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Er. Meera Kumari
Assistant Professor, Department of Agricultural Engineering, TCA, Dholi, Muzaffarpur, Bihar, India

Dr. Ir. DM Denis
Professor, Department of Irrigation and Drainage Engineering, SHUATS, Prayagraj, Uttar Pradesh, India

Er. Sudarshan Prasad
Associate Professor, Department of Irrigation and Drainage Engineering, CAET, RPCAU, PUSA, Samastipur, Bihar, India

Corresponding Author:
Er. Meera Kumari
Assistant Professor, Department of Agricultural Engineering, TCA, Dholi, Muzaffarpur, Bihar, India

To developed empirical models for irrigation level with benefit-cost ratio of mustard crop under water limiting conditions

Er. Meera Kumari, Dr. Ir. DM Denis and Er. Sudarshan Prasad

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Abstract
A two-year (2020 to 2022) research conducted at Prayagraj (Uttar Pradesh, India) in IRS farm of Sam Higginbottom University of Agriculture, Technology and Science to developed empirical models for irrigation level with benefit -cost ratio of mustard crop under water limiting conditions. Under this heading, irrigation scheduling based on the soil-water limiting condition. Mustard crop of variety Varuna (T-59) under this research work considered. The experiment was plotted in random block design. This research work included 5 treatments with three replications. Under soil-water-limited conditions, irrigation volume is lowered by 20%, 40%, 60%, and 80% of the design depth of irrigation (60 mm) in the second, third, fourth and fifth treatments, respectively. However, in the first treatment, full irrigation depth is provided without any stress. Under water limiting condition, the benefit-cost ratio of the percentage of irrigation depth showed a satisfactory connection (R^2 = 0.863).

Keywords: Soil-water-limited condition, irrigation depth, irrigation scheduling, benefit-cost ratio, total available water (TAW)

Introduction
Water supplies for irrigated agriculture are limited and steadily dwindling. "Abiotic stress can negatively impact on agricultural output by affecting an organism's metabolism, growth, and development, as well as its direct or indirect impact on physiological condition" (Vibhuti *et al*., 2015, Shahi *et al*., 2015a) [6, 5]. Therefore, it is important to put an emphasis on lowering water losses, raising water productivity, and reallocating water in irrigation-agriculture operations. By enhancing agricultural production with regard to water, the demand for water may be reduced to the greatest possible degree. (FAO Water reports, 2012) [3]. 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. There are a number of methods for determining when to irrigate plants, including the soil water depletion method (deficit irrigation), plant basis/indexes, climatic approaches, critical growth stage method, etc. Soil-water limiting is the practice of irrigating plants less frequently than they need to be watered. Such a strategy aims to optimize production per unit of water by decreasing the amount of water applied to the crop (FAO-56). The available soil moisture in the root zone is a helpful factor for scheduling irrigation in case of soil water depletion method. To lessen moisture stress in plants, soil moisture at a specific idea of water requirement based on meteorological factors, such as the values of cumulative pan evaporation, normally employed for irrigation scheduling.

The productivity of India is the lowest among the major mustard growing countries. As against the China with highest productivity of 4.10 tones/ha, the Indian average yield was only 1.4 tonnes/ha during 2019-20. The highest productivity states are Haryana (2058 kg/ha), Gujarat (1745 kg/ha), Rajasthan (1720 kg/ha), Punjab (1523 kg/ha), U.P. (1483 kg/ha) and M.P. (1422 kg/ha) with overall national yield of 1499 kg/ha (Directorate of Economics & Statistics, DAC&FW, 2020).

The average demand of mustard in UP is 40 lakh metric tonnes. Last year of mustard was grown 7.01 lakh hectare of land in the state and the total production was 10.08 lakh metric tons (Estate Agricultural department, 2021). There is a hues gap between demand and production in UP. This gap can be minimize by increasing the production and productivity of mustard by proper irrigation management. Keeping aforesaid view in mind, research work carried on to developed Empirical models for irrigation level with benefit -cost ratio of mustard crop under water limiting conditions

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 16m^2 (4m x 4m). 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(θ_{fc} – θ_{wp}) x 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.

