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NK Thakur
M.Tech. Student, Department of Soil and Water Engineering, IGKV, Raipur, C.G, India

D Khalkho
Assistant Professor, Department of Soil and Water Engineering, IGKV, Raipur, C.G, India

P Katre
Assistant Professor, Department of Soil and Water Engineering, IGKV, Raipur, C.G, India

J Tonde
Phd. Student, Department of Soil and Water Engineering, IGKV, Raipur, C.G, India

Correspondence
NK Thakur
M.Tech. Student, Department of Soil and Water Engineering, IGKV, Raipur, C.G, India

Development of optimal crop plan for IGKV, farm Raipur, Chhattisgarh

NK Thakur, D Khalkho, P Katre and J Tonde

Abstract
Water is the most precious gift of nature. Erratic nature of rain leads to water scarcity at some point during crop season requiring protective irrigation. Other extreme of it is the surplus amounts inundating the fields and requires quick removal of the water from the fields which is accomplishes by drainage. Water productivity can be improved by choosing well-adapted crop types, reducing unproductive water losses and maintaining healthy, growing crops through optimized water, nutrient, agronomic management, irrigation and drainage plan. IGKV Farm Raipur is situated at 81° 41′ 20″ to 81°43′ 15″ longitude 21° 13′ 35″ to 21° 14′ 15″ N Latitude at an elevation of 285-295 meter above MSL in Chhattisgarh Plain Agro-climatic zone. Total geographic area of the study location is 200 ha. Climate of the study area is Sub-tropical and annual rainfall of the study area is 1064.7 mm. Water diverted from diversion canal also feed tanks near colony storing an amount of 0.14 MCM in them. Present crop plan for the study area showed a net benefit of Rs 34,20,763 and proposed optimal crop plan gave net benefit of Rs 44,36,069. Net benefit of Rs. 10,15,306 is obtained by proposed optimal crop plan.

Keywords: TORA, Optimal crop plan, constraint

1. Introduction

Water is the most precious gift of nature. Irrigation and drainage, artificial application of water to land and artificial removal of excess water from land, respectively. Some land requires irrigation or drainage before it is possible to use it for any agricultural production; other land profits from either practice to increase production. Some land, of course, does not need either. Although either practice may be, and both often are, used for non agricultural purposes to improve the environment, this article is limited to their application to agriculture. Water productivity can be improved by choosing well-adapted crop types, reducing unproductive water losses and maintaining healthy, growing crops through optimized water, nutrient, agronomic management, irrigation and drainage plan.

Areas inundated by excessive rainfall and high groundwater levels have negative impacts on agricultural production and call for efficient water use, drainage infrastructure, and management to mitigate the effects. While the need to improve water use efficiency is generally recognized, land drainage has not yet been clearly incorporated into the concept of integrated water resources management. The positive effects of agricultural drainage on the land resource base as well as its impacts on agricultural productivity and farm income are as well known as are the various techniques available. However, drainage infrastructure and drainage services entail investment and maintenance costs that are difficult to meet. The basic objective of agricultural drainage is to provide for a root zone environment that facilitates plant growth and optimizes crop production. In arid and semi-arid regions, drainage is linked with irrigation to make it possible to dispose of excess irrigation water and allow for the leaching of soils; in temperate regions and the humid tropics drainage facilitates the control of high groundwater and the discharge of heavy rainfall. A review of international events shows that 'land drainage' has been recognized as an essential technique (Scheumann and Freisem 2001). The effects of saline and waterlogged land on farm economics are detrimental because they cause land to be removed from production and often result in significant yield depressions. Saline and waterlogged conditions severely limit crop choice, diversification, and intensification, adversely affect crop germination and yields, and can make soils difficult to work. Although it is difficult to give general figures on overall yield depressions.

Productivity of water is the physical mass of production or the economic value of production measured against gross inflow, net inflow, depleted water or available water. In order to improve water productivity, moisture stress tolerant crop varieties that produce more marketable yield per unit of water consumed, farm practices that optimize water use, management techniques that give farmers timely access to water.

In order to improve water management and its productivity, we need to reveal the cause-effect relationships between hydrological variables such as evaporation, transpiration, percolation or capillary rise and biophysical variables such as dry matter and grain yields under different ecohydrological conditions.

