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Case Study

# IRRIGATION PLANNING IN CANAL COMMAND AREA OF SAMRAT ASHOK SAGAR PROJECT- A CASE STUDY

**BASEDIYA SHIV SINGH*, PYASI S.K. AND SHRIVASTAVA R.N.**

Department of Soil and Water Engineering, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Adhartal, Jabalpur, 482004, India
*Corresponding Author: Email-singh.shiv154@gmail.com

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**Abstract-** A huge amount was invested on irrigation project but this project did not achieve the target. Most of these projects have very low water productivity ranging between 0.52-0.60 kg m-3 and 30-50% irrigation efficiency. Lining of the canal and transpiring the management to WUA also could not result. In this scenario, application of pressurized irrigation system in place of surface irrigation system may be a solution. Looking to these facts, this study was conducted in the command of RBC of Samrat Ashok Sagar project. The detailed survey of all the 55 villages of the command area was conducted in order to have an account of present condition. It was found that only flood irrigation system is being practiced in the whole command area. The cropping intensity of the area was determined using previous data. Existing cropping intensity varies between 115% to 196%. Similarly, the existing water productivity was determined. It varies from 0.52-0.60 kg m-3. An increase of 76% in the water productivity was observed, if border irrigation system is replaced by sprinkler irrigation system. Similarly, 116% increase in water productivity was found if flood irrigation system is replaced by sprinkler irrigation system and about 23% increase in water productivity was found if flood irrigation system is replaced by border irrigation system. In order to evaluate this in the farmer's field 15 farmers (five from each reach) were selected randomly. The ratio of 60:40 of sprinkler irrigation system and border irrigation system was found suitable for RBC command of Samrat Ashok Sagar project in view to enhance the water productivity, water use efficiency and cropping intensity in study area. The water saved through this level was found 9071431 m3 (25%) and thus the additional area 2016 ha (21.21%). may be brought under irrigation through adoption of 60-40% irrigation level technology and increasing the cropping intensity by 8.59%. Prepared conjunctive plan for surface and pressurized irrigation was implemented and evaluated in the 15th farmers field and was found suitable as per recommendations made. A complete plan for entire RBC command area that is for 9503 ha was made and also recommended for implementation.

**Keywords-** Water Productivity, Cropping intensity, pressurized irrigation, Surface irrigation, Water saving, Canal Command Area.

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## Introduction

Modernization of the irrigation system is required for improving the overall project efficiency of irrigation projects and increasing the water productivity. Modernization and optimization of irrigation systems have often been promoted in public and private agendas as tools to improve irrigation efficiency and producing more agricultural goods with less water input [7]. Shifting from surface irrigation to pressurized irrigation system to increase water use efficiency is an important component of the modernization process. Water is the most critical input for agriculture. The availability of adequate water for irrigation is a key factor in achieving higher productivity. However, poor efficiency of conventional irrigation systems has not only reduced the anticipated outcome of investments towards water resource development, but has also resulted in environmental problems *viz*. water logging and soil salinity, thereby adversely affecting crop yields [3]. Management of the water resources for diverse uses should incorporate a participatory approach: by involving not only the various governmental agencies but also the users' and other stakeholders, in an effective and decisive manner, in various aspects of planning, design, development and management of the water resources schemes. Water Users' Association and local bodies such as municipalities and Gram-Panchayats should particularly be involved in the operation, maintenance and management of water infrastructures/facilities at appropriate levels progressively, with a view to eventually transfer the management of such facilities to the user groups/ local bodies studies by [2].

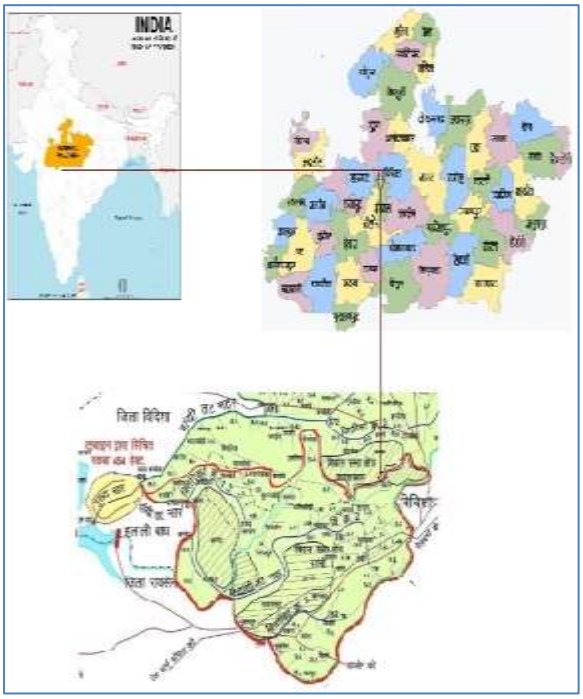
Command area development program (CADP) was launched exclusively to reduce the physical and time gap between irrigation potential created and its actual utilization through systematic land development, scientific water management and appropriate extension methods [9].

