Original Research Article

An assessment of Irrigation Requirements for Summer Paddy Cultivation on *Vertisols* in Raipur, Chhattisgarh

ABSTRACT

Water scarcity is a significant challenge in agriculture, particularly for summer crop production in central India. The long-term sustainability of the summer crop depends on the effective utilization of available water resources through proper irrigation management. This requires precise data on evapotranspiration, crop water requirements, and irrigation scheduling. The study focuses on the assessment of water requirements and its scheduling for summer paddy production on *vertisols* soil in the Raipur district of Chhattisgarh. The field experiments were observed during the summer seasons of 2023 and 2024 at the Department of Soil Science and Agricultural Chemistry, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India. The FAO-CROPWAT 8.0 model was employed for the study, which utilized FAO Penman-Monteith method to analyze meteorological data and evaluate reference evapotranspiration (ET□). The crop evapotranspiration (ETc) was computed using crop coefficient (Kc) values associated with various developmental stages. A comprehensive water balance model for summer paddy was developed, incorporating soil, climate, and crop variables. The findings indicated that the crop evapotranspiration (ETc) and irrigation water requirement (Irr Req) for both seasons were 714 mm and 723 mm, and 772 mm and 793 mm, respectively. Upon adjusting for field losses, the total net irrigation requirement (TNIR) was assessed as 988 mm and 1009 mm for 2023 and 2024, whereas combining the irrigation efficiency, the total gross irrigation requirement was evaluated at 1411 mm and 1443 mm, respectively. The study offers essential insights for managing traditional irrigation practices for paddy cultivation, fostering sustainable agriculture, and resource distribution. Employing CROPWAT 8.0 to optimize irrigation schedules and enhance water consumption efficiency facilitates comprehensive decision-making in water resource management, highlighting the necessity for customized methods to meet distinct agricultural water requirements.

Keywords: Summer paddy, Crop water requirement (CWR), Irrigation requirements, irrigation scheduling, CROPWAT 8.0.

1. INTRODUCTION

Water is an essential resource, particularly in agriculture, where it is crucial for sustaining food production and ensuring food security. Agriculture in India accounts for over 70% of total freshwater withdrawals, highlighting its significance for the economy and livelihoods (FAO, 2021). However, the country faces considerable water scarcity challenges, with projections indicating that 600 million people may have water shortages by 2030 (NITI Aayog, 2018). Ineffective water management practices exacerbate this issue, leading to shortages and declining water quality (Sharma et al., 2018). Improving irrigation efficiency could save up to 50% of the water used in agriculture without compromising crop yields (Kumar et al., 2019).

Paddy cultivation dominates Indian agriculture, occupying a quarter of cultivated land and serving as a primary food source for half of the population (Bhattacharya, 2022). Chhattisgarh, known as the "Rice Bowl" of Central India, is noted for its substantial rice production (Ram et al., 2023). Despite government recommendations to prioritize other crops during the rabi season, farmers favor summer paddy due to higher yields from favorable weather and lower pest incidence (Mongabay, India, 2020). In 2019-2020, production reached 828,000 metric tons from an area of 316,000 hectares (MoA & FW, 2021). However, this trend raises concerns about sustainable water management. The intensification of irrigation for summer paddy strains Chhattisgarh's water resources, where approximately 85% sourced from major river basins such as the Ganga, Mahanadi, Narmada, and Godavari (CGWB, 2021).

In paddy farming, check basin irrigation is commonly used for its effectiveness in maintaining stagnant water vital for rice growth. This method allows controlled water distribution and enhances water retention while reducing percolation losses. Additionally, it improves weed control and nutrient availability, thereby increasing crop yields compared to other methods like furrow or drip irrigation (Fonteh & Tabi, 2013). Efficient irrigation management is essential for food security in regions with erratic rainfall patterns. particularly on paddy cultivation and summer season. Efficient irrigation management is essential for ensuring food security in regions with erratic rainfall patterns, particularly on paddy cultivation in summer season. Accordingly, the excess water application can be controlled.

Understanding crop water requirements (CWR) and evapotranspiration (ET) is crucial for optimizing irrigation scheduling and enhancing water use efficiency in agriculture (Gautam et al., 2019). Reference crop evapotranspiration (ET□) quantifies the water demand of an ideal grass crop under optimal conditions and serves as a baseline for estimating actual evapotranspiration in various crops. The Penman-Monteith equation is the standard method for estimating ET□. CWR is derived from ET□ multiplied by the crop coefficient (Kc), indicating the volume of water needed to offset evapotranspiration losses. The irrigation requirement (IR) accounts for effective rainfall while net irrigation water requirement encompasses additional losses necessary for crop development (Michael, 2008; Pereira et al., 2015).

