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Planning and design of surface drainage system for Jhillichaur, Pusa farm, Samastipur, Bihar

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Abstract
Waterlogging in an agricultural field is the one of major causes of crop failure. The problem of waterlogging in *chaur* land is attributed to inadequate provision of outlet. The natural drainage channels have become sluggish owing to mild slope and lack of due care and maintenance. The present study was designed to evaluate the drainage coefficient of waterlogged area of RPCAU, Pusa farm.In order to estimate the maximum rainfall, probability analysis was done by Weibull's method. The maximum rainfall at seventy percent probability level was found to be 88.35 mm, 111.11 mm, 126.21 mm, 148.41mm, 164.52 mm, 175.757 mm, 189.52 mmfor 1 to 7 consecutive days for the study area. The average pan evaporation for the month of June, July, August, September and October was 3.66 mm/day. Double ring infiltrometer was used for calculating infiltration rate of the soil. The average infiltration rate for 1 day, 2 days, 3 days, 4 days, 5 days, 6 days and 7 days were 0.68, 0.52, 0.41, 0.36, 0.32, 0.29 and 0.28 mm/h respectively. Study area was divided into three categories as upland, medium land and low land according to the elevation obtained from contour map of the area. The contour map was obtained with the help of software Google Earth, TCX Converter, Arc GIS and Global Mapper. The total area of Jhilli *chaur* was 12 ha. which was divided into two parts; Jhilli *chaur*-A and Jhilli *chaur* -B, having separate outlets. Seventh day's drainage coefficient of Jhilli *chaur*- A and Jhilli *chaur*- B has been found to be 4.63 cm/day and 2.34 cm/day, respectively. It has been concluded from study that one lateral for Jhilli chaur-A and one lateral for Jhilli *chaur*- B was sufficient to drain excess water from the waterlogged field. Total volume of earth work was computed as 118.51 m^3.

Keywords: Drainage Coefficient, Soil Infiltration, Pan Evaporation, Waterlogging, Drainage outlets.

1. Introduction
Drainage is regarded as an important water management practice, and as a component of efficient crop production systems. Realistic rainfall analysis is prerequisite for proper designing of any soil and water Conservation structure. Consecutive day rainfall analysis is more relevant for drainage design of agricultural lands and should be followed in command areas where drainage networks are to be installed (Ahamdi, 1995) [3].Though evaporation is a natural process, managing crops, soil and water use to balance the need of crop production. The pan evaporation trends varied from one pan to the next (Roderick *et al.*, 2009) [2]. Hydraulic properties of the soil surface control the partition of the rainfall between infiltration and runoff. Infiltration rate is the procedure of water development starting from the earliest stage into the dirt (Uloma *et al.*, 2014) [1]. Double ring in filtro-meter having diameter 30-60cm can give better performance. Modern tools such as satellite Remote Sensing, Global Positioning System (GPS) and Geographical Information System (GIS) provide newer dimensions to monitor and manage soil resources for their effective utilization. Irrigated and rain fed lands, drainage facilities should be developed

on a step–by–step basis over the countries therefore Planners and designers need to systematically re–examine planning principles, design criteria, operating rules and management policies for new infrastructures. Designing and managing drainage systems to achieve both crop production and water quality goals will be a challenging task in the coming years.

Planning of Surface Drainage System

Preparation of any project work consists of two phases. The first phase deals with the survey and investigation for data collection and second phase involve planning and design of project. Preliminary consideration might starts on the basis of data readily available while collection of additional data and formulation of project could go on simultaneously for some time. But a detailed project report can be formulated only after necessary data collected and analyzed. Accordingly, formulation of project and preparation of project report may be done in two stages. Feasibility stage and distinctive stage which include survey and investigation (preliminary appreciation, reconnaissance survey, field survey and investigation etc.), Investigation for definitive project (topographical survey, survey for the purpose of index map of the basin, contour map preparation for the selected area, foundation investigation, metrological and hydrological investigation etc.), planning and management of drainage dystem, planning of drainage Scheme etc.

2. Materials and methods

2.1 Hydrological Analysis of Rainfall Data

The present study was conducted in Jhilli chaur Pusa Farm, RPCAU, Pusa, Samastipur, Bihar. Rainfall data of 27 years (1991 -2017) were used for the rainfall analysis by Weibull's method. Weibull's method includes the arrangement of rainfall data in descending order of their magnitude. The plotting position for the arrange data was calculated by using the formulae r/ (n+1), where, r = rank of storm, n = total number of observations. Probability analysis was done for 1 to 7 consecutive days. Daily pan evaporation data of study area for five years (2012-2016) were collected from the meteorological department Dr. RPCAU, Pusa.

