IRRIGATION SCHEDULING THROUGH WATER PRODUCTION FUNCTION FOR RABI BRINJAL WITH SURFACE AND DRIP IRRIGATION METHODS

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ABSTRACT

Studies were conducted with brinjal during rabi with surface and drip irrigation methods at Gujarat Agricultural University farms in South Gujarat region in different years. All the studies were monitored under a single technical program for the sake of uniformity. Water Production Functions (WPF) were developed for all the studies by fitting the data into 12 different established functions and the best fit function based on the maximum value of coefficient of correlation 'r^2' and minimum standard error value 'SE' was adjudged as the required WPF for the crop. Studies with surface & drip methods depicted exponential association (2) and MMF functions respectively.

Based on the developed WPFs, the corresponding requirement of water was worked out for different yield targets for the normal irrigation water availability condition, and also for 10%, 20%, 30%, 40%, & 50% deficit water availability conditions owing to variability in rainfalls. Irrigation scheduling was done for different water availability conditions with both the irrigation methods. Water use efficiency was also worked for all the corresponding yield and water requirement values. This new approach will enable the irrigator to have flexibility of either using limited water in case of low water availability or getting more production with normal water availability.

Keywords: WPF, PEF, IW/CPE ratio

INTRODUCTION

For optimizing the water use for a given yield target, the relationship between the crop yield and water used must be known. The relationship between the yield and water used for raising the crop is termed as 'Production Function'. Production function depends on crop, crop environment and sensitiveness to depth of irrigation. For successful crop production, crop must be supplied with adequate quantity of water at required frequency. Hence, for preparing irrigation schedules for crops irrigated with

different methods, production functions need to be developed for individual crops. Studies were conducted at various research stations of Gujarat Agricultural University in different climatic seasons with the following objectives:

1. To develop water production functions for *rabi* brinjal with drip and surface irrigation methods for south Gujarat region
2. To predict optimum yield and corresponding water requirement for *rabi* brinjal at normal and various deficit water availability conditions, and
3. To schedule irrigation for *rabi* brinjal for different water availability conditions for maximizing water use efficiency.

METHODS AND MATERIALS

The studies were conducted at Gujarat Agricultural University farms in south Gujarat region. All the experiments were monitored under a single technical program in order to bring uniformity in the results. The study period for the individual experiments was three years. WPFs were developed for each experiment by fitting the data into 18 different well established mathematical functions. However, the best-fit function based on the maximum value of coefficient of correlation 'r^2' and minimum value of standard error 'SE' was adjudged as the required WPF for the crop (Table 2).

Yields and the corresponding water requirements have been predicted using the WPFs for different water availability conditions like normal rainfall, 10 %, 20%, 30%, 40%, and 50% deficit rainfall conditions. Scheduling of irrigation was also done accordingly. These exercises have been done for very high rainfall high humid and low rainfall dry temperate areas of South Gujarat region.

RESULTS AND DISCUSSION

Water Production Functions (WPFs)

Both the surface Studies in two different regions of South Gujarat depicted exponential association (2) function while drip showed MMF in dry temperate low rainfall region of South Gujarat (Table 2).

An exponential association (2) WPF indicates a fairly well managed water utilization and crop production relationship. The applied water is utilized fully in the beginning and yield increases linearly. However, after attaining a peak, the yield becomes steady irrespective of the increase in water application. This indicates a steady loss of water with time owing to probably the soil condition.

An MMF function depicts a fairly well balanced water and crop yield relationship.

Table 1: Models which were fitted in the water production function data

S. No.	Type of function	Equation
1	3 degree polynomial	$Y = a + b X + c X^2 + d X^3 + \ldots\ldots$
2	Exponential Association (2)	$Y = a (1 – e^{- bX)}$
3	Exponential Association (3)	$Y = a (b – e^{- cX)}$
4	Harris Model	$Y = 1 / (a + b X^{c)}$
5	Linear Model	$Y = a + b X$
6	MMF Model	$Y = (a b + c X^d) / (b + X^d)$
7	Power Fit	$Y = a X^b$
8	Quadratic Model	$Y = a + b X + c^2$
9	Rational Model	$Y = (a + b X) / (1 + c X + d X^2)$
10	Richards Model	$Y = a / (1 + e^{b – c X})^{1/d}$
11	Sinusoidal Model	$Y = a + b \cos (c X + d)$
12	User-defined Model	$Y = a + b X$

Where X is independent (water applied) and Y is dependent variable (crop yield);
a, b, c and d are constants for equation

Table 2: WPFs developed for various studies

Method	WPF	SE	r	Constants			
				a	b	c	d
Surface(H)	Expo.	0.8799	0.9859	14.5283	0.00473	-	-
Surface(L)	Expo.	2.3927	0.9762	36.8634	0.00212	-	-
Drip	MMF	0.0	1	3.9088	182.3103	220094.64	0.54536

H = Function in high rainfall zone, L = Function in low rainfall dry zone

Prediction of crop yield and corresponding water requirement

Predicted yields and corresponding water requirements under different water availability conditions owing to variation in rainfall for all the studies have been presented in Table 3 for two different areas of South Gujarat region.

