EFFECT OF CAPACITY OF ON-FARM RESERVOIR ON WATER SAVING

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Abstract*— Next to air, it is the water which is of paramount importance for living beings. It is possible to survive without food and shelter for some days, but without water it is not possible to survive for much of time. Due of this, a lot of emphasis is being given to save and use water wisely and efficiently. Agriculture which consumes major quantity of fresh water, is under great pressure due to use of less efficient techniques of irrigation. The present study deals with maximizing saving in water for crops of various numbers of irrigation on the basis of capacity of On-farm reservoir. The study suggests that for maximum water savings, the minimum capacity of the On-farm reservoir varies with irrigation return flow.

Index Terms*— On-farm reservoir, irrigation return flow, crop of various number of irrigations, water saving.

I. INTRODUCTION

Water is a gift of the Nature to human race. All the major ancient civilizations developed along the river banks because water was available for drinking, domestic and also for irrigation purposes. Due to increase in development activities and continuous rise in population the dependency on water has increased considerably. From the studies, it has been confirmed that the use of On-farm reservoir (OFR) leads to saving of water. In this regard, the next step is to ascertain the capacity of the same. Since certain area of the agriculture field is required to construct the OFR, the capacity of the same should be optimum. In case, the capacity of OFR is kept lesser than the irrigation return flow produced by the crops, it will result in significant reduction in water saving. However, if the farmer decides to keep the capacity of OFR any thing ranging between equal to irrigation return flow to twice the irrigation return flow, water saving will be accordingly varying. On other hand, if the capacity is large, i.e., more than twice the irrigation return flow, the area under the crop reduces considerably, resulting in significant reduction in yield of the crop, hence on the economics of the investment.

II. RESEARCH METHODOLOGY

After each rotation of irrigation, the irrigation return flow of excess irrigation in the farm will make OFR either partially filled or full, depending on the storage capacity of OFR. The size of OFR depends on the type of crop(s), supplemental irrigation needs, topography and climate of the area (Palmer et al., 1981, Palmer et al., 1982 and Panigrahi and Panda, 2003). In India, a single crop in the field requiring three to seven numbers of irrigations are being practiced. Effect on water saving has been evaluated for a single crop of various numbers of irrigations by reducing the capacity of OFR from twice the irrigation return flow ($2.00*I_f$) to solo times the irrigation return flow ($1.00*I_f$). Since, the capacity of OFR is assumed to be more than irrigation return flow of first irrigation, there can be possibility of filling of remaining capacity of OFR through direct withdrawal of water also from source. Thus, the networks for crops having various numbers of irrigations are used for estimation of water saving such as shown in figure 1 (Gupta et al., 2007, Gupta., 2017).

III. ILLUSTRATIVE EXAMPLE

The Let the total area of the field be 1 hectare excluding the surface area of OFR. It is assumed that the crop grown in the field requires 30, 40, 50, 60 and 70 cm of irrigation in3, 4, 5, 6 and 7 rotations of irrigations respectively. It is given that water application efficiencies through field and supply channel are 75% and 90%, respectively. The respective coefficients due to evaporation, deep percolation and runoff through field are given as 0.25, 0.25 and 0.50. It is assumed that during entire crop period, there is no rainfall.

Solution: Using the following notations and equations for the data given in the illustrative example
$C_p = 0.25$, $K_f = 0.25$, $R_c = 0.50$, and $K_{ofr} = 0.2$,

Water required by the crop, $WR = \dfrac{TWR}{f}$ (1)

Water supplied to the crop, $WS_f = \dfrac{TWR}{\eta_f . f} = \dfrac{WR}{\eta_f}$ (2)

Deep percolation loss, $DP_f = C_p.(WS_f - WR)$ (3)
Evaporation loss from field, $EV_f = K_f.(WS_f - WR)$ (4)
Irrigation return flow from field, $I_f = R_c.(WS_f - WR)$ (5)
$S_i - S_{i-1} = NS_i = I_{fi} + P_i - EV_{ofri} - SI_i - DP_{ofri}$ (6)

and above invoking Eqs.(1), (2), (3), (4), (5) and (6), we get various quantities during first irrigation event at node "i" as $WR = 1000\ m^3$, $WS_f = 1333.33\ m^3$, $EV_{ofr} = 33.33\ m^3$, $I_f = 166.67\ m^3$, $I_c = 166.67\ m^3$, $WS_c = 185.19\ m^3$ and $O_f = 0\ m^3$.

It is further assumed that the maximum storage capacity of OFR = 2 I_f = C = 333.33 m^3 i.e. after two irrigation events OFR is full, provided there is no evaporation loss. The water required without OFR for a crop requiring three, four , five , six and seven numbers of irrigations respectively is 4000.00 m^3, 5333.33 m^3, 6666.67 m^3, 8000.00 m^3, and 9333.33 m^3. Tables 1 to 5 show the water saving (%) corresponding to the strategies for maximum water saving for various capacities of OFR, viz. 2, 1.75, 1.5, 1.25 and 1.00 times the irrigation return flow of the solo irrigation from single crop of Three to Seven numbers of Irrigations.