The contour map of the study area had been created by using four software namely Google Earth, TCX converter, Arc GIS and Global Mapper.On the basis of the map obtained and the visual inspection, the Jhilli chaur was divided into two part as Jhilli *chaur*-A and Jhilli *chaur* -B having two independent outlets.Land use pattern of Jhilli chaur, Pusa Farm has been presented in Table1.Both the zone is divided into upland, medium land and low land according to the elevation obtained from the contour map of the area.The infiltration rate of the soil was determined with the help of the double ring infiltrometer. Three sites were selected for determination of average infiltration characteristics of the problematic area.

2. Determination of Drainage Coefficient

Drainage coefficient has been evaluated on the basis of hydrological data by volume balance method. If the maximum rainfall for a period (t) is R, Area of drainage basin/ watershed is A and waterlogged area is A_l, then

$$Q_{in} = \frac{R \times A}{t} \quad \ldots 1$$

Since the water of the drainage basin accumulates in low land, evaporation and percolation losses effectively take place from the water logged area.

$$Q_{loss} = (I + E)A \quad \ldots 2$$

Where, I is Infiltration or percolation rate; mm/h and E is Evaporation rate; mm/day

By volume –balance, the water storage in the low lying area could be expressed as:

$$Q_{storage} = \frac{R_m \times A}{t} - (I + E)A_l \quad \ldots 3$$

Accordingly, the drainage coefficient (D_c) can be expressed as:

$$D_c = \frac{1}{A_l}\left[\frac{R_m \times A}{t} - (I + E)A_l\right]$$

$$D_c = \frac{R_m}{t}\left(\frac{A}{A_l}\right) - (I + E) \quad \ldots 4$$

Drainage coefficient for Pusa Farm area was evaluated for different durations of rainfall at 70 per cent probability level. Evaporation and percolation losses were taken as per actual observations.

The cross section for design of drainage system was chosen to be trapezoidal Manning's formula will be used for calculating the dimension of the drains. Side slope of the channel was assumed to be 1.5:1 as per soil characteristics of the study area, and the bed slope of the channel was calculated from the contour map that was 0.05%.

3. Results and Discussion

3.1. Rainfall Data Analysis

The plotting position for this data was calculated using Weibull's method. A graph between maximum rainfall and the corresponding plotting position had been prepared on semi-log graph The equations obtained from the graphs had been used for calculation of maximum rainfall at the probability level 60%, 70% and 80% respectively (Table 2). The magnitude of rainfall corresponding to 70% probability level were 88.33 mm, 111.06 mm, 126.37 mm, 148.44 mm, 164.53 mm, 175.80 mm and 189.50 mm respectively for 1 to 7 consecutive days rainfall. Considering the tolerance capacity of paddy and the agro-climatic condition of Bihar, seven days rainfall had been taken to be crucial for the evaluation of waterlogging in the *chaur* land. The maximum and minimum evaporation rate was found 6.25mm/day in the month of May and 0.93 mm/day in the month of December. Waterlogging problem in the *chaur* is mainly in monsoon season, the average pan rate of 3.66 mm/day was taken for the month of June, July, August, September and October for computation of drainage coefficient.

The contour maps of the study area have been shown in the Fig.1 for Jhilli -A and Jhilli -B respectively. land use pattern as upland, medium land and low land was categories as perelevation difference obtained from contour maps. was from Observations were taken at an regular interval of 5min, 10min, and 15 min respectively. Rain water of the study area get accumulated in low land and medium land so the average infiltration rate of these areas was taken for computation of drainage coefficient. Average infiltration rate was 0.68 mm/h on the first day of experiment and 0.28 mm/h on the seventh day. The initial infiltration result of upland was found to be larger than that of the low land.