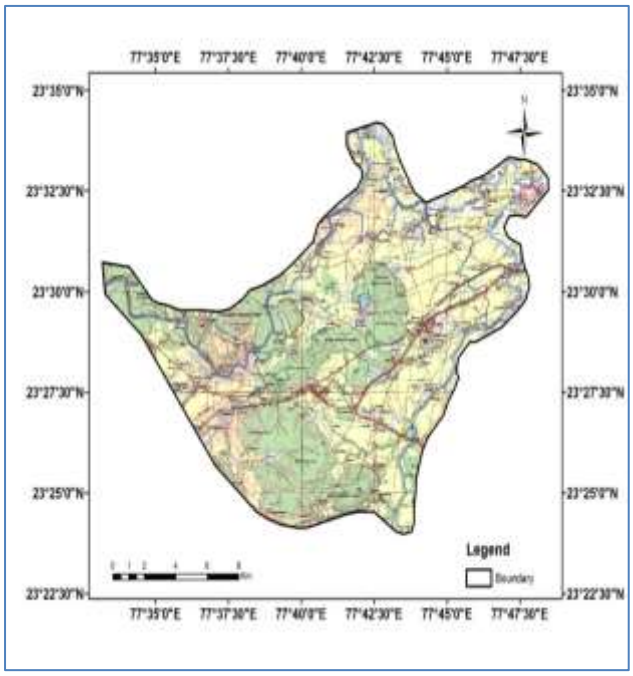
Samrat Ashok Sagar Project is a major irrigation project located in Vidisha district of Madhya Pradesh (India). The gross command area of the Samrat Ashok Sagar (SAS) project is 37419 ha, cultivable command area is 32292 ha and canal irrigated area is 30151 ha. The total irrigated area of SAS project is about 44000 ha, including irrigation through other sources. 2141 ha area out of total irrigated area is being irrigated through pumping from canal. The cultivable command area of Right Bank Canal is 14836 ha and irrigated area of RBC command is 9503 ha. Out of this 2436 ha area is being irrigated through pumping from canals as water is not reaching through gravity. The supply of canal water is stopped in the month of February to meet to increasing demand of drinking water for Vidisha Township. So in peak maturity period of crops farmers do not get water. The tail end farmers do not get water during supply period because of seepage losses, over irrigation and poor maintenance of system. This all result in low water productivity, "Pressurized irrigation in command area" is emerging as a solution of these problems as reported by [6]. With these facts in mind a about water distribution system of right bank canal command area, a detailed study with feasibility of pressurized irrigation system was conducted and prepared conjunctive plan for surface and pressurized irrigation was implemented in farmers field.

## Materials and Methods

The study was conducted in the command area of Right Bank Canal of Samrat Ashok Sagar Irrigation Project located in Vidisha district, Madhya Pradesh (India). The Samrat Ashok Sagar Project is a major irrigation project located in Vidisha district of Madhya Pradesh (India). Its command area falls in parts of Vidisha and Raisen districts. The dam is constructed on the Halali river, which is a tributary of Betwa river about 40 km. from Bhopal. Command area of Samrat Ashok Sagar lies between Longitude 77°33' E and Latitude 23°30' N, at an altitude of 426 m respectively. The project is based on catchment and gravity flow. The problems of farmer at tail end canal command area, because optimum water is not available. However individual farmers use diesel and/or electric pump sets to lift water out of the canals. This project was commenced in year 1977 to irrigate 25091 hectares in Rabi season [1].

