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# An economic assessment of irrigation scheduling (Based on water limiting conditions) for enhancement of production and profitability of mustard crop

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**Abstract**
Field studies were conducted at the IRS 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 to economic assessment of irrigation scheduling based on water limiting conditions) for enhancement of production and profitability of mustard crop (varunaT-59). Irrigation scheduling is based upon water limiting conditions. Five levels of water limiting conditions are I1 (irrigation at zero percent water stress of 60 mm designed depth of irrigation), I2 (irrigation at 20% water stress of 60 mm designed depth of irrigation), I3 (irrigation at 40% water stress of 60 mm as designed depth of irrigation), I4 (irrigation at 60% water stress of 60 mm as designed depth of irrigation) and I5 (Irrigation at 80% water stress of 60 mm as design depth of irrigation water. The experiment was conducted in Random block design with three replications. Maximum production and profitability recorded under treatment I3 at 40% water stress with 60 mm designed depth of irrigation). Maximum grain yield (2.25 t/ha) and straw yield (7.0 t/ha) recorded under treatment I3 at 40% water stress with 60 mm designed depth of irrigation. Maximum profit i.e. gross return (Rs/ha 114334.00), net return (Rs/ha. 76880.47) and (3.45) were calculated under treatment I3 (irrigation at 40% water stress of 60 mm as designed depth of irrigation).

**Keywords:** Mustard, irrigation schedule, economic returns

## Introduction
Due to hues explosion in population, tremendous amount of water required to full fill the demand. Improper utilization of water, increasing water loss, decreasing water output and may be stampede due to shortage of water among people. There is only one way to reducing water losses, increasing water productivity and water reallocation through irrigation-agriculture practices. By improving or boosting agricultural production, water and energy can conserve drastically and the demand for water can be lowered up to a greatest extent. Correct timing of irrigation is known as irrigation scheduling. Irrigation scheduling explain about when and how much water supply to a field or agricultural production for bona fide production (Geerts *et al*., 2009) [3]. There is a various approach for planning of irrigation schedules, including water limitation condition climatological approach and residual method of energy balance. Among all approaches, water limiting condition is one of the best methods for conservation of water and energy. Crop productivity per unit of water applied through water liming conditions can be maximize by proper management of water. However, there may be an impact on the yield per unit area (FAO-56). The most crucial factor in reducing the rapid demand for production and productivity of mustard crop is irrigation management. Water limiting irrigation is a method of water management that concentrates the application of seasonal water supply on moisture-sensitive crop growth stages in order to maximize the productivity of applied water. Mustered is more sensitivity regarding irrigation level and moisture stress. Moisture stress created due to low and high moisture content. Moister stress created due to low moisture is known as deficit irrigation or water limiting irrigation whilst moisture stress created due to high amount of water within the root zone known as abiotic stress which affected the yield attributes of crop. The mustard yield is vulnerable to various factor i.e., scheduling of irrigation, texture and structure of soil, climatic factor etc. Mustard (*Brassica juncea* L.) belongs to the 'Cruciferae' family. One of India's most significant oilseed crops is the mustard crop. Rapeseed and mustard make up 28.6% of India's total oilseed production, making it the fourth-largest producer in the world (review article open 2012).

The estimated global rapeseed-mustard area, output, and yield in 2018–19 were 36.59 million hectares, 72.37 million tonnes, and 1980 kg/ha, respectively (Kaliya, *et al*., 2021) [4]. Productivity has drastically grown over the past eight years, rising from 1840 kg/ha in 2010–11 to 1980 kg/ha in 2018–19, while production has increased to 1145 kg/ha ((Kaliya, *et al*., 2021) [4].

In Uttar Pradesh, mustard acreage, production, and yield have all significantly increased over the last ten years; production has nearly doubled (Kaliya *et al*. in 2021) [4]. Rajasthan is India's largest producer of rapeseed and mustard, followed by Uttar Pradesh. Mustard and rapeseed are primarily consumed in the country's eastern and northern areas. Almost half of the nation's production was produced in Uttar Pradesh and Rajasthan, which jumped from 61.64 m t in 2010–11 to 72.42 m t in 2018–19. Among the major mustard producers, India has the lowest productivity. India's average production in 2019–20 was only 1.4 tonnes/ha, much below China, which had the highest productivity with 4.10 tonnes/ha. Out of the nine major oilseed crops, India is the largest producer of soybeans (39%), followed by groundnut (26%), and mustard (24%) (Bikshapati *et al*. 2021) [1]. Uttar Pradesh, Madhya Pradesh, Rajasthan, Haryana, and Gujarat are the primary producers of Indian mustard. In mustard, the protein content ranges from 17 to 25%, while the amounts of fibre, moisture, and extractable substances are between 8 and 10%. Erucic acid is present in large amounts in mustard oil (38-57%) (Bikshapati *et al*. 2021) [1]. The highest producing states are Haryana (2058 kg/ha), Gujarat (1745 kg/ha), Rajasthan (1720 kg/ha), Punjab (1523), Uttar Pradesh (1483), and M.P., with a national yield of 1499 kg/ha (1422). (Directorate of Economics & Statistics, DAC&FW). India produced 6.78 million tonnes of rapeseed and mustard between 2011 and 2012 on an area of 5.92 million hectares, with an average crop productivity.