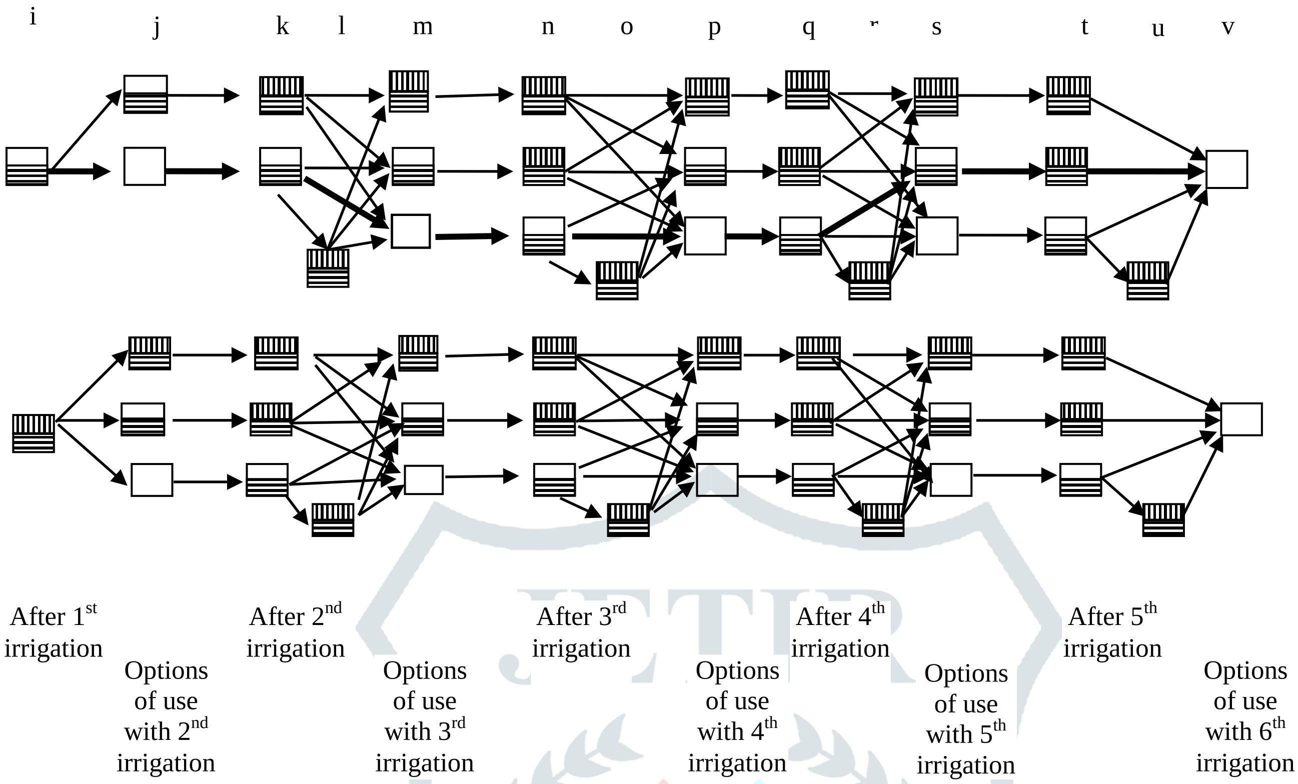

Fig.1 Network for a crop of six numbers of irrigations

Table 1: Saving of water with different capacities for a crop of three numbers of irrigations

Strategy No.	C = 2.00 * I_f		C = 1.75 * I_f		C= 1.50 * I_f		C = 1.25 * I_f		C = 1.00 * I_f	
	WS with OFR (m^3)	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**
1.	3730.00	**6.75**	3730.00	**6.75**	3730.00	**6.75**	3730.00	**6.75**	3730.00	**6.75**

It is seen from the table 1 that the maximum water saving (%) remains the same, i.e. 6.75% for any value of capacity from 2 to 1.0 times the irrigation return flow. Thus, the ideal capacity of OFR is solitary times irrigation return flow from single crop of three numbers of irrigation**.**

Table 2: Saving of water with different capacities for a crop of four numbers of irrigations

Strategy No.	C = 2.00 * I_f		C = 1.75 * I_f		C= 1.50 * I_f		C = 1.25 * I_f		C = 1.00 * I_f	
	WS with OFR (m^3)	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**
5.	5002.67	**6.20**	5002.67	**6.20**	5002.67	**6.20**	5033.33	5.63	5066.67	5.00
6.	-	-	-	-	-	-	5018.67	**5.90**	5018.67	**5.90**

From table 2 it is seen that water saving (%) remains the same, i.e., 6.20% for any value of capacity from 2 to 1.5 times the irrigation return flow. If the capacity of OFR is reduced further below 1.5 times the irrigation return flow, the amount of water saving changes to lower value, i.e. 5.90% and most efficient path also changes. This warranted the investigation of the capacity at which the water saving remains unchanged. It is found that water saving remains 6.20% till capacity of OFR is 1.35 times the irrigation return flow. Below this capacity, water saving amount reduces due to overflow (wastage) of water from the OFR. Thus, the ideal capacity of OFR is 1.35 times the irrigation return flow of the solo irrigation from single crop of four numbers of irrigations.

