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A SCIENTIFIC APPROACH FOR WATER MANAGEMENT IN RICE FIELDS

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ABSTRACT

Knowledge of onset and withdrawal of effective monsoon as well as, occurrence of critical dry spells and its duration helps in deciding sowing or transplantation dates and in planning of storage or removal of water from paddy fields according to irrigation or drainage needs of rice. June 17 and October 29 are the mean dates of onset and withdrawal of effective monsoon and on average 2 to 3 critical dry spells of about 18 days occur in a year at Bhubaneswar. Water balance simulation studies indicate that runoff and number of irrigation applications are correlated with deep percolation rates as well as ponding due to bund heights. With increase in deep percolation rates, mean per cent runoff decreases and mean number of irrigation application increases. With increase in bund height, percentage runoff and number of irrigation applications decrease.

Key words : Irrigation depth , Deep percolation, Water management, Rice.

INTRODUCTION

Sowing and transplanting dates of *Kharif* rice mainly depend on availability of rain water. So it becomes essential to know the expected dates of onset and withdrawal of effective monsoon, number of critical dry spells and their duration, rainfall distribution and average number of rainy and non-rainy days. Once this information is available one can decide the sowing and transplanting dates depending on variety of rice. During this period if field is over irrigated it causes waterlogging and affects soil health. On the contrary less irrigation reduces the crop yield. So in order to evolve irrigation criteria one is required to know all water balance components i.e. rainfall, evapotranspiration, deep percolation, runoff and bund heights (in case of rice). Daily water balance simulation study is one of the methods by which one can plan near optimal application of irrigation required by the crop at the proper time. Keeping these ideas in view, a study was taken up with two objectives: i. Determination of mean onset and withdrawal dates of effective monsoon, rainfall distribution, critical dry spells and their duration, and average number of rainy and non-rainy days; ii. Development of daily water balance simulation model to study the excess runoff percentage and number of irrigation applications corresponding to various percolation rates and bund heights.

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MATERIALS AND METHODS

In order to fulfill the first objective PC compatible computer program was developed in FORTRAN 77 language, employing the following assumptions (Ashok Raj, 1979):

First day rainfall in a spell of seven days should be greater than 'e' mm, where 'e' is average evaporation of that area. The total rainfall in a spell of seven days should be more than or equal to (5e + 10) mm. In this spell of seven days at least 4 days should be rainy days with minimum of 2.5 mm rainfall per day. If for more than 10 consecutive days there is no rainfall, it was considered as a critical period for rice.

To meet the second objective daily evapotranspiration for rice was computed for 32 years. The more commonly used formulae in estimating evapotranspiration are Blaney-Criddle, Thornthwaite, Penman and Christiansen methods as reported by Michael (1986).

Blaney-Criddle method takes into account the mean monthly temperatures and daylight hours only. This method is usually valid for estimation of monthly or seasonal evapotranspiration under irrigated conditions, where soil moisture is not available.

Estimation of mean monthly consumptive use by Thornthwaite method is based on mean monthly air temperature and seasonal or annual heat index only. Chang (1968) discussed the drawbacks of this method and concluded that this method is less successful because it does not take into account other climatological parameters.

Penman method is a combination of energy budget and aerodynamic aspects. The application of this method requires measurement of four variables viz. net radiation, air temperature, air humidity and horizontal wind movement. Doornobos and Pruitt (1975) proposed a modified Penman method for estimating crop evapotranspiration and concluded that this method estimates satisfactory ET values under widely different climatic conditions.

Christiansen method takes into account extra terrestrial radiation, temperature, wind velocity, relative humidity, per cent of possible sunshine, elevation and other empirically developed constants but due to lack of data base this method is not used commonly. Jensen (1973) concluded that Penman or modified Penman method should be recommended for estimating ET for 5 days or less period.

Considering the available data base and above mentioned conclusions drawn by various researchers, daily evapotranspiration for rice was computed employing modified Penman method, using daily maximum and minimum temperature, relative humidity, wind velocity and sunshine hours data available for Bhubaneswar.

To account for the variation in soil characteristics, five deep percolation rates (2 to 6 mm day $^{-1}$ at an increment of 1 mm day $^{-1}$) and five bund heights (150 mm to 350 mm at an increment of 50 mm) were considered in daily water balance simulation studies.

The various bund heights and deep percolation rates considered in this study are based on the experience gained by the authors after surveying the existing bunds around the farmer's fields and conducting experiments on different types of soil to know the range of deep percolation rates at various locations in Bhubaneswar. The basic water balance equation based on the principle of continuity (i.e. excess of inflow over outflow is equal to change in storage), considered in this study is given below:

$$P_J = P_{J-1} + R_J - E_J - D_J$$

where P_J is depth of ponding on J^{th} day; P_{J-1} is the depth of ponding on J-1^{th} day; R_J is rainfall on J^{th} day, E_J is evapotranspiration on J^{th} day and D_J is deep percolation on J^{th} day.

If depth of ponding on any day becomes greater than bund height, in that case runoff amounting to the difference of depth of ponding and bund height occurs and finally depth of ponding at the end of each day is revised and limited to bund height only. This runoff flows towards low lying area or near drain. In the experiments conducted to evaluate rainfall excess water was disposed off through weirs of different heights located at the field outlet and excess water was diverted to a drain after measurement.

It has been assumed that the day water disappears from the land surface, deep percolation rate reduces by 20 per cent per day and after 5 days no deep percolation takes place. Irrigation has been applied if the depth of ponding is less than the sum of three previous days evaporation and three times deep percolation. In each irrigation 50 mm depth of water is assumed to be applied. Based on these assumptions water balance simulation model has been developed and under different scenario of deep percolation rates and bund heights, the range and average of per cent runoff and number of irrigation applications have been computed.