Materials and methods

Details of Study Area

Location

Raipur district in located under the agro-climatic zone "Chhattisgarh plains" in the state of Chhattisgarh. The study area (IGKV farm Raipur) is situated 7 km away from Raipur district on Mahasamund road. The IGKV Raipur situated in 81º 41′ 20″ to 81 º43′ 15″ E longitude 21º 13′ 35″ to 21º 14′ 15″ N Latitude at elevation is 285-295 meter (MSL) and area of IGKV is 200 ha and Climate is Sub-tropical, annual rainfall recorded (yearly) 1064.7mm. The exact location of study site is depicted in Fig.

Agro climate

Chhattisgarh state has been divided into three Agro-climate zones namely Chhattisgarh plains, Baster Plateau and Northern hill zone covering 51.0%, 28.0% and 21.0% of the geographical area, respectively as per NARP classification. Chhattisgarh plain is the largest agro-climatic zone of the state covering 16 districts out of 27. The climate is sub-tropical characterized by extreme summer from March to May the study area comes under sub-tropical type of climate.

Rainfall: Land use and cropping pattern

The total area of IGKV farm Raipur where study was conducted was 200 ha. The gross cropped area in IGKV farm Raipur was 136 ha which 68% of the total geographical area. The net sown cropped area was 117 ha which 58.5% of the total geographical area. Area sown more than once area was 115 ha which 57.5% of the total geographical area. During *kharif* season crops were grown in 95 ha and in *rabi* season crops were grown in 89 ha only.

