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Journal of Agriculture and Forest Meteorology

Original Research Article

Linear Programming Approach for Maximization of Net Profit and Selection of Irrigation System

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Abstract

For long-term viability requires the application of advance technologies to improve modern agricultural practices and crop yields. This study was undertaken to optimize the automated drip irrigation system. The optimum value of various levels of attributes is calculated with the help of linear programming from the results of irrigation systems and water quality. The selection of attributes was based on plant height, number of leaves, number of branches, number of fruits and yield in respective of irrigation system, water quality and days after transplanting. The optimum value of various levels of attributes was calculated with the help of linear programming from the results of irrigation systems and water quality. The results revealed that all the independent attributes affected the plant height, number of leaves, number of fruits, number of branches and yield. The optimum value of plant height, number of leaves, number of branches, numbers of fruits and the optimum yield was higher for wireless based drip irrigation system (IS_2) with treated fruit processing waste water (WQ_2) in comparison to wired based irrigation system. Hence, the combination of treated fruit processing waste water with wireless based system is recommended.

Keywords: Automated drip irrigation system, Optimization, Attributes, Water quality, Linear programming

INTRODUCTION

The availability of water in irrigated agriculture has become a major problem in the world. United Nations projected that nearly 3.4 billion people would be residing in "water-scarce" countries by the year 2025 and India would be at the center of it. In India, 80 percent of total water use is in agriculture sector [1]. It consumes approximately 90 percent of 7,61,000 billion liters of annual freshwater withdrawals in the country [2]. The sustainability of agricultural production depends on the conservation, appropriate use and management of scarce water resources, especially in arid and semiarid areas where users compete over limited water resources and irrigation is required for the production of food and cash crops. Since the balance between water demand and water availability has reached critical levels in many regions of the world and increased demand for water and food production is likely in the future, a sustainable approach to water resource management in agriculture is essential. The sustainable water management concept refers to all practices that improve crop yield and minimize non-beneficial water losses [3].

Due to insufficient surface water sources and 39 million ha of total cultivated land is irrigated by percent of total irrigated area usually depend on ground water utilization. India has the highest groundwater-based irrigation system in the world followed by China and USA, which is 19 million ha and 17 million ha, respectively [4]. In the next 20 years, 60 percent of groundwater sources may be in a severe situation of deterioration [5]. The excessive demand for groundwater leads in abnormally rapid resource depletion, which has an adverse effect on the availability of water [6].

Micro irrigation technology is rapidly expanding globally for precise irrigation water utilization, particularly in the limited available water areas of developed countries. In the USA, Israel, and a portion of Europe, this method of irrigation is quite successful [7]. Micro irrigation can boost crop productivity and reduce input consumption, among other aspects of the production process. This technique has significantly higher water usage efficiency (90 %) due to precise application as compared to other conventional method [8].

Automated drip irrigation is of two types i.e., wired based and wireless system. The wired based system requires regular maintenance for adequate operation. There are interim installations and must be expanded or adjusted to the

Received: *February 08, 2025;* ***Revised:*** *February 17, 2025;* ***Accepted:*** *February 20, 2025*

Citation: Pandey SK, Mishra PK, Kumar M, Singh AK, Kumar V, et al. (2025) Linear Programming Approach for Maximization of Net Profit and Selection of Irrigation System. J Agric For Meterol Stud, 4(1): 1-5.

drip line as plants evolve. This system has limited life after installation due to degradation of the plastic components in a hot, dry climate when open to ultraviolet light [9]. Conventional composition based on isolated wired resolutions, offerings many complications on measuring and control systems especially over the large geographical areas [10]. Currently numerous drip irrigation systems work with successive field automation mechanism, the wiring embarrassment and high price, longer time-consuming make it obstinate to promote in reiteration [11].

In well-designed automated drip irrigation system, there is no water loss by evaporation, deep percolation or runoff. Irrigation scheduling can also be managed preciously to fit crop demands, holding the commitment of boosted yield as well as quality. In India, due to small and fragmented land holdings and the high initial cost of automated drip irrigation system made such system uneconomical for small or medium-sized farms. Keeping this point of view, a study was conducted selection of Automated Drip Irrigation System using optimization solution.