## Location and Topographic Map of the Study Area




## Irrigation Method

Irrigation in almost entire command is done by the surface method. Irrigation water is applied by flooding from a channel located at the upper reach of a field. Farmers of RBC command used free flooding surface irrigation method. No specific design criterion is followed in this method of water application. This method results wasteful losses and many times results in soil erosion and non-uniform application of water in a field [11].

## Farmers and Land Holdings

The list of farmers or water users was collected from irrigation department of Vidisha district. The president of WUAs was helpful for collecting information about farmer's namely, location of farm, land holding, power source, irrigation method etc. Farmers were categorized according to their land holding. Area less than 1 ha under marginal category, 1-2 ha in small category, 2-4 ha in medium category and more than 4 ha was categorized in large category as shown in [Table-1] [4].

**Table-1** *Detail of Water Users in RBC Command Area*

| Farmers group | Number of farmer's in different reach | | | Total farmer | % of farmers | Area (ha) | % of Area (ha) |
|---|---|---|---|---|---|---|---|
| | Head | Middle | Tail | | | | |
| Land holding | | | | | | | |
| Marginal farmers | 436 | 624 | 683 | 1743 | 36 | 1224 | 12.88 |
| Small farmers | 422 | 613 | 511 | 1546 | 31 | 2554 | 26.88 |
| medium farmers | 336 | 414 | 374 | 1124 | 23 | 3079 | 32.40 |
| Large farmers | 164 | 155 | 177 | 496 | 10 | 2646 | 27.84 |
| **Total** | **1358** | **1806** | **1745** | **4909** | **100** | **9503** | **100** |

## Results and Discussion

The study was undertaken in right bank canal command area of Samrat Ashok Sagar irrigation project of Vidisha district Madhya Pradesh for evaluating the present irrigation system and to plan improvements for enhancing water productivity and cropping intensity of the project by optimizing surface and pressurized irrigation system.

## Conjunctive Plan for Surface and Pressurized Irrigation System

It was found from the survey of the study area that about 60% of the land is owned by medium and large farmers and about 40% of the land is owned by small and marginal as shown in [Table-1]. At the same time, the fact emerged from the feasibility analysis that medium and large farmers were showing willingness and having purchase capacity also and feels no problem in handling and management of sprinkler irrigation system. On the other side small and medium farmers was not agreed fully for adoption and they have few problems along with low investment capacity. It was also reported by many researchers that flood irrigation is mainly responsible for low water productivity and it must be replaced by pressurized irrigation system and improved surface method of irritation. Looking to these facts a plan was prepared taking a hypothesis that about 60% area should be brought under sprinkler irrigation system and about 40% area under border irrigation system and no flood irrigation system should be practiced [10].

## Planning for the Entire RBC Command

It is clear that a combination of Sprinkler and border irrigation system in a ratio of 60:40 is best suitable for entire RBC command area. So the irrigation planning for the entire area was made accordingly. Based on the topography and distance from the RBC area at higher elevation undulating area and nearer to RBC was found suitable for sprinkler irrigation system while the rest of the area that is flat area was found suitable for border irrigation system. It is also recommended that flood irrigation should not be practiced. A map showing all the villages with elevation (in parentheses) is given in [Fig-1]. Villages having area recommended under sprinkler irrigation are marked red. Village wise area as recommended under sprinkler irrigation system (60%) and area should be covered by border irrigation system (40%) is presented in [Table-4] 60 [8].

