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Impact of Deficit Irrigation on Soybean Water Requirement and Yield in District Swat

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ABSTRACT

A field study was conducted on clay loam soil at the Agriculture research institute, Swat during Kharif 2012. Main objective of the study was to compare the physiological parameter and yield of soybean using two varieties (swat 84 and malakand 96) having four replicates and four irrigation level. The mean of days to emergence for I_{40}, I_{60}, I_{80}, I_{100} were 7, 6, 7 and 6 respectively. Days to emergence m^{-2} mean for I_{40}, I_{60}, I_{80}, I_{100} were 17, 15, 16 and 16 respectively. The mean of plant height for I_{40}, I_{60}, I_{80}, I_{100} were 69, 71, 71 and 74 respectively. Days to anthesis mean for I_{40}, I_{60}, I_{80}, I_{100} were 73, 76, 76 and 77 respectively. Days to maturity, mean for I_{40}, I_{60}, I_{80}, I_{100} were 95, 98, 96 and102 respectively. The plant height and days to maturity were found statistically significant ($P \leq 0.05$) for the selected soybean varieties Results showed that among both the varieties V_2 performed better on irrigation four (V_2I_{100}) therefore, it is recommended for irrigated areas of Khyber Pakhtunkhwa.

INTRODUCTION

Soybean (Glycine max) in Pakistan is adapted to both Rabi and kharif seasons. It requires warm humid climates, sensitive to frost. For germination, soil temperature must not be higher than 15°c, optimum growing temperature 20-25°C. Seed requires inoculation with bacteria before planting to fix atmospheric nitrogen.In barani areas, soybean is situated to zones with annual rainfall above 800 mm. With irrigation, soybean is situated to all areas but long days are required for vegetation growth and short days are critical for flowering. Variety selection needs to suit particular day lengths, planting dates and temperatures in Pakistan.

Water deficit adversely affects many physiological processes related to water use efficiency in soybean, thus leading to a decrease in plant productivity. Compared to other crops, soybean requires large quantities of water for a high yield (Heatherly, 1999)

Water stress imposed during pre-flowering and flowering stage reduced yield of soybean by 28% and 24% respectively. Similarly, various soybean cultivar show varying sensitivity to drought at their different development stages (Momen *et al*.1979)

Nevertheless, most soybeans are cultivated under rain-fed conditions that are prone to drought. Water stress is detrimental to soybean growth throughout its development (Karam *et al* ., 2005) and causes serious reduction in seed yield at the flowering and pod elongation stages because of flower and pod abortion

(Liu *et al* ., 2003).

Objectives

Specific objectives of the study were to:

To find the effect of different levels of deficit irrigation on physiological parameters of different varieties of soybean crop

MATERIALS AND METHODS

An experiment on 'Impact of deficit irrigation on Soybean water requirement and physiological parameter in district Swat' was conducted at Agricultural Research Station, Swat during summer 2012.

Field Preparation

The experimental field of size 20mx100m, each plot size was 6m x 4m used in the experiment. The level field was divided into 32 plots. The crop was sown at proper moisture/vatter condition after a pre-irrigation to the whole combined plot.

Experimental Design

The experiment was laid out in Randomized Complete Block Design having four replications. The detail of treatments is as follow.

Treatments

(1) **Factor A: Variety (V):** V_1(Swat 84), V_2(Malakand 96)

(2) **Factor B: Irrigation (I):** (I_1, I_2, I_3, I_4)

I_1 = 40% of full irrigation
I_2 = 60% of full irrigation
I_3 = 80% of full irrigation
I_4 = full irrigation

The experiment was repeated four times.

Total number of treatments per replication 4*2 = 8
Total number of treatments per experiment = 8*4=32

Soil Water Content Determination

Gravimetric sampling is a direct method of measuring the water content of soil samples, taken from a field. Samples were weighed, dried at 105 to 110 ˚C and reweighted after drying for 24 hrs in the oven. The following equation was used to compute the percent water content on mass basis.

$\theta_m = (W_w - W_d/W_d) \times 100$ ……..(1)

Where θ_m is moisture content on mass basis (%), W_w is wet mass of soil sample (gm) and W_d is dry mass of soil sample (gm)

Moisture on volume basis was determined from the following equation.