The water requirement under normal water availability condition in dry temperate low rainfall area with surface was more (1000 mm) than the high rainfall humid area (600 mm). Though, the yield potential of the crop was also more in low rainfall area (32.44 t/ha compared to 13.67 t/ha in high rainfall area) indicating a higher WUE. The normal water requirement with drip in low rainfall dry temperate area was 750 mm, down 25% compared to surface in the same area but the yield improved about 14.41 %.

Irrigation scheduling and water use efficiency

After doing the above exercise, there was a need to develop proper irrigation schedules in order to achieve timely application of water as required by the crop at different growth stages. Therefore, irrigation scheduling was done for each yield and corresponding water requirement values (Table 3). In order to indicate the efficiency of water use at those water availability conditions, water use efficiency had also been worked out (Table 3). WUE was found higher by about 50% with drip compared to surface in the low rainfall dry temperate area. At 600 mm of water application, WUE improved by 25 %. Further WUE increased with decrease in water availability in both the areas. WUE was found lower in high rainfall humid zone than the low rainfall dry zone.

Table 3: Irrigation scheduling, yields, and water requirements in South Gujarat

(A) Surface irrigation system in dry temperate low rainfall zone						
	Normal rainfall	10% less rainfall	20% less rainfall	30% less rainfall	40% less rainfall	50% less rainfall
Water requirement (mm)	1000	900	800	700	600	500
Possible yields (t/ha)	32.44	31.39	30.10	28.50	26.53	24.09
Irrigation ratio	1.0	0.9	0.8	0.7	0.6	0.5
W.U.E. (t/ha-mm)	0.03244	0.034878	0.037625	0.040714	0.044217	0.04818
(B) Drip irrigation system in dry temperate low rainfall zone						
Water requirement (mm)	750	675	600	525	450	375
Possible yields (t/ha)	37.117	35.378	33.512	31.496	29.294	26.860
Irrigation ratio	0.75	0.68	0.60	0.52	0.45	0.38
W.U.E. (t/ha-mm)	0.04948	0.05241	0.0558533	0.05999	0.065097	0.071626
(C) Surface irrigation system very high rainfall high humid zone						
Water requirement (mm)	600	540	480	420	360	300
Possible yields (t/ha)	13.67	13.40	13.03	12.54	11.89	11.01
Irrigation ratio	0.70	0.63	0.56	0.50	0.42	0.35
W.U.E. (t/ha-mm)	0.02278	0.024815	0.027146	0.029857	0.03303	0.0367

Comparison of irrigation methods

In low rainfall dry temperate area, for an application of 600 mm of water, drip yielded 33.5 t/ha (+26.3%) compared to 26.53 t/ha with surface. This shows a clear superiority of drip over surface. Looking to the very low yield potential in high rainfall humid area, it is advisable not to grow brinjal crop in that area.

Approaches to irrigation scheduling under water deficit conditions

- Irrigation can be applied by reducing the depth in the same proportion by which the water availability has got affected e.g. for 50 mm scheduled depth of irrigation and for 10, 20, 30, 40 & 50 % reduction in water availability; 45, 40, 35, 30 & 25 mm depth of water can be applied during each irrigation without changing in the irrigation ratio.
- Irrigation can be applied with corresponding reduction in the irrigation ratio. For example for a 10 % reduction in water availability, the irrigation ratio can be changed from 0.8 to 0.72. The total water application in the crop season gets adjusted this way.
- One or two irrigations which are not very crucial for the crop during the entire crop season can be skipped, keeping the other irrigations as such.
- In case of more than 50% reduction in water availability, irrigations should be done at the critical crop growth stages only.
- Mulching saves about 15-20 % effective moisture. Therefore, mulching can be done to compensate the deficit water availability to the crops. In other words, 15-20 % less water availability can be treated as normal water availability condition and so on.

CONCLUSION

This study has led to the following conclusions:

1. Development of WPFs helps arriving at optimum crop production with optimized water use under normal and different degrees of deficit water availability conditions.
2. The total area to be sown can be planned according to the total water availability and the irrigation ratio should be chosen in such a way that water-use efficiency achieved is maximum possible.
3. Surface method requires more water in low rainfall area than high rainfall humid area. While the drip requires less water than surface in low rainfall area.
4. Drip is useful in low rainfall dry temperate area of South Gujarat
5. Cultivation of brinjal is not advisable in high rainfall area of South Gujarat.
6. Water use efficiency is higher under deficit irrigation conditions.

REFERENCES

1. Agresco reports of various research centres of Gujarat Agricultural University.