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Crop Growth in Relation to Management Parameters and Irrigation Scheduling in a Coastal Area of West Bengal

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Abstract

Crop growth in relation to management parameters were studied in coastal areas of West Bengal. Resourcesat 2A L3 data was analyzed for vegetation index (NDVI). Soil samples and crop management data were collected from the farmers. Irrigation performance index and evaluation of irrigation scheduling was done. The vegetation index (NDVI) value of cultivated rice was 0.30-0.44, and that of vegetables was 0.25-0.40. The vegetation index of bare soil, non-cultivated grass, forest, water body etc. was found to be 0.18-0.20, 0.25-0.35, 0.45-0.55 and <0. irrigation water

application varied from 600 mm to 750 mm which gave a beta coefficient value of 0.042 which was significant. The application of N in general was within + - 20 kg /ha of the recommended dose of 80 kg/ha. This variation of N input significantly alter the yields of rice as N application was found to be significant in the regression analysis. EC and pH was negatively related to crop growth. Five and four irrigations with lower amount (35 mm and 40 mm) reduced irrigation loss as was observed in case of three irrigations (60mm) resulting in higher scheduling efficiencies.

Keywords: Crop Growth, Management, Irrigation Schedule

Introduction

The coastal areas of West Bengal suffer from high soil salinity resulting in poor crop growth. In this area the major crops cultivated in winter season are rice and vegetables. There is adequacy of rain water during monsoon season for cultivation of rice crop. Irrigation water is one of the critical inputs for agricultural production in semi-arid and arid parts of the world, especially so in many parts of India (Sampath, 1991) ^[9]. Both the amount and timing of irrigation are important and to be optimized for better crop yields. The amount of irrigation is dependent on the crop demand based mainly on climate and area under each crop, timing and frequency are dependent on crop growth stages and nature of the soil (Raut *et al.*, 2001) ^[7]. A critical problem in irrigation management is to determine when to irrigate and how much water to apply. Two situations are generally faced by farmers (i) adequate water supply, when resources are exploited to attain maximum yield per unit area at the cost of misuse of water, and (ii) inadequate supply of water when judicious scheduling is a must to maximize the yield. In the first situation, the farmer has to be provided with an optimum irrigation schedule and amount for irrigation to ensure maximum water use efficiency. In the second situation, information is to be provided for rationalizing the limited water distribution over the available land, applying water at moisture sensitive stages of crop growth and withholding irrigation at the other stages (Reddi and Reddy, 1995) ^[8]. To increase agricultural productivity through irrigation and crop management, traditional methods should be combined with the new emerging technologies. This requires a reliable information system and a package of efficient management practices. Application of remote sensing has the potential to provide quantitative, instantaneous and non-destructive information about agricultural crops. Crop data obtained from space borne remote sensing satellites can be used to obtain a relevant and adequate information covering a larger area at frequent intervals (Moran, 1992; Rao *et al.*, 1995) ^[3, 5]. In this study the irrigation performance of rice and vegetables grown in coastal West Bengal were judged through irrigation scheduling efficiencies. The irrigation performance indicators (Menenti *et al.*, 1989) ^[2] IP-1 (which is a ratio of irrigation received by individual units, such as different soil series with respect to total irrigated area) and IP-2 (which compares crop water requirement estimated from climatic data with amount of irrigation water given) were used to evaluate the irrigation performance of the study villages.

Materials and Methods

Study Area

The study area is a plain topographical area situated in South 24 Parganas of West Bengal. (21°31' N-22°02'1'N and 88°34' E-88°44'E) (Fig 1.) Resourcesat 2AL3 data for 20 th Feb., 2026 was downloaded from NRSC web portal. The study area comprises of Canning 1 and Basanti Blocks which are salt affected. The area covers soil series like Tangrakhali, Hinchakhali, Sonakhali and Chatrakhali series (Fig 1) (Maji and Bandyopadhyay, 1995). Tangrakhali series consists of silty clay to clay, whereas texture of Hinchakhali series is silty clay loam to clay. The texture of other two soils are relatively coarser and clay loam to sandy clay (Table 1). Survey of India (SOI) maps were collected from SOI office, Kolkata.