CROPWAT 8.0 is an advanced irrigation requirement computation software that integrates soil, climate, and crop data for precise irrigation calculations and scheduling. It has demonstrated high accuracy in estimating water needs for paddy cultivation, aligned with established references. Its user-friendly interface and robust features facilitate efficient water management and promote sustainable agricultural practices. Furthermore, the model adheres to FAO guidelines, ensuring reliability in addressing critical water scarcity issues in agriculture. This study employs CROPWAT 8.0 to evaluate irrigation water requirements and scheduling for summer paddy in Raipur District, Chhattisgarh, focusing on available *vertisols* soil. By incorporating environmental factors with crop-specific needs, this model aids in developing customized water resource management strategies (FAO, 2012). Study on summer paddy cultivation highlights a critical gap in agricultural studies, particularly regarding assessments of irrigation requirements. This study aims to provide insights into optimizing irrigation practices by utilizing the FAO-CROPWAT 8.0 model alongside a field experiment to effectively estimate irrigation needs and scheduling. Consequently, it promotes sustainable agricultural practices while addressing pressing water management challenges in increasingly water-scarce regions.

2. MATERIALS AND METHODS

2.1 Description of study area

On November 1, 2000, Chhattisgarh was embraced as the 26th state of India,situated between 17°46' and 24°5' North Latitude and 80°15' and 84°20' East Longitude. The Bastar Plateau, Chhattisgarh Plain, and Northern Hill are three distinct agroclimatic zones of Chhattisgarh. The Raipur district is located between 21°08' and 21°41' North Latitude and 81°14' and 81°51' East Longitude, inside the Chhattisgarh Plain Zone (Figure 1). The typical rainfall in Chhattisgarh is approximately 1200 mm. The state has net cultivated area about 4.67 million hectares, which accounts for 34% of its total geographical spreadof 13.78 million hectares. *Vertisols*, which are locally referred to as *Kanhar*or clayey soil, comprise approximately 26.4% of the cultivated land in Chhattisgarh. The medium-to-light texture, high fertility, and exceptional water-holding capacity of *vertisols* soil render it suitable for the cultivation of a variety of crops, including paddy, wheat, maize, sugarcane, and pulses, during both the kharif and rabi seasons.

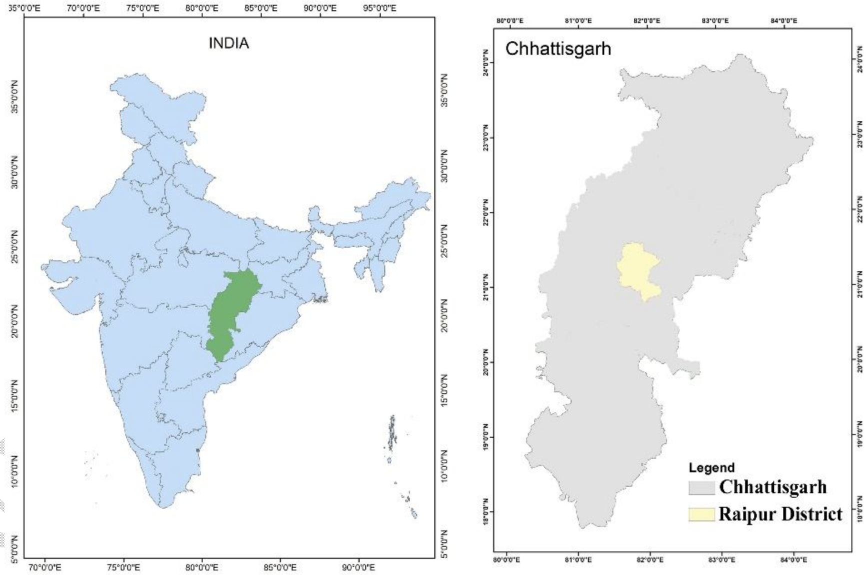

Fig. 1. Location map of the study area

2.2. Modeldescription

CROPWAT 8.0 is a software tool created by FAO that incorporates inputs like climatic data (temperature, humidity, wind speed), soil properties, crop data, and rainfall to determine irrigation requirements and its scheduling. It uses the Penman-Monteith equation to calculate reference evapotranspiration (ETo) and then predicts the crop water requirement (CWR) by using the crop coefficient values. Subsequently, produce daily soil-water balances throughout the crop duration, yielding daily irrigation water needs. To meet this demand, an irrigation plan is established, taking into account the rainfall. It enables users to modify theinputs as irrigation time and application depth based on local circumstances. This leads to optimal irrigation management customized for particular crops and soil types, improving water efficiency and agricultural production.

