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IRRIGATION SCHEDULING OF MUSTARD USING OPEN PAN EVAPORATION

A. A. SARKAR*, S. M. A. ALI, M. S. U. TALUKDER AND M. AHMED

Department of Irrigation and Water Management, Bangladesh Agriculture University, Mymensingh, Bangladesh

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An experiment was conducted at the Bangladesh Institute of Nuclear Agriculture farm during the winter season of 1987-88, for making an inrrigation schedule of the newly developed mustard mutant BINA-2 and for investigating the use of irrigation water and its effect on the yield and yield contributing characters of the mustard mutant. Results of the study indicated that single irrigation showed positive response to the increase of the yield of the mutant over control. The highest yield (about 10% higher over control) and water use efficiency were obtained with one irrigation of 3.30cm at the pre-flowering stage and in the control, respectively. The results also showed that increasing irrigation frequency, yield and water use efficiency gradually decreased indicating that application of irrigation water more than one caused the wastage of water. The results thus revealed that depending on rainfall and soil moisture condition one irrigation at the pre-flowering stage is necessary for higher yield of the mustard mutant in this location.

Key words: Mustard, Mutant, Yield, Water use, Irrigation scheduling.

Introduction

Satisfactory crop growth and yield are not possible without timely application of adequate irrigation water. However, winter crops like oil seeds can be grown successfully in areas having high residual soil moisture and rainfall in the growing period. In dry season and in places where rainfall is low, application of irrigation water is necessary for getting higher yield of mustard and for this purpose irrigation scheduling technique may be used as a guideline. Application of irrigation water without proper planning based on actual requirement of crops results not only in wastage of irrigation water but also hampers crop growth and yield *et al.* [1]. It is an usual practice to apply irrigation water on the basis of growth stages of crops. But this practice may lead to the possibility of over or under irrigation because of arbitary application of water without regard to the soil moisture or water use by the crop *et al* [2]. The open pan evaporation was found to be one of the best methods for scheduling irrigation to crops *et al* [3, 4]. Therefore, using open pan evaporation, judicious application of irrigation water may be made in the right way and according to the need of the crops.

In Bangladesh, yield of mustard is very low which is about 0.707 t/ha [5] whereas in western countries like the Sweden, the yield is 2.67 t/ha [6]. It has been reported that there is a wide scope for increasing mustard production, if proper use of irrigation water and other inputs are made *et al* [7, 8] also reported that mustard (*Brassica Juncea*) can successfully be raised on conserved moisture but satisfactory yield cannot be obtained on loamy and sandy loam soils of arid plains, unless supplemental irrigation is given at the critical stages of growth.

In consideration of the above facts, a study on irrigation scheduling of mustard using open pan evaporation method was undertaken at the farm of Bangladesh Institute of Nuclear Agriculture (BINA) with a view to study the use of irrigation water, its effects on the yield and water use of mustard mutant BINA-2 developed by BINA.

Materials and Methods

The experiment was carried at the farm of the Bangladesh Institute of Nuclear Agriculture, Mymensingh (24° 45'N, 90°24'E; and 19m above M.S.L.). The topography of the experimental area was completely flat and high land because the area is situated above normal flood level. It may be mentioned here that flood water never enters into the area but water accumulates due to rainfall of high intensity and long duration. However, this rain water drains out shortly after the recession of the rainfall. The soil of the area belongs to the Old Brahmanputra alluvial flood plain with total N(%) of 0.067, available P(ppm) of 38.5, K(Me%) of 0.107 and pH value of 7.0. The area is under cultivation for the last fifty years. Soil samples from four different locations of the experimental field were collected at random at depths ranging from 0-15, 15-30, 30-45 and 45-60cm and analysed in the laboratory to determine the particle size distribution and bulk density. Texturally, the soil was sandy loam to sand having about 62.54-88.84% sand, 3-22.30% silt and 7.76-15.16% clay. The bulk density of the soil ranged from 1.48-1.61 gm/cm^3. The moisture content of the soil held at field capacity (0.3 bar) as determined by pressure plate apparatus ranged from 21.00-27.00% by weight and that at wilting point (15 bar) ranged from 4.00-17.81% by weight (Fig. 1).

The experimental field was laid out in a Randomized Block Design (RBD) with six irrigation treatments each having three replicates. The individual 15m^2 (5m x 3m) plots were separated from each other by 1.0m wide buffer zone to prevent

* Irrigation and Water Management Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh.

seepage between nearby plots. Similarly, the replicates were separated from each other by 1.0m wide buffer zone. Measured amounts of irrigation water were applied to the individual plots using a bucket of known volume.