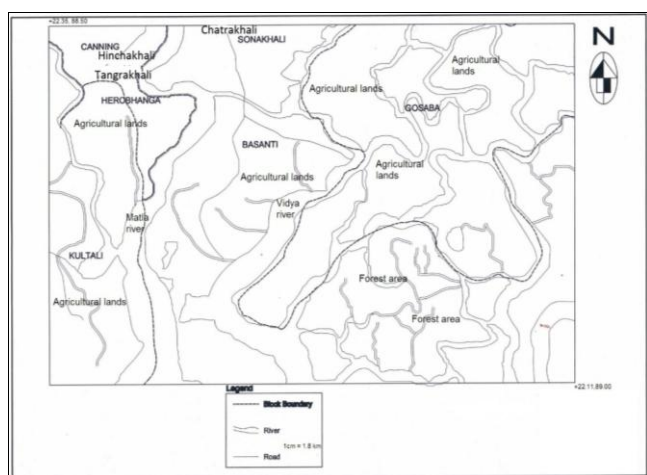


Fig 1: Study area showing Canning1 and Basanti Blocks

Data Used

IRS satellite (Resourcesat 2AL3) geocoded data for 20 th Feb., 2026 was downloaded from NRSC data center to study, soil salinity, land use and land cover and their effect on crop yields. Field data were collected from 15 farmers by quarrying. The collected data were irrigation timing and amount, N, P₂O₅, K₂O, pesticide application, yield etc. Five soil samples from each farmer's field were also collected for determining soil texture, EC and Ph. From the satellite data NDVI values for each field was calculated using Geomatica image analysis package. Thus NDVI values of rice field, vegetable fields, bare soil, uncultivated grasses, water body, forest etc were also assigned from the image. A hand held GPS was used to identify different fields. Irrigation performance indices were calculated from IP-1 and IP-2 indicators (Meneti *et al.*, 1989). Irrigation scheduling efficiencies in relation to soil series were determined from climatic and soil data in CROPWAT 8.0 of FAO.

Table 1: Different soil series coming in the study area

Soil series	Description
Tangrakhali series	Fine loamy, mixed hyperthermic Aeric Endoaquepts; texture: silty clay to clay
Hinchakhali series	Fine loamy, mixed hyperthermic Aeric Endoaquepts; texture: silty clay loam to clay
Sonakhali serie	Fine loamy mixed hyperthermic Typic Fluvaquents; texture: silty clay loam to clay
Chatrakhali series	Fine, mixed hyperthermic Fluvaquent Endoequepts; texture: silty clay loam to sandy clay

Results and Discussions

NDVI and EC values of different features

The vegetation index (NDVI) value of cultivated rice was 0.30-0.44, and that of vegetables was 0.25-0.40. The vegetation index of bare soil, non-cultivated grass, forest, water body etc. was found to be 0.18-0.20, 0.25-0.35, 0.45-0.55 and <0. The EC (1:2) value of rice crop was 0.40-2.2Ds/m and corresponding NDVI value was 0.30-0.44, the bare soil was having relatively low NDVI (0.18-0.20) value and relatively high EC value (0.70-2.0 dS/m). NDVI value of uncultivated grass was 0.25-0.35 and that of forest was high (0.45-0.55). In general, with an increase of EC value of agricultural land there was a decrease in NDVI values.

Table 2: Vegetation index (NDVI) and EC₂ values obtained from Resourcesat2AL3 for different features (2026) and classified areas

S. No	Feature type	EC ₂ (dS/m)	NDVI	Area (ha)	%TGA
1	Rice	0.40-2.2	0.30-0.44	4785	18.1
2	Vegetables	0.30-2.0	0.25-0.40	1889	7.2
3	Bare soil	0.70-2.0	0.18-0.20	3599	13.6
4	Water body	0.50-4.0	< 0	2205	8.4
5	Forest	5-10	0.45-0.55	2004	7.6
6	Uncultivated grass	0.65-1.0	0.25-0.35	9468	35.8
7	Urban areas	--	0.10-0.15	2449	9.3
8	Total area			26,399	100

IRSP6L3 data (April 12, 2013) were classified for the same area based on supervised classification. The GPS based data were used to make the area of interest (AOI) layers for different features. The classes thus obtained were rice, vegetables, urban, bare soil, fallow land and water body (Table 2). The rice area in the image was 4785 ha and vegetable area was 1889 ha. Out of a total area of 26399 ha cultivated area was around 7000 ha and non-cultivated area was around 13000 ha. Non cultivated area is fallow land and pasture. The EC values of soil increased from west to east direction (Raut *et al.*, 2015) [6].

Influence of soil and management parameters on crop growth

Table 3: Growth performance of rice crop in relation to soil and management parameters as observed in multiple regression analysis

Multiple regression Statistics				
Multiple R	0.87			
R Square	0.75			
Adjusted R Square	0.70			
Standard Error	0.016			
Observations	14			
ANOVA				
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	8	0.030	0.003	13.541
Residual	5	0.001	0.0002	P<0.005
Total	13	0.031		
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	0.134	0.136	0.990	0.367
Irrigation (mm)	0.042	0.001	3.188	0.024
N (Kg/ha)	0.001	0.001	1.19	0.028
P ₂ O ₅ (Kg/ha)	0.002	0.001	1.355	0.233
K ₂ O (Kg/ha)	0.009	0.003	2.997	0.030
Pesticide	0.259	0.243	1.063	0.336
Clay%	-0.003	0.002	-1.885	0.018
EC	-0.003	0.017	-0.166	0.874
pH	-0.002	0.012	-0.096	0.926

Soil condition influences plant growth by regulating the availability of irrigation water and nutrients. Effect of management parameters particularly of fertilizers becomes dominant factor in changing water use efficiency of crops (Mazumder and Mandal, 1984) [1]. In the present study irrigation water varied from 600 mm to 750 mm which gave a beta coefficient value of 0.042 which was significant. The application of N in general was within ± 20 kg/ha of the recommended dose of 80 kg/ha. This variation of N input significantly alter the yields of rice as N application was found to be significant in the regression analysis. On the other hand the input of P varied between 20-140 kg/ha and this range had not appreciable differences in growth performance of rice (beta coefficient 0.002). In general fine textured soils like clay % was ranging between 25-46%. This difference negatively affected crop growth (coefficient -0.003). Salinity of soil EC₂ and pH negatively affected crop growth as expressed by beta coefficients of -0.003 and -0.002, respectively. But the effect of salinity on rice growth was not significant in bringing change.