2.3 Climate data

Agro-meteorological data for reference evapotranspiration calculations in CROPWAT 8.0 were obtained from the meteorological observatory at Indira Gandhi Krishi Vishwavidyalaya in Raipur, Chhattisgarh. The correctness of the model is guaranteed by the use of daily data of 2023 and 2024. The data required for ET_0 calculation include geographical attributes such as altitude, latitude, and longitude, in addition to daily minimum and maximum temperatures (°C), wind velocities (km/day), humidity levels (%), daylight duration (h/day), and precipitation. The model used climate data from the provided daily dataset relevant to the crop season of the specified years.

2.4Field experiment and sampling details

During the summer seasons of 2023 and 2024, paddy trials were observed at Department of Soil Science and Agricultural Chemistry, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, where meticulous observations were collected with the support of the field supervisor and the scientific team of the department. The recorded data included summer paddy management practices, comprehensive crop attributes, including field preparation strategies, length of crop growth phases, rooting depth, panicle initiation, maturation time, and other relevant details, throughout the experiments. The soil sampling was also performed from the experimental field, which was analyzed for various relevant parameters. Technical information on data needed was obtained from the help section of the CROPWAT 8.0 model, which clarifies the essential inputs. Additionally, extensive datasets from credible sources, such as FAO publications and other research projects, were considered for further insights and verification.

2.5 Crop details

The summer paddy cultivation utilized MTU 1010 rice crop variety, a 120-day crop known for its short duration and an average rooting depth of 50 cm. This quality makes it well-suited for summer cultivation. In summer,this verity is frequently cultivated in *vertisols* soil in low-lying areas, where the soil shows exceptional water retention capacity.The summer paddy nursery is typically sown in mid-January and transplanted during the first week of February and the mature crop is usually harvested by mid-May after the full crop cycle.

2.6 Soil data

The soil sample collected from the field experiment was gone through the laboratory analysis at the Department of Soil Science and Agricultural Chemistry, IGKV, Raipur, Chhattisgarh. The results indicated, soil type in the field was *vertisols* which are clay-rich soils known for their high water-holding capacity and shrink-swell behavior. They are prevalent in semi-arid regions and support specific crops like rice and cotton.The CROPWAT 8.0 program necessitates specific soil-related parameters, such as total available soil moisture, maximum rooting depthand initial available soil moisture. These parameters were determined based on correlated variables outlined in the FAO 56 manual.

2.7 Rainfall data

Rainfall data for 2023 and 2024 was collected from the agrometeorological station at IGKV Raipur which is located very near to the experimental field. The data were organized and used as needed in the CROPWAT program with MS Excel software.An established percentage method was used to determine effective rainfall, defined as 70% of the total rainfall. The effective rainfall is the segment of total yearly or seasonal precipitation that directly or indirectly aids in crop production. The effectiveness of rainfall is affected by several elements, as physical and chemical features of field and soil, meteorological conditions, and the characteristics of the rainfall itself.

2.8 Reference evapotranspiration (ET_0)

Reference evapotranspiration (ET□) is the rate of evapotranspiration from a hypothetical well-watered grass crop, serving as a standard for comparing water needs of various plants under similar conditions. Relationship between the crop coefficient and the reference evapotranspiration enables the calculation of actual evapotranspiration for experimental conditions(FAO,2012). The Penman-Monteith equation, standard method for estimating ET_0 was implemented in CROPWAT 8.0, whichconsidered various parameters as minimum and maximum temperatures (°C), wind speed (km/day), relative humidity (%), sunlight duration, and topographical features including elevation, latitude, and longitude. This comprehensive approach facilitates accurate irrigation management and water resource planning.
The Penman-Monteith equation is given by:

$$[E_{To} = \frac{0.408\Delta(R_n - G) + \gamma\left(\frac{900}{T+273}\right)u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}] \qquad (1)$$