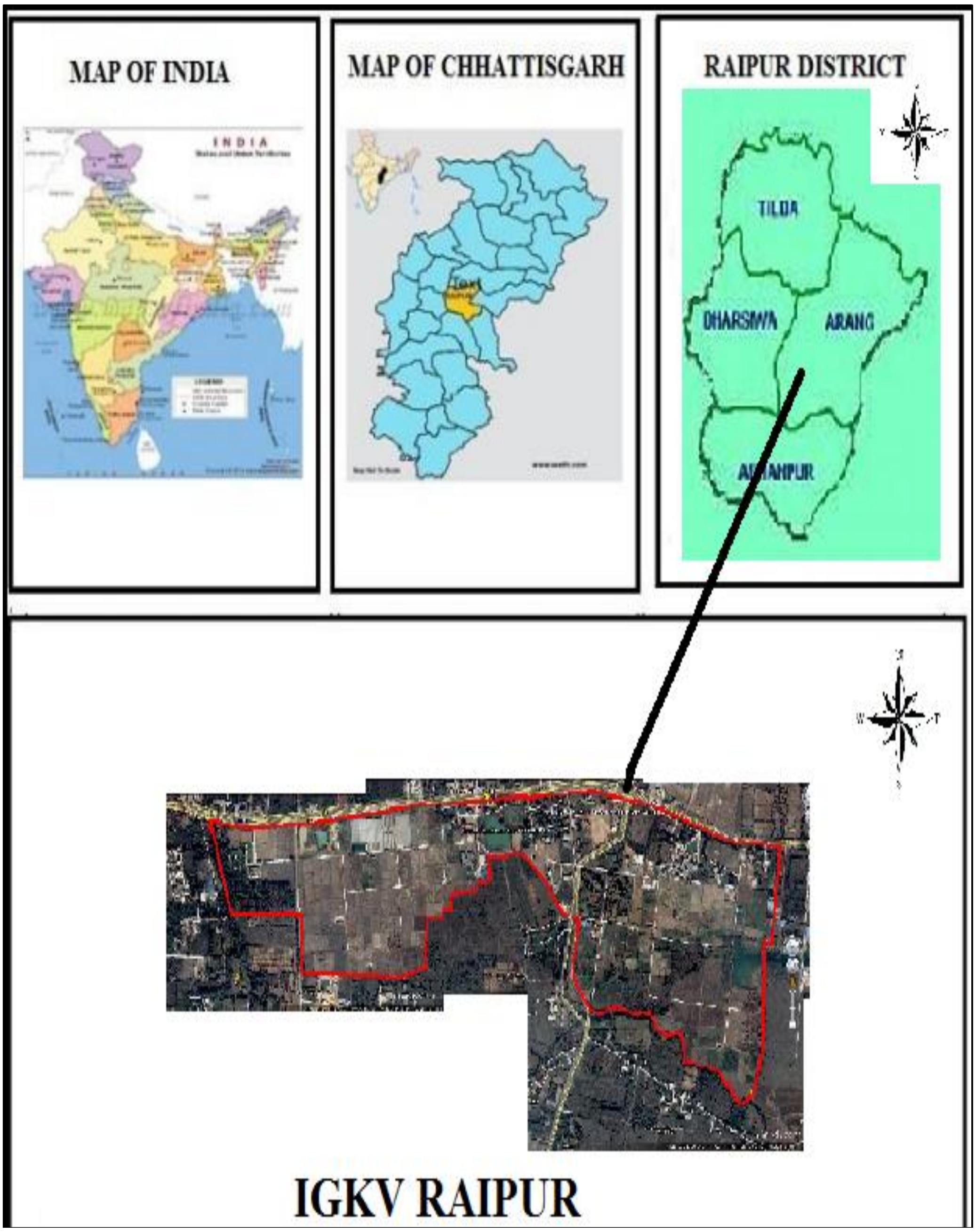

Fig 1: Location Map of the Study Area

Optimal crop plan

The linear programming technique has been used to construct the conjunctive use optimization model, to reach at the optimal allocation of surface and groundwater, for maximizing the benefits from all constant resources viz., land and water within given framework of constraints and designed cropping pattern. For the present study both *kharif* and r*abi* season has been taken into consideration. The TORA 6.1 package is used to solve the model. The objective function has been formulated for maximizing the net benefits resulting from the different crops grown in the study area. The linear programming technique is constructed with linear objective function subjected to constraints viz., water requirement constraint, area availability constraints, affinity constraint and nutritional constraints.

Existing Cropping Pattern and Water Requirement

There are three main cropping season in the area that include a *kharif* season from June to October, a *rabi* season from October to February and third *Zaid* season from March to May. These data were analyzed to find out total water requirement of existed crops, cropping pattern and area of various crop land in the watershed. Major crops during the *kharif* season are paddy and vegetables and during the *rabi* season gram, vegetables, wheat, mustard and lentil and lathyrus. During *zaid* season summer paddy and vegetables are the main crops.

Cropping intensity

Cropping intensity of the study area was evaluated on the basis of acquired crop data on village wise cropped area of different crops under *Kharif, rabi,* and *Zaid,* which was collected from office of Senior Agricultural Development Officer, Dharsiwa and Arang blocks. These data were analyzed to calculate the gross cropped area and net sown area of the watershed according to the percent of cropped area of the village comes under the watershed. These data was used into the formula which is expressed as:

Cropping intensity of the study area = Gross cropped area/Net sown area×100

Water requirement of crops during *kharif*

Total water requirement of the crop during *kharif* is estimated on the basis of net irrigation requirement. Net irrigation requirement of crops is determined by deducting effective rainfall from crop water requirement. Thus, total water requirement of paddy and vegetables were assessed with the available crop area in watershed and net irrigation requirement was calculated for the both.

Table 1: Water requirements of different *kharif* crops

S. No	Crop	Water requirement (cm)
1.	Paddy	120
2.	Soyabean	65

Source: Krishi Diary (I.G.K.V)

Water requirement of crops during *rabi*

Gram, wheat, mustard, and safflower are the major crops in the area during *rabi* season. The total water requirement of these crops is assessed with the available crop area data and their respective crop water requirements. Water requirement of different *rabi* crops are given in the Table

Table 2: Water requirements of different rabi crops

S. No.	Crop	Water requirement(cm)
1	Wheat	50
2	Gram	30
3	Mustard	30
4	Safflower	30

Source: Krishi Diary (I.G.K.V)

Productivity, net benefit and cost of cultivation of crops

1. The data related to yield and cost of cultivation of different crops grown at the field were gathered through interview and interaction with farmers. The unit cost of paddy, wheat, gram, lentil, mustard, lathyrus are taken on the basis of minimum support price (MSP). The unit price of vegetables is taken on the basis of market prices.

Objective function for rabi season

The objective function is constructed to maximize the benefits within given constraint and design cropping pattern which can be expressed as:

Maximize = $38701 \times A1 + 39201 \times A2 + 19576 \times A3 + 20687 \times A4$

Net benefit in Rs/ha

Where,

Wheat =38701, gram = 39201, mustard =19576, Safflower =20687.

$A1 \geq 65$ha, $A2 \geq 22$ha, $A3 \geq 0.6$ha, $A4 \geq 1.5$ha.