Since then, from 2015 to 2016, there has been a decrease in both acreage and productivity in Uttar Pradesh (Rana *et al*. 2019) [5]. This decline could be the result of ineffective water management and dramatic changing in microclimate pattern, especially in eastern Uttar Pradesh. With correct water/irrigation timing and management, the production and productivity of the mustard crop may be increased. Taking into account the ecological and economic importance of these areas, research title entitled an economic assessment of irrigation scheduling (based on water limiting conditions) for enhancement of production and profitability of mustard crop.

## Materials and Method

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. Allahabad 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 climate of a UP is mainly characterized by humid subtropical climate in which summers are typically long, hot and humid. Summers are extremely hot, while winters are fairly cool. During the experiment, maximum duration of sunshine and depth of pan evaporation were recorded in the month of April, while the minimum duration of sunshine and depth of pan evaporation were recorded in the month of December and January. Soil of the experiment field was sandy loam in texture. At 0 -15 cm depth, soil contains 64.9% sand, 21.8% silt, 13.3% clay, 0.17 ds/m electric conductivity, 1.19 g/cm-3 bulk density with 8.0 pH of soil. The experiment was laid out in random block Design with 3 replications and five treatments. The treatments comprised of 5 irrigation schedules *viz*., I1 (irrigation at zero percent water stress of 60 mm designed depth of irrigation), I2 (irrigation at 20% water stress of 60 mm designed depth of irrigation), I3(irrigation at 40% water stress of 60 mm as designed depth of irrigation), I4 (irrigation at 60% water stress of 60 mm as designed depth of irrigation) and I5 (Irrigation at 80% water stress of 60 mm as design depth of irrigation water).

The soil water availability for sandy loam soil at research station was found to be 120mm. The soil moisture at field capacity was found to be at 35%. The total available water (TAW) was calculated using the methodology to understand maximum amount of water that can be evaporated (FAO-56). This part of research intends to quantify the average fraction of the total available soil water that can be depleted from the root zone before moisture stress. This depleted fraction referred as a function of the evaporating power of atmosphere. It is also called depletion fraction as per the experimental design and recommended by the FAO-56 in the chapter of evaporation under soil stress conditions. The depletion for mustard is taken as 0.5 with a maximum rooting depth of 1 to 1.5 metre. In the first treatment the mustard plants are made to experience no stress or 0% water stress of 60 mm as designed depth of irrigation. However, for the remaining four treatment the irrigation amount is reduced by 20%, 40%, 60% and 80% of 60 mm as designed depth of irrigation. In first treatment the values of depletion faction (p) remain at 0.5 while the sought-after depletion fraction lies beyond 0.5 to that value of which (TAW) when applied, does have an influenced upon the yield but insignificant, while in first treatment the depth of irrigation remains at 60 mm. The second, third, fourth and fifth treatment received 48 mm, 36 mm, 24 mm and I2 mm respectively. Thus, creating moisture stress from 0% to the lower limit of radial available water. In all the cases the irrigation depth doesn't cross total available water depth (120mm). However, in the second treatment it is deemed that beyond the maximum allowable deficit of 60mm depth, the second treatment may be extracting water 12mm beyond the maximum allowable deficit level. Similarly, the third, fourth, and fifth treatment may be extracting water beyond maximum allowable deficit by 24mm, 36mm and 48mm. Under all the conditions moisture is made available in the rootzone however moisture stress varying.

## Economics of the treatment

The cost of cultivation under different treatments were calculated by adding all costs incurred in crop cultivation along with interest on the working capital. Total income by selling the produce (grain + stalk) was estimated and their gross income was calculated in rupees per hectare. Net income was obtained by subtracting the cost of cultivation from gross income. The cost-benefit ratio has been net returns divided by cultivation costs.