- ETo: Reference evapotranspiration (mm/day)
- Rn: Net radiation at the crop surface (MJ/m²/day)
- G: Soil heat flux density (MJ/m²/day)
- T: Mean air temperature (°C)
- u_2: Wind speed at 2 m height (m/s)
- e_s: Saturation vapor pressure (kPa)
- e_a: Actual vapor pressure (kPa)
- Δ: Slope of the saturation vapor pressure curve (kPa/°C)

2.9 Crop and irrigation water requirements

Evapotranspiration (ET) is the integrated process of water vaporization from surfaces and transpiration from plant leaves. The ET has various relatable parameters; ET_0 denotes the reference evapotranspiration of a sufficiently irrigated reference crop, serving as a standard for estimating evapotranspiration in other crops. The FAO Penman-Monteith equation computes ET_0 using characteristics such as solar radiation, temperature, humidity, and wind speed data.Subsequently, crop evapotranspiration (ETc), or crop water demand, is calculated using the equation $ETc = ET_0 x Kc$, where Kc is the crop coefficient that reflects the water requirements unique to various phases of crop development. The irrigation water requirement (IR) is the volume of water necessary to meet crop evapotranspiration, taking into account effective rainfall and the water supplied by precipitation. Net irrigation water requirement includes all water necessary for crop development, including losses such as percolation, leaching, application, and other losses. Furthermore, including irrigation efficiency in Net irrigation water requirement results in the Gross Irrigation Water Requirement (Michael, 2008).Theseparametersareimportant for irrigation management and improving water utilization in agriculture; compressive knowledge of these irrigation parameters is crucial for maintaining crop health and enhancing agricultural output (Pereira et al., 2015).Figure 2 illustrates a flowchart depicting the methodology for estimating crop water requirements, irrigation needs, and the subsequent irrigation scheduling used in the research.

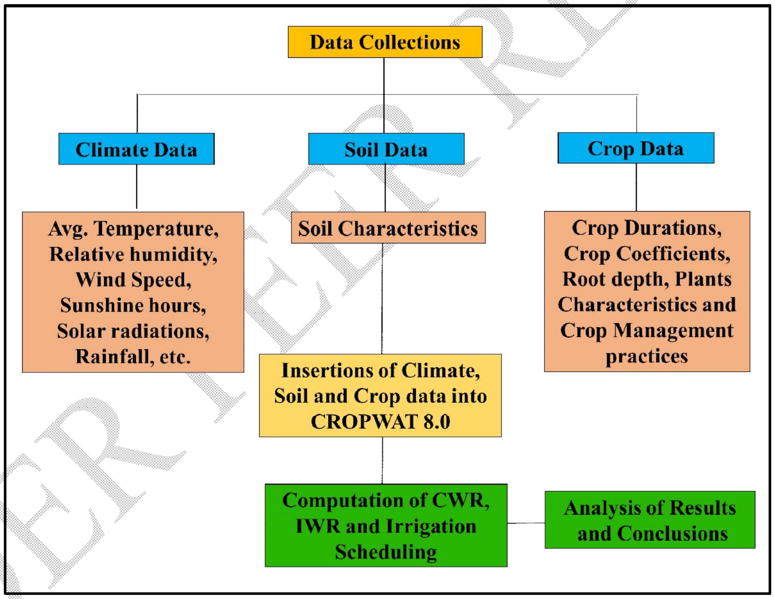

Fig. 2. Flow chart for estimation of irrigation water requirements and irrigation scheduling in CROPWAT 8.0

2.10 Scheduling the irrigation water needs

Paddy exhibits significant sensitivity to water shortage the optimal conditions for rice production need continual irrigation to satisfy varying water requirements throughout distinct development stages and seasons. After transplantation, it is essential to maintain a water depth of roughly 3 cm. As the paddy plants mature, water levels should progressively rise to a range of 5–10 cm, which must be maintained until the field is emptied 7–10 days before harvest to dry out the field to support the harvesting operation. (Kumari *et al.*, 2021).

The field experiment and irrigation scheduling also employed standardized irrigation methods predicated on particular thresholds: irrigation commences when the water depth attains 10 cm and is uniformly applied throughout all phases of the crop's life cycle. Following the irrigation discontinued when the water depth attains 4 cm in the early stages, 5 cm throughout development and midway stages, and 2 cm in the late-season stage. Irrigation is derived from a proximate borewell, with an estimated efficiency of 70%.