MATERIALS AND METHODS

Afield experiment was conducted for optimization of Automated Drip Irrigation System (ADIS).

To achieve this objective tomato crop was transplanted in the month of August 2015 at the research farm of JISL Jalgaon and was irrigated with wired and wireless based drip irrigation system. To achieve the optimization the evaluation of the system was done considering weather and biometric attributes. Based on these parameters, the optimum values of attributes were found using regression analyses.

Based on the environmental attributes the best system was identified. To economize overall system design, the indigenous control circuitry was implemented using various pressure levels and emitter discharges. To further verify the optimization of the both the system was also carried out by considering biometric attributes: To optimize the ADIS (Wired and wireless), dependent and independent parameters were considered. The details of experiment are given as follows:

Experimental layout of automated drip irrigation system

Two different irrigation sources were applied for growing tomato crop, through wired and wireless ADIS with five replications. Dependent and independent parameters are listed in **Table 1** and the detailed specification of layout of experiment is shown in **Figure 1** and **Table 2**. The details of treatments and sub treatments are given below:

- WQ_1- Ground water (GW)
- WQ_2- Treated fruit processing waste water (TFPWW)
- IS_1- Wired Irrigation System
- IS_2- Wireless Irrigation System

The experimental field size of 1000 m^2 was selected. Field was divided into 20 plots, having size of each plot 9 × 4 m. The factorial randomized block design was selected for the study.

Table 1. Dependent and independent parameters,

Treatments	Levels detail	Observed parameters
Irrigation system	Wired and Wireless	• Crop characteristics • Temperature • Soil moisture • Humidity • Soil temperature • Evaporation
Water quality	Ground water and Treated fruit processing waste water	

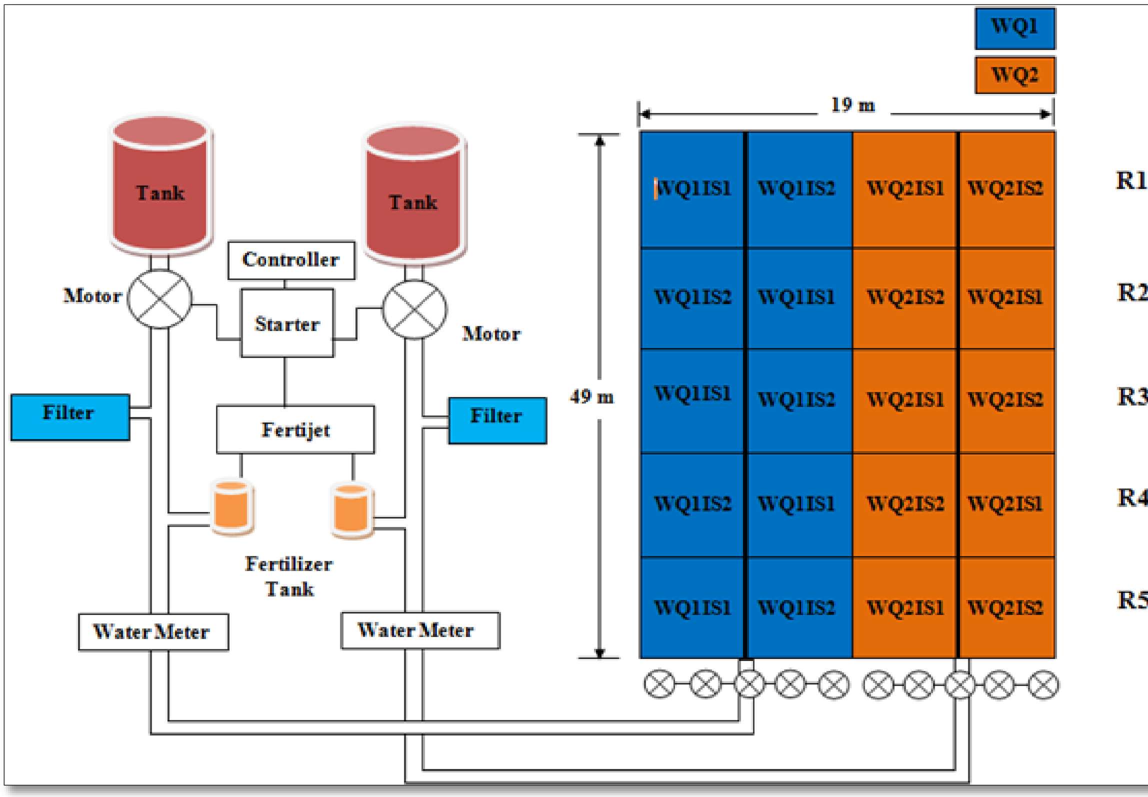

Figure 1. Schematic layout of automated drip irrigation system.