**Table-2** *Area Proposed Under Sprinkler and Border Irrigation Methods*

| Name of WUA | Name of village | Canal irrigated area (ha) | Area proposed under irrigation methods | |
|---|---|---|---|---|
| | | | Border (40%) | Sprinkler (60%) |
| Sarchampa | Bansakheda | 477 | 152 | 325 |
| | Silwaha | 245 | 122 | 123 |
| | Sarchampa | 365 | 225 | 140 |
| Ucher | Moralikhedi | 184 | - | 184 |
| | Narauda | 65 | - | 65 |
| | Gulgaonv | 140 | 25 | 115 |
| | Firojpur | 240 | 40 | 200 |
| | Chiroli | 177 | 175 | 2 |
| | Fatehpur | 262 | 100 | 160 |
| | Uneeda | 52 | 22 | 30 |
| | Airan | 188 | 40 | 148 |
| | Dhaniyakhedi | 138 | 130 | 8 |
| | Anauri berkhedi | 360 | 48 | 312 |
| | Ucher | 257 | 98 | 159 |
| | Dargava | 50 | 30 | 20 |
| | Kanakheda kalan | 195 | 50 | 145 |
| | Mada | 170 | 48 | 122 |
| | Madvai | 400 | 104 | 296 |
| | Kamapar | 243 | 38 | 205 |
| | Nonakhedi | 89 | 15 | 74 |
| Medaki | Dakana chapana | 220 | 15 | 205 |
| | Medaki | 354 | 249 | 105 |
| | Suakhedi | 130 | 130 | 0 |
| | Sookhansen | 50 | 40 | 10 |
| | Aamkheda | 102 | 102 | 0 |
| | Ratanpur girdhari | 155 | 145 | 10 |
| | Kachhi kanakheda | 180 | 180 | - |
| | Vilori | 145 | 145 | - |
| | Nagori | 105 | 105 | - |
| | Piparia khurd | 80 | 80 | - |
| | Mudiakheda | 5 | - | 5 |
| | Muktapur | 25 | - | 25 |
| | Sunari | 25 | - | 25 |
| | Rataltai | 20 | - | 20 |
| | Khamkheda | 15 | 15 | - |
| Sayar | Sayar | 660 | 72 | 588 |
| | Bagaud | 291 | 99 | 192 |
| | Parasi khurd | 122 | 122 | - |
| | Patharia | 12 | 12 | - |
| | Karela | 256 | 72 | 184 |
| | Madaiya khurd | 78 | 73 | 5 |
| | Suganakhedi | 258 | 70 | 188 |
| | Bala barkheda | 35 | - | 35 |
| | Bamora | 183 | - | 183 |
| Neemkheda | Neemkheda | 684 | 180 | 504 |
| | Sunpura | 289 | 54 | 235 |
| | Karaiya haveli | 172 | 52 | 120 |
| | Rangai | 75 | 70 | 5 |
| | Berkhedi | 85 | 27 | 60 |
| | Padariya maphi | 75 | 70 | 5 |
| | Udaygiry | 90 | 90 | - |
| | Base | 132 | 32 | 100 |
| | Vighan | 98 | 38 | 60 |
| **Total** | **-** | **9503** | **3801** | **5702** |


**Fig-1 Planning in RBC Command Area**

**Implementation and Evaluation at Farmer's Field**

In order to implement and evaluate the plan at farmer's field 15th farmers (5 head, 5 middle and 5 tail reach) were selected from the farmers list using random number technique. To fit the experiment in statistical design six levels of sprinkler irrigation system and border irrigation system combination at a width of 10 and 20 intervals were tried. The level 0-100, 10-90, 20-80, 30-70, 40-60, 50-50, 60-40, 70-30, 80-20, 90-10 and 100-0 (sprinkler- border irrigation system) was not found fit in statistical analysis whereas the levels (sprinkler- border irrigation system) 0-100, 20-80, 40-60, 60-40, 80-20 and 100-0 were found fit for implementation in the command area. Experiment was laid down having all these levels of irrigation at each farmer's field. Thus, a total of six treatments were taken at each field. Crop variety and other crop management was kept same for all replications. Observations were recorded for each level and have been presented in [Table-3], [6]. [Table-4. and 5] reveals about the impact of pressurized irrigation method and border irrigation method at various level through the technique of ANOVA. The sprinkler irrigation method and border irrigation method were taken to at width of 20 interval considering over all 100 at each level of irrigation including sprinkler irrigation method and border irrigation method. Significant difference in the yield was found and it was concluded that sprinkler irrigation method was having more yield than border irrigation method. The ANOVA [5]. table indicated that the irrigation method differing at an interval of 20% was found to be significant at 5% and 1% level of significance. When the data were analyzed using the same technique taking concentration at 10 percent interval, they were not found to significant. It concluded that the irrigation method differed significantly when the concentration different were more than 10%. The null hypothesis was postulated as below.

$H_0$: There is no significant difference among all the level of the combination of sprinkler irrigation method and border irrigation method.

$H_1$: There is significant difference among all the level of the combination of sprinkler irrigation method and border irrigation method.