Before sowing, each plot was fertilized uniformly with a basal dose of 80 kg of N/ha as urea, 80 kg of P_2O_5/ha as muriate of potash, 4 kg of zn/ha as zinc oxide and 20 kg of s/ha as gypsum. Another 80 kg of N/ha as urea was applied in two equal splits, one at the active vegetative stage and the other at the flowering stage.

A newly developed high yielding mustard mutant BINA-2 *(Brassica Juncea)* was sown at the rate of 7.5 kg/ha on November 19, 1987. The seeds were sown in lines 20 cm apart. The surrounding area of the experimental plots were also sown to provide a buffer crop for the experimental plots. Fifteen days after sowing, weeding and thinning of the seedlings were done. After 30 days of sowing, weeding, thinning and mulching were done again keeping approximately equal number of plants in each row of each plot.

The six irrigation treatments were as follows:

1_0 = No. irrigation (control)

I_1 = One irrigation at the pre-flowering stage (35 to 40 days after sowing)

1_2 = Irrigation as in I_1 plus late irrigation at $\frac{IW}{CPE}$ of 0.2

I_3 = Irrigation as in I_1 plus late irrigation at $\frac{IW}{CPE}$ of 0.4

I_4 = Irrigation as in I_1 plus late irrigation at $\frac{IW}{CPE}$ of 0.6

I_5 = Irrigation as in I_1 plus late irrigation at $\frac{IW}{CPE}$ of 1.0

Where, IW is irrigation water to a fixed depth and CPE is cumulative pan evaporation from USWB class-A open pan minus rain since previous irrigation.

First irrigation was applied 38 days after sowing in all the treatments except the control (1_0) and late irrigations were applied in accordence with the irrigation treatments. It should be mentioned here that irrigation water was applied using flooding method. Soil moisture in the experimental plots were measured grametrically at sowing, before and after each irrigation and at hargest. Distribution of profile soil water content in the experimental plots was determined. The water use by the crops or evapotranspiration (E_t) was calculated by the following equation after Sammis *et al.*[9].

$$E_t = I + R - D + \Delta S_m$$

where, E_t is water use by the crop or evapotranspiration (cm), I is irrigation (cm), R is rainfall (cm), D is drainage (cm) and ΔSm is change in soil moisture (cm) in the experimental plots from beginning to the end of the growing season. Drainage was ignored in this experiments.

As area of 8m² (4m x 2m) was harvested from each of the 18 plots at the final maturity of the crops. The harvested crops were dried, in open sunlight and threashed by hand. The grain and straw were dried, cleaned and weighed. Data on crop characters viz. plant height, number of pods/plant, number of seeds/pod, pod length, 1,000 grain weight and grain and straw yield were collected. The data were then analysed for analysis of variance and the mean values were adjudged by Duncan's New Multiple Range Test.

The water use efficiency expressed in t/ha/cm was calculated as the ratio of yield to the total amount of water used by the plants during the entire crop growing period. Water expense was calculated adding the irrigation water with rainfall. The major climatic parameters of the experimental area viz. the rainfall and the pan evaporation data were collected from the nearby Weather Yard which is shown in Fig. 2.

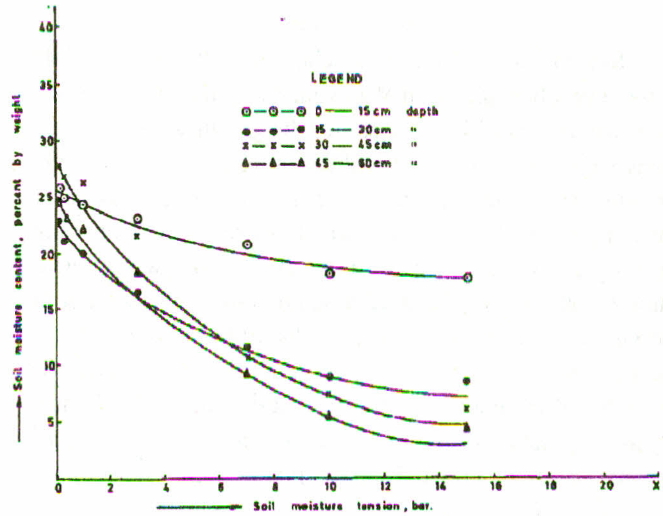

Fig. 1. Soil Moisture Characteristic Curves of the Experimental Field Soil at Different Depths.

