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Under climatological method to develop empirical model for the irrigation level and benefit-cost ratio of mustard crops

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Abstract
A two-year (2020–2022) studied conducted entitled Under climatological method to develop empirical model for the irrigation level and benefit-cost ratio of mustard crops at Sam Higginbottom University of Agriculture, Technology and Science's IRS farm in Prayagraj, Uttar Pradesh, India. Under this research, Scheduling of irrigation based on climatological method. As a crop, mustard crop of verity Varuna (T-59) considered. Plotting the experiment using a random block design. This research work included 5 treatments with three replications. Under the climatological approach, irrigation is scheduled at five values of IW/CPE ratio i.e. 1.75 IW/CPE ratio (T_1), 1.5 IW/CPE ratio (T_2), 1 IW/CPE ratio (T_3), 0.75 IW/CPE ratio (T_4), and 0.5 IW/CPE ratio (T_5). Design depth of irrigation (60 mm) calculated on the basis of total available water (TAW) by using field capacity, permeant wilting point of soil and root zone depth of the crop. Under climatological method, the benefit-cost ratio of the percentage of irrigation depth showed a satisfactory connection (R^2 = 0.863). During the first trial (2020-2021) and second experiment (2021-22), the total seasonal water supplied ranged between 120 mm to 360 mm and the average yield fluctuates between 1.03 and 2.2 t/ha. A strong correlation between yield and irrigation level was shown in Fig. 1. (R^2 = 0.768). Mustard crop is very diplomatic regarding irrigation level and moister stress. Treatments I_4 and I_5 have relatively low yields and shallow irrigation depths, respectively, because mustard is extremely sensitive to water depth or moisture stress, the yield is much lower under treatments I_4 and I_5 due to a lack of moisture.

Keywords: Climatologic method, depth of irrigation, Irrigation scheduling benefit-cost ratio, total available water (TAW), yield of crop

Introduction

Irrigation is one of basic needs for crop and it must be applied properly for maximum output. Surface irrigation is a traditional irrigation technique that is often carried out manually. It stands for application of irrigation techniques in which water is applied to the surface of the field., due to gravity force water convey from upper field boundary to lower field boundary. It has the benefit of being the least expensive of all irrigation methods. The term "surface irrigation" also refers to the flood irrigation method. The agricultural sector is the backbone of the Indian economy, and timing irrigation is one of the best ways to conserve energy and water. Irrigation scheduling basically involves choosing when and how much water distribute to a field or agricultural crop. The goal of irrigation scheduling is to maintain proper level of soil moisture with the sufficient depth of water along with maximizing irrigation efficiency without compromising yield reduction. (Geerts *et al*., 2009) [4].

The IW/CPE ratio is advised for optimum irrigation scheduling. The method is based on the close connection between crop evapotranspiration and pan evaporation. Similar to how water evaporates from an open pan evaporimeter, irrigation causes soil to lose water through evapotranspiration. It is the "ratio of irrigation water (IW) applied to cumulative pan evaporation (CPE)". Every day, the pan evaporation figures are summed up until they equal a predetermined proportion of the water applied as irrigation**.** The IW/CPE ratios for various crops at different agro climatic conditions in India have been determined under ICAR Coordinated Project for Research on Water Management. Jadhav *et al*. (1995) [5] conducted the study at Wakaw Ali, Maharashtra, and reported that irrigation scheduled at a different stage, branching and flowering increased the plant height of mustard over-application of irrigation at 100 mm CPE (.06 IW/CPE) with and without mulching. As per Indian mustard gave average yields of 0.9 and 1.3 tones/ha, respectively with an irrigation ratio of 0.6 and 1W/CPE ratio of 0.6. treatments IW/CPE (Chandra T. (2005) [1] while Dobariya and Mehta (2005) [7] concluded from their field experiment during rabi seasons of 2001-2002 and 2002-2003 at the Department of Agronomy, BA College of agricultural, Gujarat Agricultural University, that the oil content of mustard was significantly increased by 15% and grain yield was increased by 4.2% when the crop was irrigated at IW/CPE ratio of 0.9 as compared to IW/CPE ratio of 0.4. Conducted the study at PDKV Akola, Maharashtra to compare the effects of different Irrigation schedules on the mustard crop during 2007-2008, and reported that with IW/CPE ratio 0.25, 0.50, and 0.75 gave an average yield of 0.8, 0.83 and 0.9 tones/ha respectively. The idea of water requirement based on meteorological factors, such as the values of cumulative pan evaporation, normally employed for irrigation scheduling. The depth of irrigation water (IW) and the ratio cumulative pan evaporation (CPE), use to measure the scheduling irrigation under climatological approach.