**Table-3** *Impact of Sprinkler Irrigation System and Surface Irrigation System on the Yield of Wheat Crop*

| Name of farmers | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Max. (q ha$^{-1}$) | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tm | sprinkler area % | border area % | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | | |
| $T_1$ | 0 | 100 | 32 | 35 | 34 | 32 | 33 | 33 | 35 | 36 | 31 | 32 | 32 | 34 | 35 | 35 | 36 | 36 | 33.67 |
| $T_2$ | 20 | 80 | 36 | 35 | 33 | 37 | 36 | 35 | 36 | 37 | 37 | 35 | 37 | 36 | 35 | 35 | 36 | 37.40 | 35.80 |
| $T_3$ | 40 | 60 | 37 | 36 | 37 | 38 | 39 | 38 | 39 | 39 | 37 | 36 | 36 | 39 | 38 | 39 | 37 | 39.40 | 37.69 |
| $T_4$ | 60 | 40 | 40 | 40 | 40 | 40 | 39 | 40 | 40 | 41 | 40 | 40 | 40 | 40 | 40 | 39 | 41 | 41 | 39.99 |
| $T_5$ | 80 | 20 | 41 | 42 | 41 | 41 | 41 | 41 | 42 | 42 | 41 | 41 | 43 | 43 | 43 | 41 | 42 | 43.00 | 41.63 |
| $T_6$ | 100 | 0 | 44 | 45 | 46 | 45 | 42 | 43 | 42 | 46 | 44 | 45 | 44 | 44 | 45 | 44 | 43 | 46.00 | 44.13 |
| **Average** | | | - | | | | | | | | | | | | | | | | **38.82** |

Note:- Tm – is treatment, Y – is yield (q ha$^{-1}$) and 1, 2, 3.....15 name of farmers

**Table-4** *Difference Among all the Level of the Combination of SprinklerIrrigation and Border Irrigation Method.*

| Treatment | Mean | $T_1$-$T_1$- ....$T_6$ | $T_2$-$T_1$-....$T_6$ | $T_3$-$T_1$-....$T_6$ | $T_4$-$T_1$-....$T_6$ | $T_5$-$T_1$-....$T_6$ | $T_6$-$T_1$-....$T_6$ |
|---|---|---|---|---|---|---|---|
| $T_1$ | 33.67 | 0.00 | 2.13 | 4.03 | 6.32 | 7.96 | 10.47 |
| $T_2$ | 35.80 | -2.13 | 0.00 | 1.89 | 4.19 | 5.83 | 8.33 |
| $T_3$ | 37.69 | -4.03 | -1.89 | 0.00 | 2.29 | 3.93 | 6.44 |
| $T_4$ | 39.99 | -6.32 | -4.19 | -2.29 | 0.00 | 1.64 | 4.15 |
| $T_5$ | 41.63 | -7.96 | -5.83 | -3.93 | -1.64 | 0.00 | 2.51 |
| $T_6$ | 44.13 | -10.47 | -8.33 | -6.44 | -4.15 | -2.51 | 0.00 |

**Table-5** *Structure of ANOVA Table*

| S. No | S.V. | d.f. | S.S. | M.S. | F. cal. | F.tab. |
|---|---|---|---|---|---|---|
| 1 | Replication | 14 | 22.93 | 151.04 | 183.07 | 5% = 2.35<br>1% = 3.29 |
| 2 | Treatment | 5 | 755.20 | | | t = 2 |
| 3 | Error | 70 | 57.76 | 0.825 | | C.D =0.65 |

To arrive an optimum ratio of border irrigation method and sprinkler irrigation method. The percent area ratio for adoption of sprinkler irrigation method and border irrigation method was grouped as 0-100%, 20-80%, 40-60%, 60-40%, 80-20% and 100-0%. The experiment was planned in 15 farmers' fields having percent area distribution under border irrigation system and sprinkler irrigation system as shown in [Table-3]. The yield of wheat was obtained in each treatment and it was found that maximum yield 46 q $ha^{-1}$ was found under treatment $T_6$ (100-0) that is 100% sprinkler and 0% border followed by $T_5$ (43 q $ha^{-1}$), $T_4$ (41 q $ha^{-1}$), $T_3$ (39 q $ha^{-1}$), $T_2$ (37 q $ha^{-1}$) and $T_1$ (36 q $ha^{-1}$). The overall average yield of wheat was found 38.82 (q $ha^{-1}$). In present situation the entire area under experiment could not be replaced by either sprinkler irrigation system or border irrigation system as far as feasibility of adoption and economics of farmers is concerned. Wheat yield 39.99 q $ha^{-1}$ under the treatment $T_4$ (60:40) is almost nearest to average yield 38.82 (q $ha^{-1}$). Hence, it is recommended that in first phase 60% of total RBC command area must be replaced by sprinkler irrigation system and 40% area must be replaced by border irrigation system in place of flood irrigation system to enhance the water productivity and water use efficiency.