Calculation of soil moisture content: on the basis of oven-dry method (a soil sample is retrieved from the field, weighed, and then placed in an oven set at105°C for 24 hours) moisture of soil is calculated: -

$$Moisture\ content\ (\%) = \frac{W2-W3}{W3-W1} \text{ X } 100 \ldots\ldots (1.0)$$

Treatment details of soil-water limiting conditions. By using the deficit irrigation technique, water use efficiency can be maximized in case of limited water resources. The practice of effective irrigation with minimum amount of water is known as soil water limitation condition. By Minimizing the amount of water to achieve maximum crop production is the goal of such a practice.

Scheduling of irrigation for various values of soil water limiting conditions

Ks1 =1.0 depth of irrigation= 60×1 = 60 mm
Ks2 =0.8 depth of irrigation= 60×0.8 = 48mm
Ks3 =0.6 depth of irrigation = 60×0.6 = 36mm
Ks4 =0.4 depth of irrigation= 60×0.4 = 24mm
Ks =0.2 depth of irrigation= 60×0.2 = 12mm

Irrigation water applied when soil moisture reached up to 16-18%.

Results and Discussion

The total cost of production varied between 32959.49 to 40822.63 and 32118.64 to 39981.78 ₹/ha for different percentage of depletion of moisture in experiment first (2020-21) and second experiment (2021-22) respectively from table 2.1.(a), 2.1.(b), 2.1.(c). The variation in total cost of production with different percentage of deficit irrigation was recorded because of variation in water development, water pumping, packaging and transportation cost. The slight deviation in total cost of production in between two experiment was observed due to slight variation in operating cost. Gross return at different levels of irrigation and moisture deficit influenced the gross income. Maximum gross income (₹/ha 115447.00) was recorded when irrigation was scheduled through Irrrigation level 0.6 with 40 % moisture stress in treatment I_3 in first experiment (2020-21). In contrast minimum gross income (₹/ha 49714.80) was recorded when irrigation was scheduled through Irrrigation level 0.2 with 80 % depletion of moisture in treatment I_5 during first experiment. Same trend followed for second year experiment. During second year (2021-22) experiment Maximum gross income (₹/ha 113221.00) was recorded when irrigation was scheduled through Irrrigation level 0.6 with 40 % depletion of moisture in treatment I_3 whilst in contrast minimum income was recorded when irrigation was scheduled through Irrrigation level 0.2 with 80 % depletion of moisture in treatment I_5 with 72mm depth of water. Variation in deficit moisture, affected the gross income of mustard. Gross return directly proportional to Yield and depth of water.

There was significant difference in net return due to depletion of moisture. The maximum net return of ₹/ha 78555.94 per hectare was recorded at Irrrigation level 0.6 with 40 % depletion of moisture in treatment I_3 whilst minimum net return of ₹/ha 16755.31 per hectare recorded under treatment Irrrigation level 0.2 with 80 % moisture stress in treatment I_5 during first experiment. Similar variation in net return was estimated in second year experiment during 2021-22. Maximum net return ₹75205.00 per ha was recorded under treatment I_3 while minimum net return ₹/ha 13553.91 observed in treatment I_3. Differenced in depletion of moisture caused a variation in net return per hectare.