RESULTS AND DISCUSSIONS

3.1 Rainfall pattern during study periods

The rainfall records for the years of 2023 and 2024 were studied for rainfall analysis in study, providing a thorough comprehension of the rainfall patterns. It revealed an average annual rainfall of 1720.9 mm in 2023 and 1273.3 mm in 2024. The substantial rainfall recorded in 2023 was a considerable divergence from the average, in contrast to the lesser amounts measured in 2024, highlighting the variability of rainfall distribution. This fluctuation underscores the need for adaptive techniques in agricultural planning and water resource management to address uncertain rainfall patterns and maintain sustainable practices despite changing environmental circumstances. July had the maximum rainfall for both years, followed by August and September, while February, January, and November saw the lowest precipitation. The effective rainfall is considered as at 70% of total rainfall, with the corresponding statistics shown in Table 1 and the Figure 3 below.

Table 1. Monthly rainfall pattern for the year of 2023 and 2024

Month	2023		2024	
	Rainfall (mm)	Eff rainfall (mm)	Rainfall (mm)	Eff rainfall (mm)
Jan	1.8	1.3	8.6	6
Feb	0.0	0.0	5.8	4.1
Mar	21.8	15.3	28.9	20.2
Apr	34.8	24.4	62.2	43.5
May	71.4	50	13.2	9.2
Jun	226.4	158.5	188.2	131.7
Jul	501.8	351.3	361.9	253.3
Aug	348.6	244	323	226.1
Sep	479.6	335.7	217.9	152.5
Oct	11.9	8.3	44.6	31.2
Nov	5.0	3.5	8.4	5.9
Dec	17.8	12.5	10.6	7.4
Total	1720.9	1204.6	1273.3	891.3

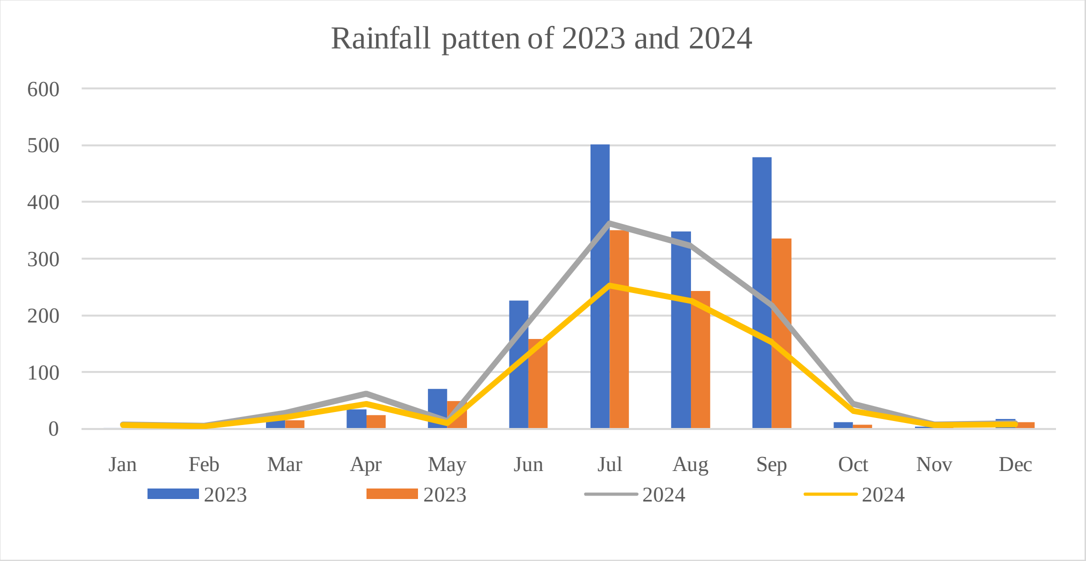

Fig. 3. Rainfall pattern for the years of 2023 and 2024

3.2 Reference evapotranspiration (ET_0) during study period

Athorough assessment of the meteorological variables influencing reference evapotranspiration (ET_0) was conducted to estimate the ET_0 for the years 2023 and 2024. The model employed Penman-Monteith equation to compute reference evapotranspiration (ET_0) using meteorological datasuch asdaily averages for minimum and maximum temperatures (°C), wind speed (km/day), relative humidity (%), sunshine duration, and topographical data, including elevation, latitude, and longitude. Table 2 and 3 presents the monthly values of several parameters used to compute ET0, together with the corresponding ET0 values for the whole year, including the summer paddy cultivation months from January to May.The monthly ET0 values reveals the peak readings in May for both years, recorded as 6.81 and 7.05 mm/day, while the minimum values occurred in December, at 2.42 and 2.45 mm/day, respectively. Abdullahi et al. (2013) also reported comparable findings, identifying the highest values of ET0 as 6.0 - 7.3 mm/day. The dataset offers valuable insights into the monthly variations of meteorological parameters and their impact on ET0, essential for informing agricultural practices, water management strategies, and climate adaption initiatives in the study area.