Table 2. Specifications of experimental layout.

Particular	Details
Design of layout	Factorial Randomize Block design
Number of experimental plots	20
Plot dimensions	9m x 4m
Experimental plot area	1000 m^2
Tank capacity	5000 liters
Filter type	Sand and disc filter
Pump	2.5 HP
Number of replications	5

Optimization

The linear programming was done for the study to optimize the dependent/independent parameters for both irrigation systems. This method is based on the concept that the selected parameters must be given equal weight. This technique ensures that the optimize combination will be closest to the positive ideal irrigation system. The different parameters under wired and wireless irrigation system were identified for the purpose of optimization. The optimum values of the different levels of independent attributes were derived from the results of the evaluation of irrigation system and linear programming then equation of linear programming was developed.

Different parameters were identified under wired and wireless irrigation system for optimization. The optimum values of the several levels of independent attributes were derived from the results of the evaluation of irrigation system and linear programming. After, linear programming, equation was generated. The optimum combination of independent parameters was selected on the basis of significance and maximum observed value of the dependent parameter.

RESULTS AND DISCUSSION

A programmed was written on spread sheet to optimize the linear programming formulation. For both seasons, the total crop water yield was predicted to be 286.79 ton/ha over the cropping period. The linear programming model consisting of three major components: an objective function for maximization of net returns, a set of linear constraints and set of non-negativity constraints was developed. The model was formulated to allocate water supplies among the different water treatment, in order to maximizing the net profit. The following equation was used as objective function:

$$P = 1.04x + 1.21y$$

Where, P is the profit; x is yield from IS_1 (Wired based irrigation system); y is yield from IS_2 (Wireless based irrigation system)

The above objective function is formed by knowing the contribution of both irrigation systems towards the net profit. It is the ratio of total income generated from yield of different irrigation system.

$$\text{Contribution of irrigation system} = \text{Profit generated by irrigation system (Rs)} / \text{Yield obtained from irrigation system (kg)}$$

For IS1 (Wired based irrigation system)

$$= 144995/139643 = 1.04\ \text{Rs.}/\text{kg}$$

For IS2 (Wireless based irrigation system)

$$= 178138/147147 = 1.21\ \text{Rs.}/\text{kg}$$

Yield constraint

The constraints state that the maximum yield generated from both irrigation systems should not exceeds 286790 as it shown by equation given below

$$x + y <= 286790$$

The objective function is subjected to constraints $x + y <= 286790$

Water quality constraint

The constraints state that the maximum yield depended upon water quality should be as stated in equations for WQ_1 and WQ_2

For WQ_1

$$68717x + 70926y <= 141206$$

For WQ_2

$$72490x + 74657y <= 145583$$

The above objective function is solved in the excel spread sheet using excel solver and the decision variables are obtained for maximizing the net profit (i.e. objective function) is shown in **Table 3**.

Table 3. Developed linear programming model for irrigation systems.

Irrigation System	IS_1	IS_2	Total	Max.
Net Profit	1.04	1.21	2.23	2.25
WQ_1	68717	70926	138309	141206
WQ_2	72490	74657	145583	145583

The LP formulation considered the yield obtained from different water quality and irrigation system as decision variables.

Thus, the maximum value of Net profit (P) Rs. 343509 and this occurs when x=0 and y=283892.The maximum profit as per the model shows is obtained when only IS_2 employed and for maximum yield WQ_2 was selected as model use its full capacity which is not in case of WQ_1.

CONCLUSION

The ADIS system was optimized for wired and wireless-based irrigation system to economize the system. The weather parameter and biometric parameter were analyzed for wired and wireless based irrigation system considering crop production of one-hectare area. The findings of study showed that wireless system is better than wired based irrigation system for precise irrigation management.

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