Benefit-cost ratio affected due variation in gross return and net return. The maximum benefit-cost ratio of 3.13 was calculated at Irrrigation level 0.6 with 40 % depletion of moisture in treatment I_3 whilst minimum benefit cost-ratio 1.51 recorded under treatment at Irrrigation level 0.2 with 80 % depletion of moisture in treatment I_5 during first experiment. Similar variation in benefit -cost ratio was estimated in second year experiment during 2021-22. Maximum (2.98) and minimum (1.40) benefit-cost ratio were recorded under treatment I_3 and I_5. Differenced in gross return and net return caused a variation in benefit cost ratio Pooled (mean of experiment 1 and experiment 2) cost of production, gross return, net return and ratio of benefit cost ratio presented in table 2.(c). The maximum cost of production (₹39419.31per hectare) was observed under treatment I_2, whilst in case of maximum gross return (₹.114334.00 per hectare), net return (₹/ha 76880.47) and benefit cost ratio (2.98) were observed under treatment I_3. The variation in pooled cost of production occurred due to variation in experiment 1 and experiment 2. The minimum pooled cost of production (₹/ha 33521.96 per hectare), minimum gross return (₹/ha 48676.57), net return (₹/ha 48676.57) and benefit cost ratio (1.45) were observed under treatment I_5.

Table 2.1. (a): Effect of soil-water limiting condition on gross return, net return and ratio of benefit cost ratio during first experiment (2020-21)

Treatment	Total cost production (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B/C Ratio
I1 (360 mm)	40822.63	84830.00	44007.37	2.08
I2 (288 mm)	38856.84	87669.00	48812.16	2.26
I3 (216 mm)	36891.06	115447.00	78555.94	3.13
I4(144 mm)	34925.27	80699.00	45773.73	2.31
I5(72.0 mm)	32959.49	49714.80	16755.31	1.51

Table 2.1. (b): Effect of soil-water limiting condition on gross return, net return, and ratio of benefit cost ratio during second year experiment. (2021-22)

Treatments	Total cost production (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B/C Ratio
I1 (360 mm)	32118.64	84722.17	52603.53	2.64
I2 (288 mm)	39981.78	99821.67	59839.88	2.50
I3 (216 mm)	38016.00	113221.00	75205.00	2.98
I4(144 mm)	36050.21	74908.33	38858.12	2.08
I5(72.0 mm)	34084.43	47638.33	13553.91	1.40

Table 2.1. (c): Pooled (mean of experiment 1 and experiment 2) gross return, net return, and ratio of benefit cost ratio.

Treatment	Total cost production ₹/ha	Gross return ₹/ha	Net return ₹/ha	B/C Ratio
I1 (360 mm)	36470.64	84776.08	48305.45	2.36
I2 (288 mm)	39419.31	93745.33	54326.02	2.38
I3 (216 mm)	37453.53	114334.00	76880.47	3.05
I4(144 mm)	35487.74	77803.67	42315.92	2.19
I5(72.0 mm)	33521.96	48676.57	15154.61	1.45

Empirical model for benefit cost ratio and depth of irrigation

In Fig.1. the relationship between the benefit-cost ratio and various deficit irrigation depths for the trial years 2020–2021 and 2021–2022 is shown. For varying percentages of deficit irrigation, the benefit-cost ratio in experiments 1 and 2 ranged from 3.13 to 1.51 and 2.98 to 1.40, respectively. For the years 2020–2021 and 2021–2022, the benefit–cost ratio with irrigation levels showed a similar quadratic connection. For experiment 1, the benefit-cost ratio with respect to the percentage of irrigation depth showed a satisfactory connection (R^2 = 0.863) from Fig 1. At 0.6 irrigation level (216 mm depth of irrigation) with 40% moisture depletion, the benefit-cost ratio was at its highest; thereafter, it began to drop (Fig. 1). The outcome showed that the benefit-cost ratio substantially falls as moisture stress grows above the level specified.