$\theta_V = (\rho_b/\rho_w)_x \theta_m$ ……..(2)

Where ρ_w and ρ_b are the densities of water $1 g_m cm^{-3}$ and soil is $1.45 g_m cm^{-3}$ respectively.

In the similar manner the actual water consumed by the crop in the field for the whole season for all irrigations were added. From which their respective rainfall were deducted. These were the given actual evapotranspiration (ETa) for the whole season.

Management Allowed Deficit (MAD)

Management Allowed Deficit for soybean crop of 65% was estimated the amount of water that can be used as full irrigation which was assumed that was not adversely affecting the plant growth. The MAD was determined using the formula:

MAD = RAW/AW ……..(3)

Where, MAD is management allowed deficit, RAW is readily available water, AW is available water, which can also be written as

$AW = D_{rz}(fc-pwp)/100$……..(4)

$RAW = D_{rz} (fc-\theta c)/100$ ……..(5)

Where, D_{rz} is depth of root zone which in present study is taken as 100 cm, fc is field capacity(28%), Pwp is permanent wilting point(16%) by volume.

Combining equation 4 and 5, then we get;

$$\theta c = \frac{FC-(MAD \times AW)}{Drz} \times 100 \quad \text{…….. (6)}$$

Where θc is the critical moisture(20.2% by volume)

The depth of irrigation to be applied to each plot was calculated from per-irrigation soil moisture relationship:

$$dw = \frac{Drz(FC - \theta i)}{100} \quad \text{…… (7)}$$

Where,

Dw is Depth of water to be applied as full irrigation(7.8cm), the other deficit irrigation were applied accordingly.

θi is Soil moisture content at the spot before irrigation in percent by volume.

Time required to obtain the desired depth of irrigation for each plot was calculated as suggested by Jensen (1998).The irrigation application time t (hours) was computed from given equation for the full irrigation at 65 % MAD.

$$t = \frac{A \times dw}{Q} \quad \text{……(8)}$$

Where:

t is time (sec) required to irrigate each sub plot for different levels, A is area of subplot (m^2), dw is depth of water applied (mm), and Q is discharge from the watercourse which has been taken as 10 liters per second to all sub plots at different levels of irrigation.

Physiological parameter:

i. Days to emergence

Days to emergence was recorded from the date of sowing till 80% plants emerged in each plot.

ii. Emergence m^{-2}

Data on emergence m^{-2} was recorded in one square meter from row length of one meter wide arround in each plot at 3 places and then their average was calculated.

iii. Plant height

Plant height (cm) data was recorded at maturity by measuring the height of ten representative plants from bottom to the tip of spike in each subplot randomly selected which was then averaged.

iv. Days to anthesis

Days to anthesis data was recorded from the date of sowing till when 80% pods emerged in each plot and then averaged.

v. Days to maturity

Days to maturity data was recorded from the date of sowing till when all the plants get physiological maturity in each plot.

Statistical Analysis

Statistical Analysis data was subjected to analysis of variance (ANOVA). According to the methods described by (Steel and Torrie,1980). and mean difference between treatments was compared by least significant difference 5% level of probability.

RESULTS AND DISCUSSION

A field study was conducted to compare physiological parameter of Malakand 96 and Swat 84 soybean varieties during the Kharif 2012, at Agriculture Research Institute Swat. The data was collected on crop yield and its components, crop water productivity (CWP) and harvest index (HI) and yield response factor of malakand 96 and swat 84 of soybean varieties. The results of the study are presented and discussed in the following sections.

Physiological Parameters

Days to Emergence

There was no much difference in both (swat 84 and malakand 96) varieties with regard to emergence. The number of days to emergence for V_1I_{40},V_1I_{60} ,V_1I_{80} and V_1I_{100} varieties were obtained 7,6,6 and 6 respectively, and for V_2I_{40},V_2I_{60} ,V_2I_{80} and V_2I_{100} were obtained 7,6,7 and 6 respectively. Mean days to emergence for swat84 and malakand 96 soybean varieties were 6 and 7 respectively (Table 1) . Furthermore, statistical analysis showed non significant difference in days to emergence data of studied varieties

Table 1 Days to emergence of the selected soybean varieties

Irrigation	I_{40}	I_{60}	I_{80}	I_{100}	Mean
Variety$_1$	7	6	6	6	6a
Variety$_2$	7	6	7	6	7a
Mean	7 ns	6 ns	7ns	6ns	