Table 2. Reference evapotranspiration (ET_0) for the year of 2023

Month	Min Temp °C	Max Temp °C	Humidity %	Wind speed km/day	Sunshine hours	Rad MJ/m²/day	Eto mm/day
January	13.2	29.6	62	52	7.2	15.3	2.75
February	12.7	33	49	66	8.3	18.6	3.7
March	18.7	34.9	53	86	8.5	20.9	4.69
April	22.8	37.9	46	126	8.7	22.6	6
May	24.4	39.4	45	163	8.6	22.8	6.81

June	27	39.5	52	213	5.2	17.7	6.4
July	25.7	32.2	80	197	2.9	14.2	3.8
August	25.1	31.7	78	166	3	14	3.65
September	25	31.4	82	106	5	16.1	3.67
October	20.9	32.5	66	63	7.4	17.8	3.71
November	17.7	30.7	64	50	7.8	16.4	3.03
December	13.8	27.3	65	45	7.2	14.7	2.42
Average	20.6	33.3	62	111	6.7	17.6	4.22

Table 3. Reference evapotranspiration (ET_0) for the year of 2024

Month	Min Temp °C	Max Temp °C	Humidity %	Wind speed km/day	Sunshine hours	Rad MJ/m²/day	Eto mm/day
January	14.3	27.9	65	52	7.2	15.3	2.65
February	17.5	31.4	59	66	8.3	18.6	3.65
March	20.6	35.8	51	86	8.5	20.9	4.84
April	23.1	37.9	53	126	8.7	22.6	5.91
May	26.5	41	44	163	8.6	22.8	7.05
June	26.5	37.3	59	213	5.2	17.7	5.81
July	24.8	31.4	81	197	2.9	14.2	3.67
August	24.6	30.3	84	166	3	14	3.36
September	24.4	31.3	82	106	5	16.1	3.62
October	21.3	31.4	73	63	7.4	17.8	3.62
November	15.6	30	64	50	7.8	16.4	2.93
December	11.9	28.1	62	47	7.3	14.8	2.45
Average	20.9	32.8	65	111	6.7	17.6	4.13

3.3 Crop water requirement during study period

Table 4 illustrates the crop water requirements (CWR) for the summer paddy experiment of rice variety MTU 1010, respective to different periods of crop development for both research years. The CWR was estimated by multiplication of crop coefficient (Kc) and reference evapotranspiration (ET0). The results indicate similar reference evapotranspiration (ET0) for both years, as the Kc values exhibit a consistent trend. In January, the crop is in the nursery phase with a Kc of 0.3, leading to negligible evapotranspiration. February marks the initial (init) stage characterized by fluctuating Kc values, signifying heightened water requirements as the crop develops, leading to elevated ETc values. March signifies the development stage, during which Kc values continue to rise as the crop grows, resulting in heightened ETc levels. The mid-season period in March and April has a peak in Kc, and ETc values, signifying the highest water need during this growth phase. As the crop advances into the late-season phase in April and May, Kc levels diminish, indicating decreased water demands as the crop cycle concludes. Table 4 shows the crop water requirement for 2023 and 2024.

The model's findings correspond with those presented by Kumari *et al.* (2022), demonstrating the temporal variations in Kc and ETc values during different development stages of paddy. The crop water requirement for the year 2023 was estimated as 714 mm, whereas for 2024 it was calculated as 771.6 mm, with the highest crop water demand in the mid- and late-season stages because at this time there is high water consumption that is needed by plants. It seems to be as equitable as the study conducted by Jangre *et al.*, (2022), who calculated crop evapotranspiration (ETc) during the kharif season as the average CWR was determined to be 575.64 mm. Hembram et al. (2020) also determined the crop water requirement for summer paddy in Odisha, India, as 920 mm.This comprehensive research underscores the variable water needs over the several development phases of summer paddy (MTU1010), offering critical insights for improving irrigation strategies to enhance water management and increase crop yield.