Oil-seed crops, such as mustard, are widely cultivated due to their usefulness in industry and cuisine. Tropical and subtropical climates can support mustard plants. From the 26.0 million hectares of oil seed agricultural land in the nation, an estimated 30.0 million tonnes of mustard are produced. The amount of land used and harvested for mustard cultivation in Uttar Pradesh has declined between 2015–2016 (Rana *et al.*, 2019) [6]. Inconsistent weather patterns and wasteful use of water resources, especially in eastern Uttar Pradesh, could be to blame for this decline. A thoughtful watering approach and efficient water management can increase production and mustard yields. Research was conducted to create empirical models for irrigation level and benefit-cost ratio of mustard crop under climatological method, by keeping the previously perspective in mind.

Materials and Methods

Field studies were conducted at research farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (Allahabad), Uttar Pradesh, India for two consecutive seasons; November 2020 to April 2021 and November 2021 to April 2022. Prayagraj is situated in the South -eastern part of the State Uttar Pradesh. It lies between the parallels of 24°77´ and 25°47´ north latitudes and 81°21´and 82°21´ east longitudes. The field experiment is layout in randomized block design, with three replications and fifteen treatments. The details of different treatments are presented in table 3.5. The area of each plot was 16 m^2 (4 m x 4 m). Table.1 show the e Experiment details. Under research mustard crop(variety, T-59) considered, which seed rate is 5 Kg/ha and recommended dose of fertilizer of NPK is 80:40:40.The available water holding capacity of root zone**,** $TAW = 1000(\theta_{fc} - \theta_{wp}) \times Z_r$**,** TAW = 1000(0.28 – 0.16) x 1**,** TAW =120 mm**,** Water depletion from soil (p) for mustard crop = 0.5 from FAO-56.Net depth of irrigation water in the root zone = water holding capacity of the root zone x Water depletion from soil (p). Net depth of irrigation = 120 x 0.5 = 60 mm.

Irrigation scheduling based on climatological approach IW/CPE Ratio

Different moisture regimes were created by different irrigation schedules based on IW/CPE Ratio For this purpose, cumulative pan evaporation for respective treatments of IW/CPE ratio were determined using predetermined IW by using following equation: -

$$CPE = \frac{IW}{Ratio} \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Pan evaporation data were recorded daily and cumulative figure were by calculated subtracting the rainfall. In IW/CPE approach a known amount of irrigation water was applied when CPE reached up to a predetermined level, determined from equation (1)

Scheduling of irrigation for different values of IW/CPE
RATIO: (net depth of irrigation is 60 mm)
IW/CPE RATIO (C_1) =1.75
CPE= IW/1.75=60/1.75 = 34.2 mm
Irrigation water applied when 34.2 mm water evaporate from the soil
IW/CPE RATIO (C_2) = 1.5
CPE= IW/1.5=60/1.5 = 40 mm
Irrigation water applied when 40 mm water evaporate from the soil
IW/CPE RATIO (C_3) = 1.0
CPE= IW/1.0=60/1 = 60 mm
Irrigation water applied when 60 mm water evaporate from the soil
IW/CPE RATIO(C_4) = 0.75
CPE= IW/0.75=60/.75 = 80 mm
Irrigation water applied when 80 mm water evaporate from the soil
IW/CPE RATIO (C_5) = 0.5
CPE= IW/0.25 =60/0.5 =120 mm
Irrigation water applied when 120 mm water evaporate from the soil.

Results and Discussion

Table 1. (a). and table 1. (b) shows the overall cost of production, gross return, net return, and benefit-cost of mustard crop as impacted by climatological technique during first year trial (2020-21) and second year experiment (2021-22) respectively. While table 1. (c.) show the pooled data.