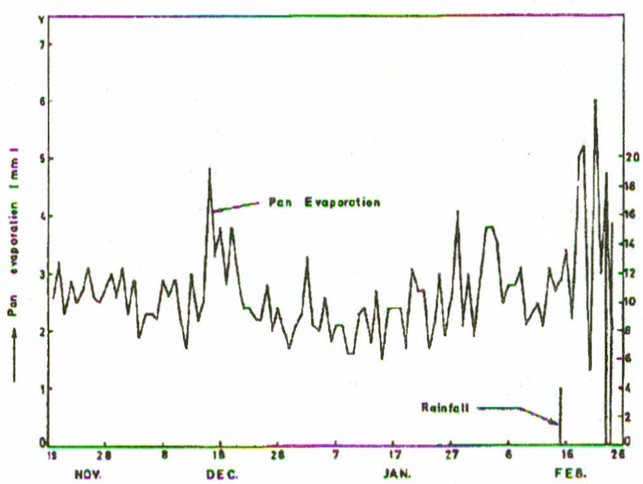

Fig. 2. Daily Evaporation and Rainfall During the crop Growing Season.

Results and Discussions

The effect of irrigation on the yield and yield components of mustard mutant BINA-2 is presented in Table 1. Irrigation showed significant effect on plant height and the highest plant height was observed in treatment I_3 followed by I_5 and the lowest in treatment I_2. Irrigation had no significant effect on the number of pods/plant, number of seeds/pod/plant, pod length, 1,000 grain weight and straw yield. From the tables (Table1 and 2) it was found that the irrigation treatments did not show any significant effect on the increase of the grain yield of the mustard mutant (BINA-2) over control and the highest grain yield was obtained in treatment I_1 with one irrigation of 3.30 cm applied at the pre-flowering stage (38 days after sowing). This may be due to the higher sowing time soil moisture and rainfall of about 4.0 cm during the experimental period. Similar results are available from Yadav [10] who did not find any significant effect of irrigation on the grain yield of mustard when the crop received 10.5cm rainfall during the growing season. The results also showed that with the increase of the irrigation frequency the grain yield gradually decreased, thus producing the lowest grain yield in treatment I_5 where 5 irrigations were applied with a total of 12.09cm irrigation water given at 38,56,67,75 and 82 days after sowing. This indicated that one irrigation was sufficient for obtaining the optimum grain yield and application of irrigation water more than one was simply wastage of water. The above finding is in conformity with that of Maini *et al.* [11] who reported that one irrigation after sowing showed significant increase in growth and seed yield of mustard and further irrigations seemed to be needless. Similar results were also reported by Hassan and Rahman [12], Sarkar and Hassan [13] who found significant effect of irrigation on the grain yield of mustard and suggested for one irrigation after 20-25 days of sowing.

Table 2 shows the yield, water expense, total number and time interval of irrigation from the date of sowing under different irrigation treatments. The crop received the maximum number of irrigation (5 irrigations) in treatment I_5 followed by treatment I_4 (3 irrigations), treatment I_3(2 irrigations) and treatments I_2 and I_1 (1 irrigation each). The results indicated that irrigation interval gradually decreased with the increase of the growing stage.

The water expense, water use and water use efficiency of mustard are presented in Table 3. The water expense was minimum in control (I_0) obviously because of no irrigation. The highest water expense was found in treatment I_5 because of good number of irrigation applied in this treatment. The water use increased with the increase in number of irrigations. The highest water use efficiency was, however, observed in the control (I_0) because of no irrigation. The water use efficiency decreased with the increase of irrigation number and it was lowest in treatment I_5.

The yield of mustard as a function of water expense has been depicted in Fig. 3. It may be noted that the grain yield in the treatment plot increased over control (I_0) for one irrigation intreatment (I_1) and then gradually decreased with increasing irrigation frequency showing that the slope of the straight line is negative in nature. It is evident from Fig. 3 that the grain

TABLE 1. EFFECT OF IRRIGATION ON THE YIELD AND YIELD COMPONENTS OF MUSTARD MUTANT (BINA-2).

