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 ≤ 0.05) for the selected soybean varieties Results showed that among both the varieties V_{2} performed better on irrigation four (V_{2}I_{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 oC, 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.
Moisture on volume basis was determined from the following equation.

\[ \theta_m = \frac{(W_w - W_d)}{W_d} \times 100 \]  

Where \( \theta_m \) 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).

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.

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Combining equation 4 and 5, then we get;

\[ \theta_v = \frac{(\rho_b \rho_m)}{\theta_m} \]  

Where \( \rho_m \) and \( \rho_b \) are the densities of water 1g\( \cdot \)cm\(^{-3} \) and soil is 1.45 g\( \cdot \)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:

\[ \text{MAD} = \frac{\text{RAW}}{\text{AW}} \]  

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

\[ \text{AW} = \frac{D_i fc-pwp}{100} \]  

\[ \text{RAW} = \frac{D_i fc-0c}{100} \]  

Where, \( D_i \) 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;

\[ \theta_c = \frac{\text{RAW} \times (\text{MAD} \times \text{RAW})}{\text{Dw}} \times 100 \]  

Where \( \theta_c \) 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:

\[ \text{Dw} = \frac{\text{Dw} \times (\text{fc} - \theta_i)}{100} \]  

Where,

\( \theta_i \) 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.

\[ t = \frac{A \times \text{Dw}}{Q} \]  

Where:

\( t \) is time (sec) required to irrigate each sub plot for different levels, \( A \) is area of subplot (m\(^2\)), \( \text{Dw} \) 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**

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>$I_{40}$</th>
<th>$I_{60}$</th>
<th>$I_{80}$</th>
<th>$I_{100}$</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety 1</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6a</td>
</tr>
<tr>
<td>Variety 2</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>7a</td>
</tr>
<tr>
<td>Mean</td>
<td>7 ns</td>
<td>6 ns</td>
<td>7ns</td>
<td>6ns</td>
<td></td>
</tr>
</tbody>
</table>

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 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 2 Days to emergence $m^2$ of the selected soybean varieties**

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>$I_{40}$</th>
<th>$I_{60}$</th>
<th>$I_{80}$</th>
<th>$I_{100}$</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety 1</td>
<td>17</td>
<td>15</td>
<td>17</td>
<td>15</td>
<td>16a</td>
</tr>
<tr>
<td>Variety 2</td>
<td>17</td>
<td>16</td>
<td>16</td>
<td>17</td>
<td>17a</td>
</tr>
<tr>
<td>Mean</td>
<td>17ns</td>
<td>15ns</td>
<td>16</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

**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**

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>$I_{40}$</th>
<th>$I_{60}$</th>
<th>$I_{80}$</th>
<th>$I_{100}$</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety 1</td>
<td>72</td>
<td>71</td>
<td>71</td>
<td>74</td>
<td>71.6a</td>
</tr>
<tr>
<td>Variety 2</td>
<td>67</td>
<td>71</td>
<td>71</td>
<td>74</td>
<td>70.6b</td>
</tr>
<tr>
<td>Mean</td>
<td>69c</td>
<td>71b</td>
<td>71b</td>
<td>74</td>
<td>74a</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>I$_{40}$</th>
<th>I$_{60}$</th>
<th>I$_{80}$</th>
<th>I$_{100}$</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety$_1$</td>
<td>74</td>
<td>76</td>
<td>76</td>
<td>78</td>
<td>75.31a</td>
</tr>
<tr>
<td>Variety$_2$</td>
<td>77</td>
<td>76</td>
<td>77</td>
<td>76</td>
<td>76.68a</td>
</tr>
<tr>
<td>Mean</td>
<td>73ns</td>
<td>76ns</td>
<td>76ns</td>
<td>77ns</td>
<td>75.51a</td>
</tr>
</tbody>
</table>

4.1.5 Days to maturity

Days to maturity of variety V$_1$I$_{40}$, V$_1$I$_{60}$, V$_1$I$_{80}$ and V$_1$I$_{100}$ varieties were obtained 97, 95, 96 and 102 respectively, and for variety V$_2$I$_{40}$, V$_2$I$_{60}$, V$_2$I$_{80}$ and V$_2$I$_{100}$ 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$_1$I$_{100}$ 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

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>I$_{40}$</th>
<th>I$_{60}$</th>
<th>I$_{80}$</th>
<th>I$_{100}$</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety$_1$</td>
<td>97</td>
<td>95</td>
<td>96</td>
<td>102</td>
<td>97.3a</td>
</tr>
<tr>
<td>Variety$_2$</td>
<td>94</td>
<td>101</td>
<td>97</td>
<td>102</td>
<td>98.4a</td>
</tr>
<tr>
<td>Mean</td>
<td>95c</td>
<td>98b</td>
<td>96bc</td>
<td>102a</td>
<td></td>
</tr>
</tbody>
</table>

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$_1$V$_2$ and Lowest (17) for I$_1$V$_1$.
- Highest days anthesis (78) was observed for I$_2$V$_1$ and Lowest (74) for I$_1$V$_1$.
- Highest plant height (74) was observed for I$_1$V$_2$ and lowest (67) for I$_1$V$_2$.
- Highest days maturity (102) was observed for I$_1$V$_2$ and I$_1$V$_1$ and Lowest (94) for I$_1$V$_2$.

Recommendation/ Suggestions

Among both the varieties variety V$_2$ performed best with regard potential to plant height, days to maturity and days to anthesis.

REFERENCES