3.4 Irrigation water requirement during study period

The irrigation water requirement was calculated by considering the effective rainfall on crop water requirement which is shown in Table 4The irrigation water requirements were determined to be 771.6 mm for 2023 and 793.1 mm for 2024. Similar results were reported by Hembram et al. (2020), who calculated a summer paddy water requirement of 844.95 mm in Orisha, India. Additionally, it was noted that during the first weeks of February, a total of 164.4 mm and 149.1 mm of water were consumed in the years 2023 and 2024, respectively for the field preparation operations,these resulted in a heightened need for irrigation water throughout the first crop phase and transplanting.

The irrigation water requirement was determined by considering the effective rainfall on crop water requirement, which is presented in Table 4. The irrigation water requirement were estimated as 771.6 mm for 2023 and 793.1 mm for 2024. Hembram et al. (2020) found similar findings, determining a summer paddy water demand of 844.95 mm in Orisha, India. Furthermore, it was observed that in the first weeks of February, a total of 164.4 mm and 149.1 mm of irrigation in the years 2023 and 2024, respectively were utilized for field preparation activities particularly on puddling operation. This led to an increased need for irrigation water during transplanting.

Table4. Crop and Irrigation water requirement for the years of 2023 and 2024

Month, dec	Stage	CWR (mm/dec)		IWR (mm/dec)	
		2023	2024	2023	2024
Jan 2	Nurs	0.3		0.3	
Jan 3	Nurs	1	0.8	1	0
Feb 1	Init	17.2	1.9	164.4	149.1
Feb 2	Init	42.6	42.7	42.6	38.6
Feb 3	Deve	38.9	37.1	38.9	37.1
Mar 1	Deve	54	52.6	53.1	52.6
Mar 2	Deve	56.9	58.7	49.2	41

Mar 3	Mid	74.2	77.3	67.5	74.8
Apr 1	Mid	72.9	75	72.2	54.4
Apr 2	Mid	88.1	74.9	88.1	61.6
Apr 3	Late	80.9	87.5	57.2	77.8
May 1	Late	74.5	91	25.1	85.9
May 2	Late	81.4	78.5	80.8	75.5
May 3	Late	31.2	45.3	31.2	44.7
Total		714	723.1	771.6	793.1

3.5 irrigation scheduling plan for summer paddy during study period

A detailed irrigation schedule for summer paddy cultivation was estimated and presented for the years 2023 and 2024, highlighting the different developmental stages and irrigation needs in relation to certain days after transplanting. The data covers the period from early February, specifically a transplant date of February 7, 2023, to mid-May, culminating in a harvest date of May 24, 2023, includes pre-puddling to the end of the crop cycle. In 2024, the transplanting date was February 11th, while the harvesting was performed at May 26th. It emphasizes the precise management of irrigation operations, including puddling and irrigation applications. During the various stages as puddling, initial, development, mid-season, and late season, then harvest, the irrigation scheduling efficiently sustains ideal soil moisture levels essential for crop growth and development. In the first weeks of February, a land preparation operation was conducted, requiring a substantial volume of water for puddling, as shown by the higher water demand during this time and the significant percolation was observed.