Days to emergence m^{-2}

The number of days to emergence m^{-2} for V_1I_{40},V_1I_{60} ,V_1I_{80} and V_1I_{100} varieties were obtained 17,15,17 and 15 respectively, and for V_2I_{40},V_2I_{60} ,V_2I_{80} and V_2I_{100} were obtained 17,16,16 and 17 respectively. Mean number of days to emergence m^{-2} ranged 16 and 17 respectively for swat 84 and malakand 96 and mean of I_{40}, I_{60}, I_{80} and I_{100} were ranged 17, 15, 16 and 16 respectively.(Table 2). Statistical analysis showed non significant difference in days to emergence per meter squere.

Table 2 Days to emergence m^{-2} of the selected soybean varieties

Irrigation	I_{40}	I_{60}	I_{80}	I_{100}	Mean
Variety$_1$	17	15	17	15	16a
Variety$_2$	17	16	16	17	17a
Mean	17ns	15ns	16	16	

Plant Height

The plant height mean of I_{40}, I_{60} , I_{80} and I_{100} irrigation were obtained 69,71,71 and 74 respectively for both varieties. Maximum plant height was 74 for both the varieties. V_1 showed best result on I_{100}, Mean of plant height of V_1 (swat84) was 71 and plant height of V_2 (malakand 96) was 70.6 (Table 3). Furthermore the statistical analysis showed significant difference in plant height of the varieties.

Table 3 Days to plant height of the selected soybean varieties

Irrigation	I_{40}	I_{60}	I_{80}	I_{100}	Mean
Variety$_1$	72	71	71	74	71.6a
Variety$_2$	67	71	71	74	70.6b
Mean	69c	71b	71b	74a	

LSD value for variety of 5% level probability: 0.6501

LSD value for irrigation of 5% level probability: 0.9279

Days to Anthesis

Days to anthesis mean of I_{40},I_{60} ,I_{80} and I_{100} irrigation were obtained 74,76,76 and 76 respectively for both

varieties. There were no much difference in both varieties. Mean of days to anthesis for variety V1 (swat 84) and variety V2 (malakand 96) were 75.31 and 76.68 respectively (Table 4). Statistical analysis showed non significant difference in the varieties.

Table 4 Days to anthesis of the selected soybean varieties

Irrigation	**I_{40}**	**I_{60}**	**I_{80}**	**I_{100}**	**Mean**
Variety$_1$	74	76	76	78	75.31a
Variety$_2$	77	76	77	76	76.68a
Mean	73ns	76ns	76ns	77ns	

4.1.5 Days to maturity

Days to maturity of variety V_1I_{40},V_1I_{60} ,V_1I_{80} and V_1I_{100} varieties were obtained 97,95,96 and 102 respectively, and for variety V_2I_{40},V_2I_{60} ,V_2I_{80} and V_2I_{100} were obtained 94,101,97 and 102 respectively. For maturity both varieties showed best result on I_{100}. Maximum days to maturity 102 of $V_1I_{100}$was obtained. Mean of variety V_1 and Variety V_2 were 97.3 and 98.4 respectively (Table 5). Statistical analysis showed significant difference in the varieties.

Table 5 Days to maturity of the selected soybean varieties

Irrigation	**I_{40}**	**I_{60}**	**I_{80}**	**I_{100}**	**Mean**
Variety$_1$	97	95	96	102	97.3a
Variety$_2$	94	101	97	102	98.4a
Mean	95c	98b	96bc	102a	

LSD value for variety of 5% level probability: 1.55
LSD value for irrigation of 5% level probability: 2.201

Conclusions

Some of the conclusions of the study are as follows:

Highest days emergence(17) was observed for I_4V_2 and Lowest (17) for I_2V_1.
Highest days anthesis (78) was observed for I_4V_1 and Lowest (74) for I_1V_1.
Highest plant height (74) was observed for I_4V2 and lowest (67) for I_1V2.
Highest days maturity(102) was observed for I_4V_2 and I_4V_1 and Lowest (94) for I_1V_2.

Recommendation/ Suggestions

Among both the varieties variety V_2 performed best with regard potential to plant hight, days to maturity and days to anthesis.

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