## Result and Discussion

### Effect on yield and economics

Irrigation scheduling based on water limiting conditions significantly affected the stover yield and grain yield and Pooled data of two-year experiment 2020-2021 and 2021-2022 are presented in the Table-1.0. The maximum seed yield

(2.25 t ha$^{-1}$) and stover yield (7.0 t ha$^{-1}$) were recorded under treatment I3 (at irrigation level 0.6 with 40% moisture stress of design depth of irrigation) which was significantly superior over rest of the irrigation. Seed yield was 22.02, 34.73, 47.05 and 125.0% more than I2 (at irrigation level 0.8 with 20% moisture stress of design depth of irrigation), I1 (at 1.0 irrigation level with zero percent moisture stress of design depth of irrigation), I4 (at 0.4 irrigation level with 60% moisture stress of design depth of irrigation) and I5 (at 0.2 irrigation level with 80% moisture stress of design depth of irrigation) respectively. Among all treatments minimum yield was recorded under treatment I5. Minimum stover yield 4.69 ton /ha was also observed in treatment I5. For yield and yield attributes, most appropriate condition was observed in treatment I3 (irrigation level 0.6 with 40% moisture stress) whilst most unfavourable condition for production of mustard was observed in treatment I5 (irrigation level 0.2 with 80% moisture stress) due to higher moisture stress rather than other treatments. The yield of any crop species depends upon the source-sink relationship and is the cumulative function of various growth parameters and yield attributing characters.

## Effect on economy

The mean values of two-year experiment (2020-2021 and 2021-2022) for gross return, net return and benefit-cost of mustard crop influenced by different irrigation level are presented in Table 2.0.Gross return at different levels of irrigation and moisture deficit influenced the gross income. Maximum gross income (Rs/ha. 114334.00**)** was recorded when irrigation was scheduled through Irrrigation level 0.6 with 40% moisture stress in treatment I3 whilst minimum gross income (Rs/ha 48676.57) was recorded when irrigation was scheduled through Irrrigation level 0.2 with 80% moisture stress in treatment I5 during. Variation in deficit moisture, affected the gross income of mustard. Gross return directly proportional to Yield and depth of water. The maximum net return of Rs. 76880.47 per hectare was recorded at Irrrigation level 0.6 with 40% deficit moisture in treatment I3 whilst minimum net return of Rs. 15154.61 per hectare recorded at Irrrigation level 0.2 with 80% moisture stress in treatment I5. Differenced in moisture stress 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 3.05 was calculated at Irrrigation level 0.6 with 40% deficit moisture in treatment I3 whilst minimum 1.45 benefit cost-ratio recorded under treatment at Irrrigation level 0.2 with 80% moisture stress in treatment I5 during first experiment.

**Table 1:** Effect of water limiting conditions on pooled yield and Stover yield of mustard crop

| Treatment | Seed yield (t ha-1) | Stover Yield (t ha-1) |
|---|---|---|
| I1 | 1.67 | 6.5 |
| I2 | 1.85 | 6.5 |
| I3 | 2.25 | 7.0 |
| I4 | 1.53 | 6.2 |
| I5 | 0.96 | 4.7 |
| LSD (=0.05) | 0.057 | 0.11 |
| SE(m) | 0.189 | 0.37 |

**Table 2:** Effect of water limiting condition on pooled (mean of experiment 1 and experiment 2) gross return, net return, and ratio of benefit-cost ratio.

| Treatment | Gross return Rs/ha | Net return Rs/ha | B/C Ratio |
|---|---|---|---|
| | 84776.08 | 48305.45 | 2.36 |
| | 93745.33 | 54326.02 | 2.38 |
| | 114334.00 | 76880.47 | 3.05 |
| | 77803.67 | 42315.92 | 2.19 |
| | 48676.57 | 15154.61 | 1.45 |
| | 4.55 | 3.30 | 0.016 |
| C.D. | 10.55 | 9.44 | 0.055 |

## Conclusion

The maximum seed yield (2.25 t ha$^{-1}$) and stover yield (7.0 t ha$^{-1}$) were recorded under treatment I3 (at irrigation level 0.6 with 40% moisture stress of design depth of irrigation) which was significantly superior over rest of the irrigation. Maximum gross income (Rs/ha 113221.00), net return of Rs. 75205.00 per hectare and maximum benefit cost ratio recorded under treatment I3 at Irrrigation level 0.6 with 40% deficit moisture. Result revealed that irrigation level at 0.6 with 40% moisture stress, is most optimal condition for growth parameter and yield attributes of mustard.

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