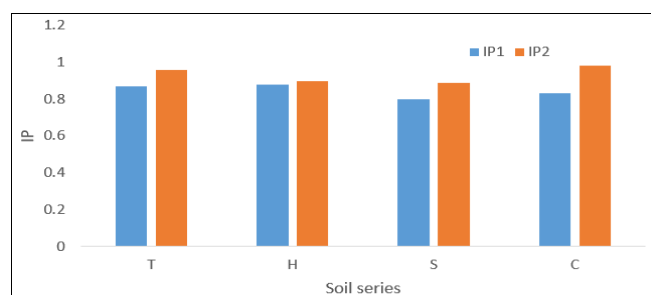


Fig 2: Irrigation performance index obtained in different soils (T: Tangrakhali, H: Hinchakhali, S: Sonakhali and C: Chatrakhali)

Irrigation performance indices

The irrigation performance indices (IP-1 and IP-2) were studied. IP-1 is based on irrigated and non- irrigated area and IP-2 is based on crop water demand in comparison to supply (Fig 2). Irrigation performance indices reveal that Tangrakhali and Hinchakhali soils were receiving relatively higher amount of water (more than 700 mm) compared to other soil series (average 650 mm). The growth performance of rice under these soil series was high (average NDVI is 0.38 as compared to others (0.30 in Sonakhali and 0.28 in Chatrakhali). Water received by rice was little lower than supply to the crop (IP-1 values were less than 1.0) and water demand was also lower than supply (IP-2 values were less than 1.0) in different soils.

Evaluation of irrigation schedules

Table 4: Major irrigation schedules for vegetables practiced in the study area

No. of irrigation	Schedules
Three irrigation	15,30,45/20,40,60/10,30,60
Four irrigation	15,30,45,60/20,40,50,60/10,15,35,65
Five irrigation	10,15,30,45,60/15,25,40,60,65/20,25,35,45,60

Table 5: Best irrigation schedules obtained in CROPWAT 8.0 for different soils

Irrigation schedules Time in DAT	Schedule efficiency			
	Tangrakhali	Hinchakhali	Sonakhali	Chatrakhali
20,40,60	76.0	75.0	77.0	77.5
15,30,45,60	87.0	87.5	88.0	90.1
15,25,40,60,65	87.5	88.0	88.0	90.5

*DAT: Days after transplanting

The farmer's applied irrigation schedules are shown in table 4. Since in the study area crop planting or sowing for a particular crop was similar, rate of crop development, length of growing season, irrigation after sowing and climatic conditions did not differ much, crop coefficient values were taken same for the crop for whole area. Irrigation scheduling efficiencies were more for Chatrakhali series for all types of water applications. Sonakhali series performed 2nd to Chatrakhali. Tangrakhali and Hinchakhali series performed below the above two soils. (Table 5). The available water capacities (AWC) of Chatrakhali and Hinchakhali soils were higher (280 mm⁻¹ and 230 mm⁻¹, respectively) than the other two soils. The higher AWC and medium texture of Chatrakhali and Sonakhali soils might have resulted in more scheduling efficiencies. The irrigation scheduling efficiencies of five and four times of applications were higher for all soils as compared to two times of applications. This possibly might have resulted from right amount of applications (35mm and 40 mm) at critical growth stages in case of five and four times of applications. In case of three times of application higher amount of irrigation (60 mm each time) were not effective in bringing high efficiencies because of wastages (Panigrahi *et al.*, 2010).

Conclusions

The vegetation index (NDVI) value of cultivated rice was 0.30-0.44, and that of vegetables was 0.25-0.40. The vegetation index of bare soil, non-cultivated grass, forest, water body etc. was found to be 0.18-0.20, 0.25-0.35, 0.45-0.55 and <0. The EC (1:2) value of rice crop was 0.40-2.2Ds/m. In general, with an increase of EC value of agricultural land there was a decrease in NDVI values. Five and four irrigations with lower amount (35 mm and 40 mm) reduced irrigation loss as was observed in case of three irrigations (60mm) resulting in higher scheduling efficiencies. The variation of irrigation scheduling efficiencies was mainly due to difference in water holding capacities of soils. Performance of irrigation for rice was evaluated by indices which showed that the quality of applied irrigation distribution was slightly non-uniform among different soil associations (IP values are not varying much) and the amount applied was less than demand.

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