Irrigation treatment	Plant height (cm)	No. of pods/ plant	No. of seeds/ pod/ plant	Pod length (cm)	1,000 grain weight (gm)	Grain yield (t/ha)	Straw yield (t/ha)
I_0	125.20b	72.57	13.80	5.13	3.50	1.34ab	4.04
I_1	123.17b	70.13	13.00	5.79	3.80	1.47a	4.67
I_2	114.60c	71.33	14.80	5.42	3.70	1.30b	3.64
I_3	133.82a	50.87	12.03	5.60	3.53	1.29b	4.41
I_4	119.50bc	70.37	13.20	5.11	3.46	1.25b	4.08
I_5	126.76ab	59.43	12.16	5.04	3.40	1.22b	4.36

Any two means followed by the same letter are not significantly different from each other at 5% level.

TABLE 2. YIELD, WATER EXPENSE, TOTAL NUMBER AND TIME INTERVAL OF IRRIGATION FROM THE DATE OF SOWING UNDER DIFFERENT IRRIGATION TREATMENTS.

Parameters	Irrigation treatments					
	I_0	I_1	I_2	I_3	I_4	I_5
Rainfall (cm)	3.90	3.90	3.90	3.90	3.90	3.90
Irrigation (cm)	0.00	3.30	3.30	5.40	8.06	12.09
Water expense (cm)	3.90	7.20	7.20	9.40	11.96	15.99
Total number of irrigation	0	1	1	2	3	5
Time interval of irrigation from the date of sowing (days)	0	38	38	38,75	38,65,81	38,56,67 75,82.
Grain yield (t/ha)	1.34	1.47	1.30	1.29	1.25	1.22
Seasonal open pan evaporation (cm)	26.29	26.29	26.29	26.29	26.29	26.29

TABLE 3. WATER EXPENSE, WATER USE AND WATER USE EFFICIENCY OF MUSTARD MUTANT (BINA-2).

Irrigation treatments	Water expense (cm)	Water use (cm)	Grain yield (t/ha)	Water use efficiency (t/ha/cm)
I_0	3.90	6.86	1.34	0.195
I_1	7.20	8.41	1.47	0.174
I_2	7.20	8.86	1.30	0.146
I_3	9.40	9.95	1.29	0.129
I_4	11.96	12.84	1.25	0.097
I_5	15.99	16.92	1.22	0.072

yield increased by the application of irrigation water upto a certain limit and then gradually decreased though the number and amount of irrigation water were increased. The results indicated that the crop obtained the required moisture in treatment I_1 for its maximum growth, as well as grain yield and more than one irrigation reduced the grain yield. This is in agreement with the findings of Hasan and Rahman [12] who concluded that if fertility is not a constraint, the grain yield of a disease free dryland crop is a direct function of its water use.

The seasonal water expense under various irrigation treatments with season a open pan evaporation is shown in Fig 4. The seasonal water expense under I_0, I_1, I_2, I_3, I_4 and I_5 treatments were 3.90, 7.20, 7.20, 9.40, 11.96 and 15.99 cm, respectively whereas, the seasonal open pan evaporation was 26.29 cm. All the treatments except control, used 3.30 cm of irrigation water within 40 days of sowing and the remaining water was used during the rest of the crop growing period. The rate of increase of open pan evaporation was almost similar in the whole crop growing period. During the first 40 days of sowing the open pan evaporation was about 10.90 cm and the remaining 15.39 cm evaporation occurred during the pest of the crop growing period.

Fig. 5 shows the distribution of profile soil water content in the experimental plots. Since equal flood irrigation was done and the experimental field was flat, plot to plot variation in soil water content for various depths was negligible. Hence, profile soil water distribution for all the treatments was shown in a single figure (Fig. 5) considering the four depths. It appears from the result that there was little variation in soil water content among various depths.