Table 3: Saving of water with different capacities for a crop of five numbers of irrigations

Strategy No.	C = 2.00 * I_f		C = 1.75 * I_f		C= 1.50 * I_f		C = 1.25 * I_f		C = 1.00 * I_f	
	WS with OFR (m^3)	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**

20.	6238.93	**6.42**	6238.93	**6.42**	6253.33	**6.20**	6286.67	5.70	6320.00	5.20
21.							6259.20	**6.11**	6259.20	**6.11**

From table 3 it is seen that the water saving (%) remains the same, i.e., 6.42% for the capacities 2 and 1.75 times the irrigation return flow. However, water saving (%) reduces to 6.20% for the capacity 1.5 times the irrigation return flow. This warranted the investigation of the capacity at which the water saving remains unchanged. It was found that water saving remains 6.42% till capacity of OFR is 1.6 times the irrigation return flow. Below this capacity, water saving amount reduces due to overflow (wastage) of water from the OFR. Thus, the ideal capacity of OFR is 1.60 times the irrigation return flow of the solo irrigation from single crop of five numbers of irrigations.

Table 4: Saving of water with different capacities for a crop of six numbers of Irrigations

Strategy No.	**C = 2.00 * I_f**		**C = 1.75 * I_f**		**C= 1.50 * I_f**		**C = 1.25 * I_f**		**C = 1.00 * I_f**	
	WS with OFR (m^3)	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**		**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**
76.	7477.76	**6.53**	7477.76	**6.53**	7485.33	**6.43**	7518.67	6.02	7552.00	5.60
77							7496.32	**6.30**	7496.32	**6.30**

From table 4 it is seen that the water saving (%) remains the same i.e. 6.53% for the capacities 2 and 1.75 times the irrigation return flow. However, water saving (%) reduces to 6.43% for the capacity 1.5 times the irrigation return flow. This warranted the investigation of the capacity at which the water saving remains unchanged. It was found that water saving remains 6.53% till capacity of OFR is 1.6 times the irrigation return flow. Below this capacity water saving amount reduces due to overflow (wastage) of water from the OFR. Thus, the ideal capacity of OFR is 1.60 times the irrigation return flow of the solo irrigation from single crop of six numbers of irrigations.

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Table 5: Saving of water with different capacities for a crop of seven numbers of irrigations

Strategy No.	**C = 2.00 * I_f**		**C = 1.75 * I_f**		**C= 1.50 * I_f**		**C = 1.25 * I_f**		**C = 1.00 * I_f**	
	WS with OFR (m^3)	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**		**WS with OFR (m^3)**	**Saving (%)**	**WS with OFR (m^3)**	**Saving (%)**
84	8715.56	**6.62**	8715.56	**6.62**	8725.87	**6.51**	8759.20	6.15	8792.53	5.79
85							8734.81	**6.41**	8734.81	**6.41**

From table 5 it is seen that the water saving (%) remains the same, i.e., 6.62% for the capacities 2 and 1.75 times the irrigation return flow. However, water saving (%) reduces to 6.51% for the capacity 1.5 times the irrigation return flow. This warranted the investigation of the capacity at which the water saving remains unchanged. It was found that water saving remains 6.62% till capacity of OFR is 1.6 times the irrigation return flow. Below this capacity water saving amount reduces due to overflow (wastage) of water from the OFR. Thus, the ideal capacity of OFR is 1.60 times the irrigation return flow of the solo irrigation from single crop of seven numbers of irrigations.

IV. Discussions

The effect on water saving has been evaluated for single crops of various numbers of irrigations having different capacities of OFR ranging from 2.00* I_f to 1.00* I_f. It can be concluded that the water saving remains unaffected if capacity of OFR is ranged between 2.00* I_f to 1.60* I_f for a single crop of various numbers of irrigations (ranging from 3 to 7). Thus suggesting that maximum water saving can be obtained, if capacity of OFR is about 1.60* I_f. This is due to the fact that maximum storage level in OFR in the entire critical path of the network does not exceed 1.60 times irrigation return flow from solo irrigation of the crop(s) for the assumed values of various parameters in the study. It is hoped that these guideline will help the farmers to construct OFR of required capacity for the crop of any numbers of irrigations (ranging from 3 to 7) in case of single crops.

V. Conclusions

With regard to effect of different capacities of OFR ranging from 2.00*I_f to 1.00*I_f on water saving for a single crops of various numbers of irrigations, it is found that maximum water saving can be obtained, if capacity of OFR is about 1.60times the irrigation return flow from the field.

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