	41804
Gross income, ₹/ha	54744	47752	58665	53720
Net Profit, ₹/ha	13577	6005	16168	11917
BCR	1.33	1.14	1.38	1.28
Selling price, cumin ₹/kg	140.0	140.0	140	
Selling price, Straw ₹/kg	1.0	1.0	1	

Table 3: Year wise results of growth and yield attributes, yield, Water use efficiency and economics for cultivation of mustard

Character/Parameter	2019-20	2020-21	2021-22	Mean
Plant height, cm	197	162.9	174.0	178.0
Total number of branches/plant	16.0	8.4	9.7	11.4
Length of main branch, cm	100.6	80.6	83.5	88.2
Number of Siliqua of main branch (Nos.)	50	54.3	72.2	58.8
Seed yield, kg/ha	1248	1156	1203	1202
Stalk yield, kg/ha	5549	4229	4010	4596
Water applied, mm @ 0.6 IW/CPE	240	210	190	213
WUE, kg/ha mm	5.20	5.50	6.33	5.68
Cost of cultivation, ₹	22400	23600	23000	23000
Annual capital cost of Farm pond, ₹	12400	12400	12400	12400
Annual capital cost of pump unit and MIS, ₹	6667	6667	6667	6667
Total cost, ₹/ha	41467	42667	42067	42067
Gross income, ₹/ha	55469	56229	76190	62629
Net Profit, ₹/ha	14002	13562	34123	20562
BCR	1.33	1.32	1.81	1.49
Selling price, mustard ₹/kg	40.0	45.0	60	
Selling price, Stalk, ₹/kg	1.0	1.0	1	

Table 4: Year wise results of growth and yield attributes, yield, and water use efficiency and economics for cultivation of dilseed

Parameter/Character	2019-20	2020-21	2021-22	Mean
Plant height, cm	136.4	127.9	133.8	132.7
No. of umbels/plant	22.0	18.6	21.6	20.7
Number of umbelet/umbe	24.6	26.1	23.3	24.7
Seed weight, kg/ha	924	1422	1448	1265
Stalk weight, kg/ha	3063	3975	4095	3711
Water applied, mm @ (0.5 IW/CPE)	240	180	180	200
WUE, kg/ha mm	3.85	7.90	8.04	6.60
Cost of cultivation ₹/ha	26000	20480	19880	22120
Annual capital cost of farm pond, ₹	12400	12400	12400	12400
Annual capital cost of pump unit and MIS, ₹/ha	6667	6667	6667	6667
Total cost, ₹/ha	45067	39547	38947	41187
Gross income, ₹/ha	58503	82185	103650	81446
Net Profit, ₹/ha	13436	42638	64703	40259
BCR	1.3	2.1	2.7	2.03
Selling price of dilseed grain, ₹/kg	60.0	55.0	70.0	61.7
Selling price, stalk, ₹/kg	1.0	1.0	1.0	1.0

Year wise cumin seed yield was obtained highest 410 kg/ha in the 2021-22 and lowest in 2020-21 with mean seed yield of 336 kg/ ha. The water applied was observed from 220 mm to 280 mm with three year mean value of 247 mm. The water use efficiency (three year mean) was recorded 1.5 kg/ha-mm. The net profit of cumin cultivation (mean) was obtained ₹11917/ha with 1.28 BCR using harvested water in farm pond. As such water requirement of the crop is low however, needed minimum two light irrigations 25 mm each at 5-6 day interval for germination besides pre-sowing irrigation of 50 mm. The crop was applied 4-5 irrigations each of 30 mm at the interval at 12-15 days up to 75 days after sowing (DAS) using sprinkler irrigation system.

Mustard: Mustard is one of the important oilseed crops of the North Gujarat having comparatively low water requirement than other regional *Rabi* crops like castor and wheat. Besides pre sowing irrigation the crop was applied 4-5 irrigations each of 30 mm at the interval of 12-15 days up to January using sprinkler irrigation system. The crop growth and yield attributes are presented in Table 3. Year wise mustard seed yield was obtained highest 1248 kg/ha in 2019-20 and mean seed yield of three years was found to be 1202 kg/ha (Table 3). The net profit (mean) of mustard cultivation was obtained ₹20562/ha with 1.49 BCR. The mean water applied was 213 mm and mean water use efficiency was obtained 5.68 kg/ha-mm.

Dilseed: Dil Seed is one of the spices crops of the North

Gujarat with low water requirement grown particularly in Patan and Banaskantha districts. Dilseed is cultivated in post monsoon conserved moisture. In areas with loamy soil also, many farmers grow dilseed on availability of good rainfall during post monsoon period. As per experimental design dilseed was cultivated successfully for three years during 2019-20, 2020-21 and 2021-22 (Table 4). The mean seed of dilseed for three years was obtained 1265 kg/ha (Table 4). One pre sowing irrigation of 50 mm and one irrigation of 30 mm one week after sowing required for germination. Besides, four irrigations each of 30 mm at the interval of 25-30 days required for the crop to reach to maturity. The net profit of dilseed cultivation (mean) was obtained ₹ 40259 per ha with 2.03 BCR. The mean quantity of water applied was 200 mm and mean water use efficiency was obtained 6.60 kg/ha-mm under experimentation.

Ex-situ water management for enhanced water productivity: The comparative performance of different *Rabi* crops is presented in Table 5. The water use efficiency was obtained higher in dilseed (6.60 kg/ha-mm) followed by mustard (5.84 kg/ha mm) and cumin (1.57 kg/ha-mm). Accordingly, the net profit per ha and BCR was found to be higher in dilseed. Therefore the harvested water can be economically used to grow crops with low water requirement. Ramamurthy, *et al.* 2009 ^[2] and Bhandarkar, 2009 ^[6] also quoted use of harvested water for growing *Rabi* crops. Dhanapal, *et al.*, 2009 ^[4] also advocated use of harvested water for growing *Rabi* crops in Alfisol.

Table 5: Comparative performance of different crops grown using harvested rainwater in existing farm pond.

Parameter	Cumin	Mustard	Dilseed
Seed weight, kg/ha	377	1202	1265
Stalk weight, kg/ha	987	4596	3711
Water applied, mm	247	213	200
WUE, kg/ha mm	1.53	5.68	6.60
Cost of cultivation ₹/ha	22737	23000	22120
Annual capital cost of farm pond, ₹	12400	12400	12400
Annual capital cost of pump unit and MIS, ₹/ha	6667	6667	6667
Total cost, ₹/ha	41804	42067	41187
Gross income, ₹/ha	53720	62629	81446
Net Profit, ₹/ha	11917	20562	40299
BCR	1.28	1.49	2.03

Summery and Conclusion

The harvested water in CC lined farm pond of was used to grow regional *Rabi* crops with low water requirements. The volume of water harvested, evaporation losses and seepage losses year wise were worked out. The cost of farm pond construction was considered for deriving the economics. Based on the comparative performance of the crops on water use, dilseed crop was found to be higher over mustard and cumin. Therefore, farmers may be suggested to grow dilseed for higher net return using harvested water in farm pond.

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