## Enhancing Water Productivity

It was found that average water productivity in case of sprinkler irrigation system, border irrigation system and flood irrigation system was recorded as 1.32 kg $m^{-3}$, 0.75 kg $m^{-3}$ and 0.61 kg $m^{-3}$ respectively as shown in [Table-6]. An increase of 76% in the water productivity was observed, if border irrigation system is replaced by sprinkler irrigation system. Similarly, 116% increase in water productivity was found if flood irrigation system is replaced by sprinkler irrigation system and about 23% increase in water productivity was found if flood irrigation system is replaced by border irrigation system.

**Table-6** *Average Wheat Crop Yield and Water Productivity for Three Irrigation Method in Command Area*

| S. No. | Irrigation Method | Average Water Productivity (kg $m^{-3}$) | Average Yield (t $ha^{-1}$) |
|---|---|---|---|
| 1 | Sprinkler | 1.32 | 4.40 |
| 2 | Border | 0.75 | 3.36 |
| 3 | Flood | 0.61 | 2.88 |

## Irrigation Area Increased through Adoption of Technology

Combination of recommended irrigation methods that is 60% area was covered by sprinkler irrigation system and 40% area was covered by border irrigation system was adopted for irrigating the wheat crop in the entire command area of RBC. [Table-7] reveals that 25% saving in water is obtained and consequent upon it 2016 ha additional area may be brought under irrigation and thus increasing the cropping intensity by 8.60%.

**Table-7** *Increase in Irrigated Area through Adoption of Technology*

| Irrigation | % Area | Total | Water | % Saving of | Irrigated |
|---|---|---|---|---|---|
| Flood | 100% | 45349494 | 4772.1 | Nil | Nil |
| Sprinkler | 60% | 19122113 | 3353.6 | 42.29 | - |
| Border | 40% | 17155950 | 4513.5 | 5.73 | - |
| Sprinkler | 100% | 36278063 | 3817.53 | 25.00 | 2016 |

## Conclusion

This study was planned to assess the present irrigation system, water productivity and cropping intensity of the right bank canal command area of Samrat Ashok Sagar project by optimizing the border and sprinkler irrigation. The techno-economic feasibility of pressurized irrigation system was also assessed in view of conjunctive plan preparation for surface and pressurized irrigation system as well as implementation of plan at farmer's field. It was concluded that the ratio of 60:40 of sprinkler irrigation system and border irrigation system was found suitable for RBC command of Samrat Ashok Sagar project in view to enhance the water productivity, water use efficiency and cropping intensity in study area. The water saved through this level was found 9071431 $m^3$ (25%) and thus the additional area 2016 ha (21.21%) may be brought under irrigation through adoption of 60-40% irrigation level technology and increasing the cropping intensity by 8.59%. Prepared conjunctive plan for surface and pressurized irrigation was implemented and evaluated in the 15 farmers field and was found suitable as per recommendations made under 2(b). A complete plan for entire RBC command area that is for 9503 ha was made and also recommended for implementation on the basis of results obtained.

**Application of research:** This research article highlights the importance of water productivity Cropping intensity, pressurized irrigation, and Water saving in Canal Command Area.

**Research Category:** Water productivity, Major irrigation project Halali command

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***Principle Investigator: Dr S.K. Pyasi**
**University:** Jawaharlal Nehru Krishi Vishwa Vidyalaya, Adhartal, Jabalpur, 482004, India
**Research project name or number: [If any], PhD Thesis, MSc Thesis, or Project**

**Abbreviations:**

| | |
|---|---|
| CWC | Central Water |
| RBC | Right Bank Canal |
| D1 | Distributary one |
| D 2 | Distributary two |
| D 3 | Distributary three |
| CD | Critical Difference |
| SAS | Samrat Ashok Sagar |
| SV | Sum of Variance |
| SS | Sum of Square |

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