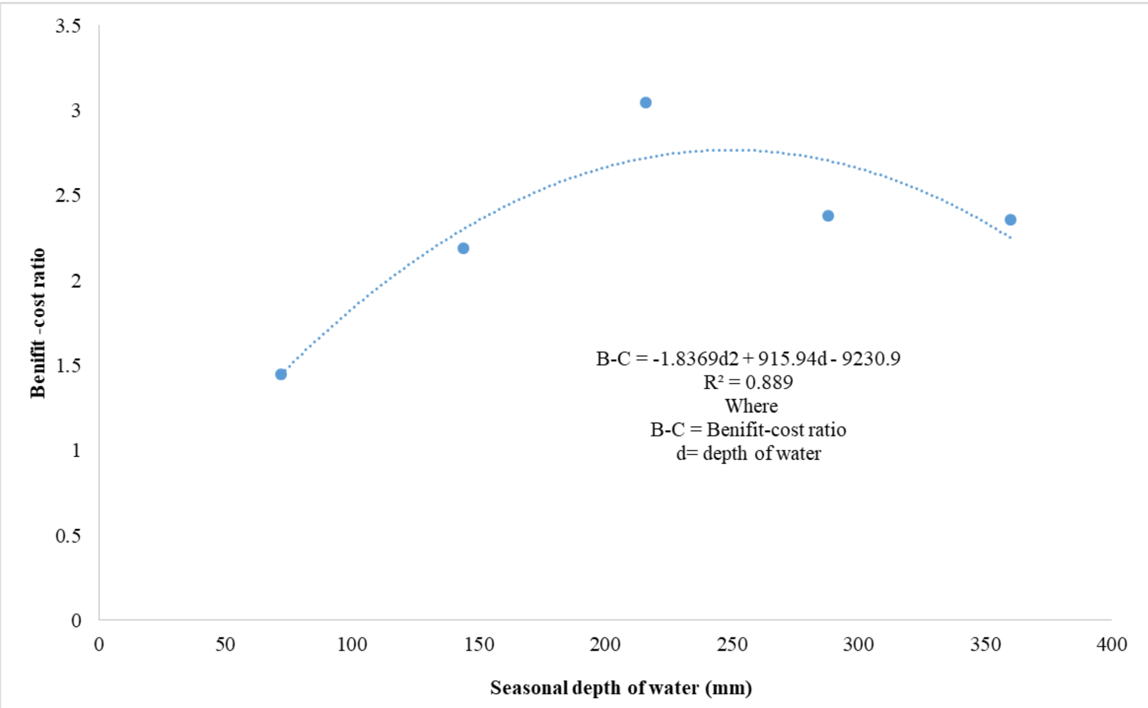

Fig 1: Relationship between Benefit-Cost ratio and depth of deficit irrigation.

Conclusion

Irrigation was scheduled as influenced by limiting soil water conditions and the maximum grain yield 2.26 ton/ha was found with 216 mm of total water supplied at irrigation level 40 % soil moisture depletion. The maximum benefit cost ratio 3.05 was found with 216 mm of total water applied at irrigation level 40% soil moisture depletion. The seasonal water applied/ irrigation levels and benefit-cost ratio of mustard crop established good quadratics relationship in all approaches of irrigation scheduling.

References

1. Bartels D, Sunkar R. Drought and salt tolerance in plants. Critical Reviews in Plant Science. 2005;24:23-58.
2. FAO-56, Crop evaporation. (Guidelines for computing crop water requirements). FAO's work on Climate Change. Climate-change@fao.org.
3. FAO. Water Reports, 38. Coping with water scarcity. An action frame work for agriculture and food security; c2012.
4. Rana K, Singh JP, Parihar M. Manifestation of improved cultivars, irrigation and Sulphur in mustard growth, productivity, quality and profitability: A review. Journal of Pharmacognosy and Phytochemistry. 2019;8(3):2778-2782.
5. Shahi C, Vibhuti KB, Bargali SS. Influence of seed size and salt stress on seed germination and seedling growth of wheat (*Triticum aestivum* L.). Indian Journal of Agricultural Sciences. 2015b;85(9):1134-1137.
6. Vibhuti SC, Bargali K, Bargali SS. Seed germination and seedling growth parameters of rice (*Oryza sativa* L.) varieties as affected by salt and water stress. Indian Journal of Agricultural Sciences. 2015;85(1):102-108.