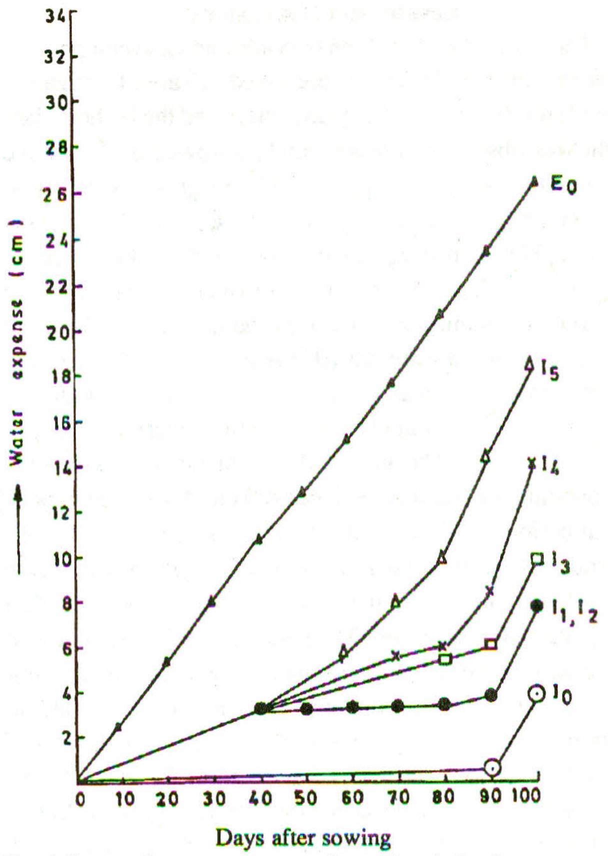

Fig. 4. Seasonal water expense under various irrigation treatments and Open Pan Evaporation.

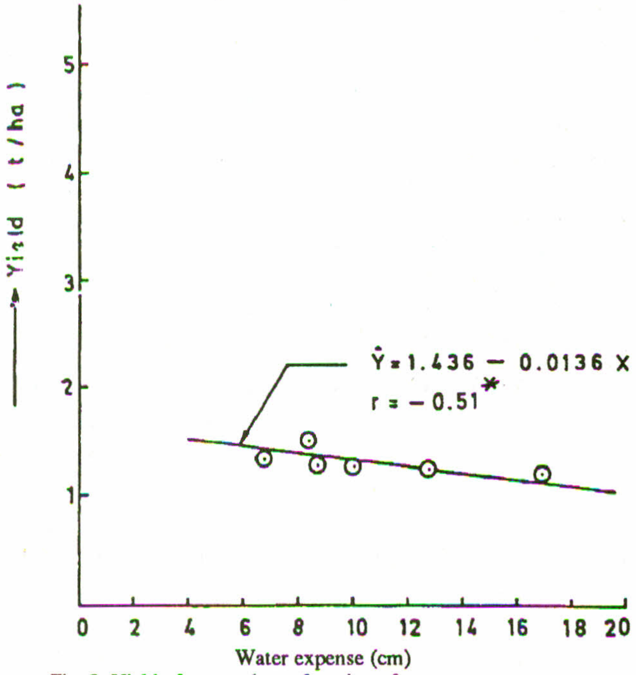

Fig. 3. Yield of mustard as a function of water expense.

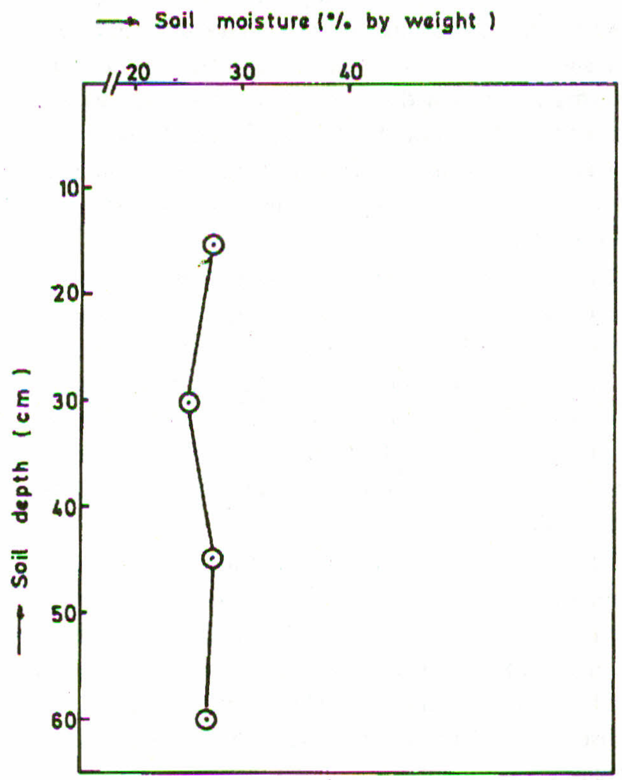

Fig. 5. Distribution of profile soil water content in the experimental Plot

From the above findings it can be revealed that the mustard mutant (BINA-2) has a good response to irrigation but over irrigation is harmfull. Therefore, in order to obtain a positively higher yield of the mutant one irrigation of about 4.0 cm at the pre-flowering stage is necessary depending on the rainfall and soil moisture condition during the growing season in this location.

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