$A1 + A2 + A3 + A4 \leq 115$

Where,

2. A1= Area of wheat (ha)
3. A2= Area of gram (ha)
4. A3= Area of mustard (ha)
5. A4= Area of safflower (ha)
6. The objective function is to be maximized and subjected to variety of constraints:

Water constraint

The irrigation water requirement of all the crops in command area shall be fulfilled by surface and ground water use. Therefore, water constraint for the crops can be written as:

Water constraint- $A1 \times 0.5 + A2 \times 0.3 + A3 \times 0.3 + A4 \times 0.3 \leq 50$ ha-m

Where,

7. A1= Area of wheat (ha)
8. A2= Area of gram (ha)
9. A3= Area of mustard (ha)
10. A4= Area of safflower (ha)

Water requirement-

11. (wheat = 0.5m, gram = 0.3m, mustard = 0.3m, safflower r= 0.3m)

Result and Discussions

Cropping Intensity

Cropping intensity of the area computed on the basis of gross cropped area and net sown area of the study area. The same had been shown in table 4.30. Cropping intensity of the study area is 116.24 %.

Cropping intensity

Table 3: cropping intensity

Gross cropped area (ha)	Net cropped area (ha)	Cropping intensity (%)
136	117	116.24

Water Requirement Assessment

Table 4: Water requirement of major *kharif* crops

S. No.	Crop	Area (ha)	Water requirement (cm)	Total water requirement (Mm^3)
1	Paddy	70	120	0.84
2	Soyabean	25	65	0.16

Table 5: Water requirement of major *rabi* crops

S. No.	Crop	Area (ha)	Water requirement (cm)	Total water requirement (Mm^3)
1	Wheat	65	50	0.325
2	Gram	22	30	0.066
3	Mustard	5	30	0.015
4	Safflower	5	30	0.015

Productivity, Net Benefit and Cost of Cultivation of Crops

Net benefit on the basis of total receipt and cost of cultivation were worked and compiled in table.

Table 6: Net benefit of different crops (2014-2015)

Crops	Average Yield (q/ha)	Unit Price (Rs/q)	Total Receipt (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Benefit (Rs)
Paddy	48.5	1410	68385	30094	38291
Wheat	26.9	1525	41022	14674	26348
Gram	11.6	3424	39718	22431	17287
Safflower	15.0	3300	49500	38713	10787
Mustard	8.0	3350	26800	10574	16226
Soybean	16.0	2600	41600	23500	18100

Table 7: Net benefit of different crops (2015-2016)

Crops	Yield (q/ha)	Average Yield (q/ha)	Unit Price (Rs/q)	Total Receipt (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Benefit (Rs)
Paddy	35-50	42.5	1410	59925	30094	29831
Wheat	30-40	35.0	1525	53375	14674	38701
Gram	16-20	18.0	3424	61632	22431	39201
Safflower	16-20	18.0	3300	59400	38713	20687
Mustard	8-10	9.0	3350	30150	10574	19576
Soyabean	15-20	17.5	2600	45500	23500	22000

Objective function for rabi season

The objective function is constructed to maximize the benefits within given constraint and design cropping pattern which can be expressed as:

For maximization of net annual benefit

Maximize = $38701 \times A1 + 39201 \times A2 + 19576 \times A3 + 20687 \times A4$

Net benefit in Rs/ha

Wheat = 38701, gram = 39201, mustard = 19576, Safflower = 20687.

$A1 \geq 65$ha, $A2 \geq 22$ha, $A3 \geq 0.6$ha, $A4 \geq 1.5$ha.

$A1 + A2 + A3 + A4 \leq 115$

A1 = area of wheat (ha)

A2 = area of gram (ha)

A3 = area of mustard (ha)

A4 = area of safflower (ha)

The objective function is to be maximized and subjected to variety of constraints:

Water constraint

The irrigation water requirement of all the crops in command area shall be fulfilled by surface and ground water use. Therefore, water constraint for the crops can be written as:

Water constraint- $A1 \times 0.5 + A2 \times 0.3 + A3 \times 0.3 + A4 \times 0.3 \leq 50$ ha-m

Where,

A1= area of wheat (ha)

A2= area of gram (ha)

A3= area of mustard (ha)

A4= area of safflower (ha)

Water requirement- (wheat=0.5m, gram=0.3m, mustard=0.3, safflower=0.3)

When above formulation is run on TORA linear programming package the feasibility is obtained by allocation of surface water and ground water and land resources available.

Conclusion

Optimal crop plan for the study area for *rabi* season has been worked out which resulted in increase in the profits to the tune of Rs 10,15,306 annually besides ensuring optimal use of available surface water.

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