In the first experiment (2020–2021) and the second experiment (2020–21) respectively, the total cost of production ranged from 28517.64 t/ha to 36373.7 t/ha and 34296.5 t/ha to 42028.6 t/ha for different irrigation schedule based on climatological method from Table1. (a). and 1. (b). respectively. Due to a little change in operating costs, there was a small difference in the overall cost of production between the two experiments.

The gross income was impacted by the gross return at various irrigation levels. Maximum gross revenue (t/ha 114580.0) was recorded in treatment I_3 when irrigation was planned at 1.0 IW/CPE ratio with 240 mm of water depth, whereas in the first experiment during 2020-2021 from table 1. (a)., minimal gross return (54808.00 t/ha) was noted in treatment I_5 (at 0.5 IW/CPE ratio with 120 mm of water). The second year of the trial showed the same pattern. Maximum gross return (110765.2 t/ha) was recorded during the second year of the experiment in 2021–2022 from table 1.(b)., when irrigation was scheduled at 1.0 IW/CPE ratio in treatment I_3, but minimal gross income was reported when irrigation was scheduled at 0.5 IW/CPE ratio in treatment I_5.

The gross income of mustard was impacted by variations in irrigation depth.

Due to different irrigation scheduling based on climatological approach, there was a significance variance in net return. In the first trial (2020-2021) treatment I_3 had the highest net return of Rs. 82196.00 per hectare while treatment I_5 had the lowest net return of Rs. 26290.4 per hectare. Similar variations in net return were predicted during the experiment's second year, 2021–2022. During the trial 2021–2022, treatment I_3 had a maximum net return of 72602.6 per ha and a minimum net return of Rs. 15866.8 per ha in treatment I_5 was observed. Net return per hectare varied due to variations in irrigation depth.

Benefit-cost ratio impacted by differences in gross and net returns. In the first trial, highest benefit-cost ratio of 3.50 was recorded under treatment I_3, whereas lowest net return 1.92 observed in treatment I_5. A similar pattern was predicted for the experiment's second year, 2021–2022, in the benefit-cost ratio. The highest benefit-cost ratio (2.91) and the lowest benefit-cost ratio (1.5) were noted for treatments I_5 and I_3, respectively. Benefit cost ratio changed due to variations in gross return and net return.

Table1. (c).presents the pooled production costs (mean of experiments 1 and 2), gross returns, net returns, and benefit-cost ratios. The maximum gross return (Rs. 112672.59 per hectare), as well as the net return (Rs. 77399.5per hectare) and benefit cost ratio 3.2 under treatment T_3 was calculated. Under treatment I_5 minimum gross return (₹/ha 52485.67), net return (₹/ha 21078.6), and benefit cost ratio (1.7) were noted.

Table: 1. (a): Total cost production, gross return, Net return and benefit cost ratio on mustard crop influenced by climatological approach during first year experiment (2020-21)

Experiment -1(2020-2021)				
Treatment	**Total cost of production ₹/ha**	**Gross return ₹/ha**	**Net return ₹/ha**	**B/C Ratio**
I_1 (360 mm)	36373.7	85853.7	49480.1	2.4
I_2(300 mm)	34316.7	91612.0	57295.3	2.7
I_3(240 mm)	32383.6	114580.0	82196.4	3.5
I_4(180 mm)	30450.6	73423.0	42972.4	2.4
I_5(120 mm)	28517.6	54808.0	26290.4	1.9

Table: 1. (b): Total cost production, gross return, Net return and benefit cost ratio on mustard crop influenced by climatological approach during second year experiment (2021-22).

Experiment-2(2021-2022)				
Treatment	**Total cost of production ₹/ha**	**Gross return ₹/ha**	**Net return ₹/ha**	**B/C Ratio**
I_1 (360 mm)	42028.6	74013.0	31984.4	1.8
I_2(300 mm)	40095.6	83485.6	43390.0	2.1
I_3(240 mm)	38162.6	110765.2	72602.6	2.9
I_4(180 mm)	36229.5	67011.3	30781.8	1.8
I_5(120 mm)	34296.5	50163.3	15866.8	1.5

Table: 1. (c.): Pooled data of total cost production, gross return, Net return and benefit cost ratio on mustard crop influenced by climatological approach.