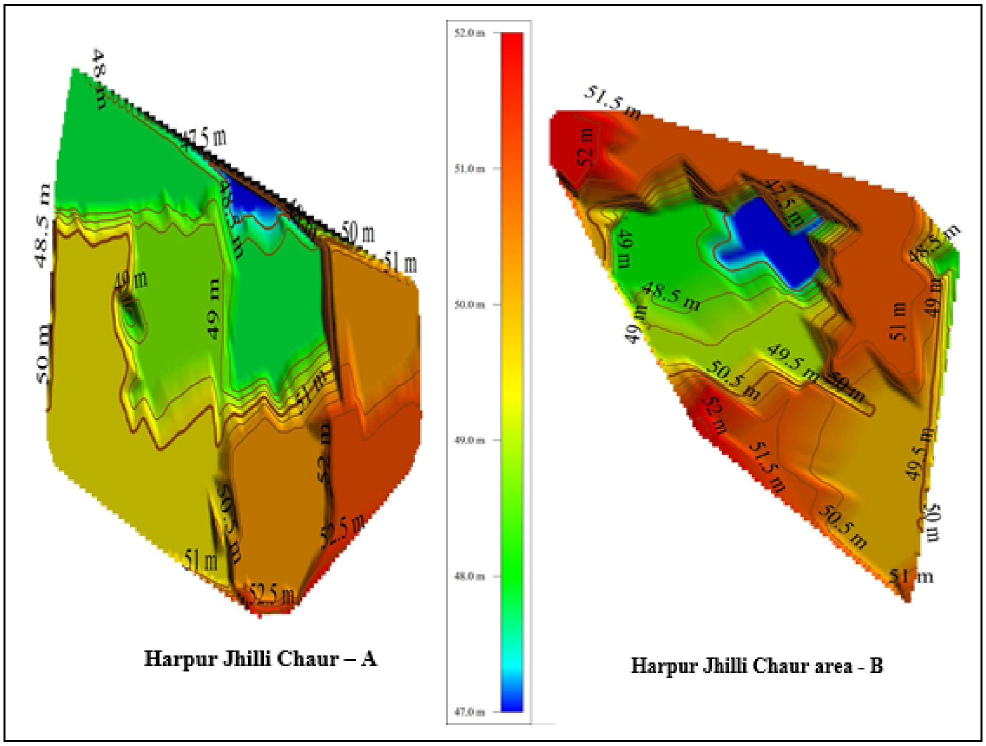

Fig 1: Contour Map of Harpur Jhilli Chaur – A and Harpur Jhilli Chaur area - B

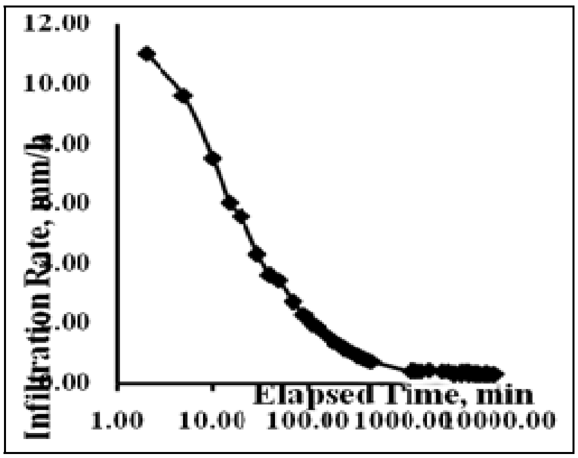

Fig 2: Relation between infiltration rate and elapsed time for low land

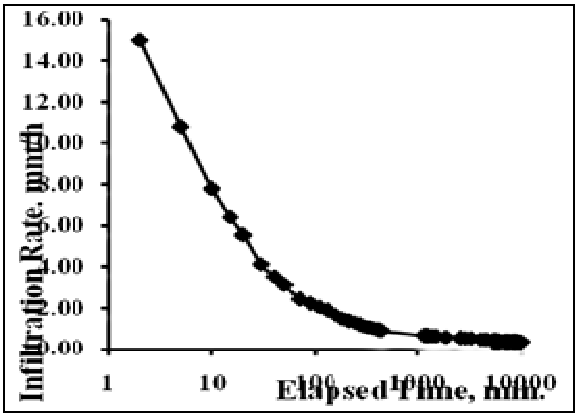

Fig 3: Relation between infiltration rate and elapsed time for low land

2. to duration. 4 has been -4was found suitable.for were study was for were found which was used for designing of drainage system. Dimensions of proposed lateral drain for Jhilli *chaur* -A : length =190.5m, width = 0.13m and depth =0.28 and for Jhilli *chaur* -B : length= 294.66m, width =0.125m and depth =0.272m. Dimensions of main drain were: length= 185.5, width =0.165m and depth =0.357m (Figures: 2 % 3)

Table 1: Land use pattern of Jhilli chaur area, Pusa Farm

Types of land	Contour elevation (m)	Area (ha)	
		Jhilli chaur A	Jhilli chaur B
Upland	51-53	1.289 (26.6%)	1.671 (19.8%)
Medium land	49-51	2.312 (47.8%)	4.705 (55.9%)
Low land	47-49	1.235 (25.5%)	2.033 (24.17%)

Table 2: Maximum rainfall (mm) at different probability level (%)

Duration	Maximum rainfall (mm) and Probability level (%)		
	60%	70%	80%
One day	96.29	88.33	81.44
Two days	125.16	111.06	98.86
Three days	143.68	126.37	111.37
Four days	165.81	148.44	133.39
Five days	182.52	164.53	148.95
Six days	193.90	175.80	160.13
Seven days	207.42	189.50	173.98

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