RESULTS AND DISCUSSION

Study of rainfall data at Bhubaneswar shows that out of average annual rainfall of 1496.7 mm, 1303.8mm (87.11%) occurs in monsoon period i.e. (June to October) with 61 rainy days average. Analysis of occurrence of critical dry spells (exceeding 10 days) at Bhubaneswar reveals that out of 42 years of record available, for 3 years no critical dry spell (CDS); for 9 years 1 CDS; for 14 years 2 CDS; 12 years 3 CDS; and 4 years 4 CDS occurred. The average duration of first, second and third critical dry spell was 17, 18 and 18 days, respectively. Mean date of onset of effective monsoon was found to be June 17 and withdrawal date was October 29. The mean dates of occurrences of first, second and third critical dry spells were July 25, September 9 and October 1, respectively.

After knowing the average date of onset and withdrawal of effective monsoon and considering the crop duration as 135 days, the average dates for sowing and crop

maturity were considered as 18th June and 29th October, respectively. The minimum, maximum and average rainfall during this period was 814.1, 1569.4, and 1213.2 mm, respectively. Similarly minimum, maximum and average evapotranspiration computed from modified Penman method was 594.7, 802.5 and 714.1 mm, respectively. Corresponding to five deep percolation rates varying from 2 to 6 mm day $^{-1}$ at an interval of 1 mm day $^{-1}$ and bund heights of 150 to 350 mm at an interval of 50 mm, the mean and range of per cent runoff as well as number of irrigation applications are given below in Table 1.

Table 1. Effect of various deep percolation rates and bund heights on per cent runoff and number of irrigation applied

Deep percolation (mm day^{-1})	Bund height (mm)	Mean per cent runoff	Range of runoff	Mean number of irrigations applied	Range of number of irrigations applied	Depth of irrigation applied (mm)
2	150	23.71	0-41.06	2.00	0-7	0-350
	200	19.52	0-37.87	1.56	0-6	0-300
	250	15.64	0-34.76	1.44	0-6	0-300
	300	12.19	0-31.50	1.44	0-6	0-300
	350	9.24	0-28.32	1.44	0-6	0-300
3	150	18.11	0-35.47	2.88	0-8	0-400
	200	14.01	0-30.90	2.38	0-7	0-350
	250	10.53	0-27.72	2.03	0-7	0-350
	300	7.77	0-24.53	1.94	0-7	0-350
	350	5.52	0-21.35	1.94	0-7	0-350
4	150	14.07	0-29.56	4.03	0-9	0-450
	200	9.91	0-24.88	3.38	0-9	0-450
	250	6.84	0-20.82	2.97	0-9	0-450
	300	4.41	0-17.64	2.81	0-9	0-450
	350	2.74	0-14.45	2.75	0-9	0-450
5	150	10.81	0-26.06	5.19	1-10	50-500
	200	7.08	0-24.10	4.56	1-10	50-500
	250	4.37	0-19.42	4.16	1-10	50-500
	300	2.68	0-14.74	3.97	1-10	50-500
	350	1.55	0-10.19	3.88	1-10	50-500
6	150	8.17	0-23.65	6.38	2-13	100-650
	200	4.71	0-18.75	5.81	2-12	100-600
	250	2.66	0-14.07	5.59	1-12	50-600
	300	1.51	0-9.47	5.41	1-12	50-600
	350	0.54	0-5.64	5.28	1-12	50-600

Table 1 reveals that for deep percolation rates of 2, 3, 4, 5 and 6 mm day $^{-1}$ and corresponding bund heights varying from 150 mm to 350 mm the average per cent runoff varies from 23.71 to 9.24 per cent, 18.11 to 5.52, 14.07 to 2.74, 10.81 to 1.55 and 8.17 to 0.54 per cent, respectively while average number of irrigation

applications varies from 2 to 1.44, 2.88 to 1.94, 4.03 to 2.75, 5.19 to 3.88 and 6.38 to 5.28, respectively.

CONCLUSION

Expected dates of onset and withdrawal of effective monsoon, occurrence and duration of critical dry spells, amount of rainfall and its distribution play important role in deciding sowing and transplanting dates, maturity dates and storage or removal of water to meet the irrigation or drainage requirements of rice. Daily water balance simulation studies indicate that the amount of expected runoff and number of irrigation applications depend on the depth of standing water in the rice fields, daily rainfall, daily evapotranspiration, deep percolation rates, and height of the bund around the rice fields. Studies also show that if deep percolation rate increases, the number of irrigation applications increases and per cent runoff decreases. Corresponding to a particular deep percolation rate on increasing the bund height runoff percentage as well as number of irrigation applications decrease.

REFERENCES

Annual Report. 1995-96, Water Technology Centre for Eastern Region, Bhubaneswar – 751 016, Orissa.

Ashok Raj, P.C. 1979. *Onset of effective monsoon and critical dry spells.* IARI Research Bulletin No.11, IARI, New Delhi.

Chang, J.H. 1968. *Climate and Agriculture – An Ecological Survey*, Aldine Publishing Company, Chicago : 304 pp.

Dooronbos, J. and Pruitt, W.D. 1975. *Crop water requirements.* Irrig. And Drain. Paper no. 24, FAO, Rome : 179 pp.

Jensen, M.E. 1973. *Consumptive use of water and irrigation water requirements*, ASCE, New York, NY, 215 pp.

Michael, A.M. 1986. *Irrigation : Theory and Practice*, Vikas Publishing House, New Delhi, pp: 522-536.