Pooled				
Treatment	**Total cost of production ₹/ha**	**Gross return ₹/ha**	**Net return ₹/ha**	**B/C Ratio**
I_1 (360 mm)	39201.1	79933.4	40732.2	2.1
I_2(300 mm)	37206.1	87548.8	50342.7	2.4
I_3(240 mm)	35273.1	112672.6	77399.5	3.2
I_4(180 mm)	33340.1	70217.2	36877.1	2.1
I_5(120 mm)	31407.0	52485.7	21078.6	1.7

Empirical model developed between irrigation levels and economic returns

The relation between the irrigation depth and the benefit-cost ratio is shown in figure. 1. In the pooled data, the benefit-cost ratio and irrigation depth showed a good quadratic connection (R^2 = 0.79). Benefit-cost ratio values ranged from 1.9 to 3.5 for the first experiment (2020–21) and from 1.5 to 2.91 for the second experiment (2021–2022), respectively, at different irrigation depths. Maximum (3.2) and minimum (1.71) B/C ratios were obtained in the polled data in treatments I_3 and I_5 respectively.

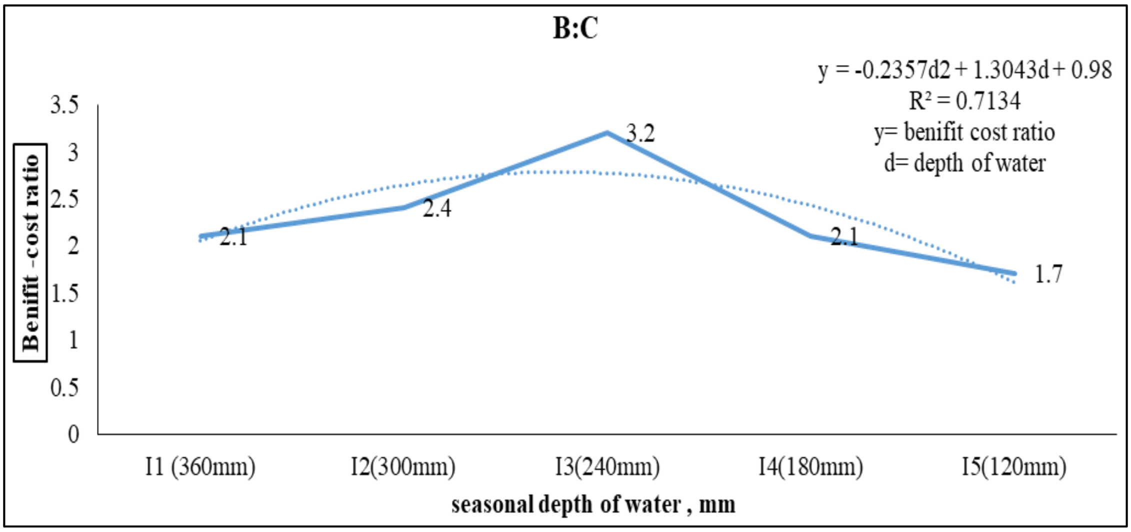

Fig 1: Relationship between Benefit-Cost ratio and depth of irrigation (mm).

Conclusion

In treatment I_3 (at 1.0 IW/CPE ratio with 240 mm depth of water), I2 (1.5 IW/CPE ratio with 300 mm depth of water), I_1 (at 1.75 IW/CPE ratio with 360 mm depth of water), I_4 (at 0.75IW/CPE ratio), and treatment I5 (at 0.5 IW/CPE ratio with 120 mm depth of water), the overall mean of yield (mean of experiments 1 and 2) was recorded as 2.22 t/ha. In the current experiment, two irrigation schedules with IW/CPE ratios of 1.0 with 240 mm of water and 1.5 with 300 mm of water provided greater gains, biological yields, and stover yield than other irrigation schedules based on climatological method. There is good quadratics relationship between irrigation levels and benefit-cost ratio of mustard crop under irrigation scheduling based on climatological approach.

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