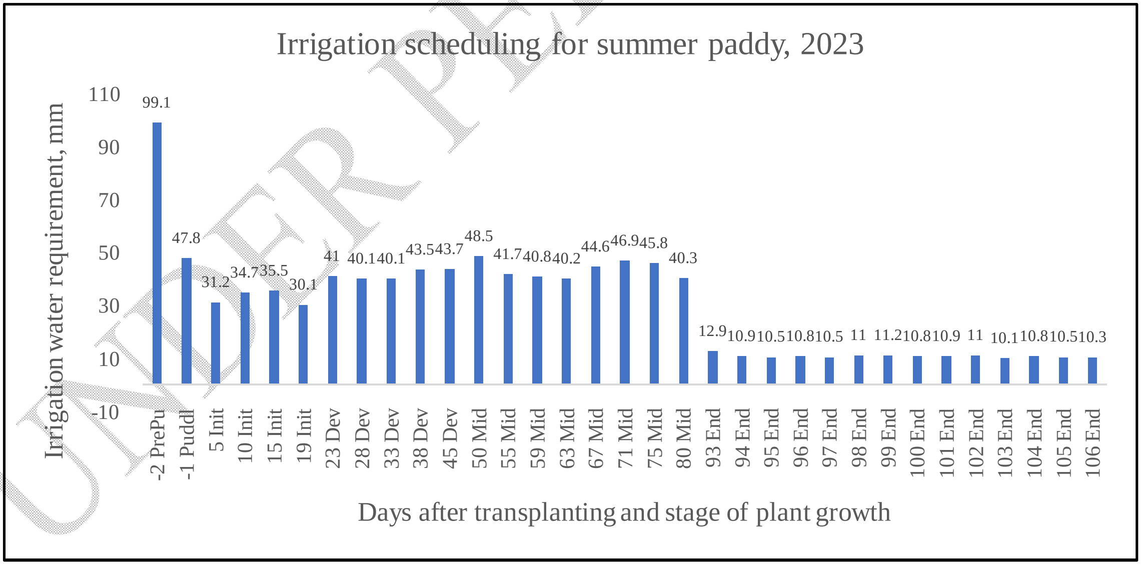

Fig. 4. Irrigation scheduling plan for summer paddy, 2023

The results demonstrate that the total net irrigation requirement (TNIR) for summer paddy, including crop water needs, soil preparation, and field percolation, was 988 mm for 2023 and 1009 mm for 2024. The total gross irrigation need was calculated to be 1411 mm for 2023 and 1443 mm for 2024, assuming an irrigation source efficiency of 70%. Pandey et al. (2010)

similarly assessed the irrigation water demand for the summer season to be 1680 mm. This comprehensive irrigation scheduling technique is essential for enhancing water management in summer paddy cultivation, resulting in increased crop yields and sustainable agricultural practices. Figure 4 and 5 shows the irrigation scheduling plan for years 2023 and 2024.

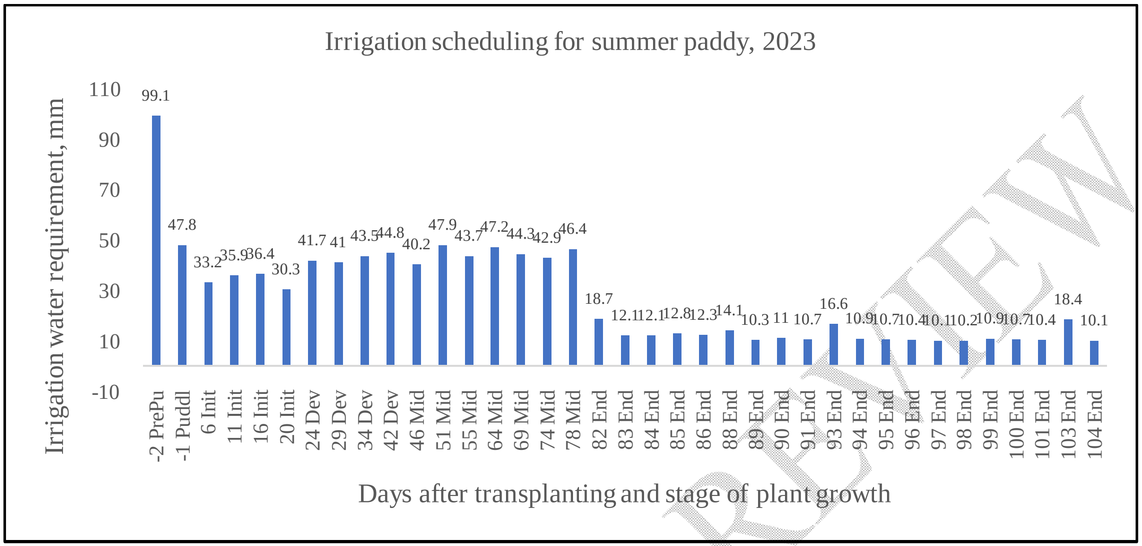

Fig.5. Irrigation scheduling plan for summer paddy, 2024

3. Conclusion

Analyzing rainfall variability, climatic influences on evapotranspiration, and fluctuating water demands throughout crop development phases enhances comprehension of paddy crop water management. As shown in the study, irrigation water requirements were assessed for *vertisols* in Raipur District, Chhattisgarh. The findings suggest that accurately assessing the water needs of summer paddy can enhance water resource management and crop production. Scientific tools such as CROPWAT 8.0 can evaluate the crop water requirement (CWR) with considerable precision, enhancing optimized irrigation scheduling and sustainable water resource management. The results highlight the need for customized strategies to meet irrigation water requirements, guaranteeing the prudent use of water resources in light of changing agricultural practices. The findings of this research may assist agriculturists and water resource planners in future strategies, facilitating water conservation while adhering to crop water requirements for productive crop growth with appropriate quantity and frequency of crop irrigation.

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