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The Response of Different Soybean Varieties Yield and Yield Components to Different Reduced Irrigation Levels in District Swat of Pakistan

Gul Daraz, Muhammad Hameed, Fayaz Ahmad and waheedullah
Department of Water Management, Faculty of Crop Production Sciences, The University of Agriculture, Peshawar-Pakistan
Corresponding E-mail: muhammadhameed46@yahoo.com
Contact no +92-3018056991

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 yield, yield components and harvest index of soybean using two varieties (swat 84 and malakand 96) having four replicates and four irrigation level. Mean of productive pods for I_{40}, I_{60}, I_{80}, I_{100} were 1078, 1039, 1237 and 1257 respectively. The grain yield mean was obtained for V_1 and V_2 was 2969 and 3302 respectively and mean of grain yield for I_{40}, I_{60}, I_{80}, I_{100} were 2724, 2963, 3317 and 3536. Mean of biological yield for I40, I60, I80 and I100 were 6042,6131, 6392, 6558 respectively.Mean harvest index 44% was recorded for V_1 and 45% for V_2. 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, Pakistan

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^{o}c, optimum growing temperature 20-25^{o}C..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.

Soybeans are legumes, native to East Asia, that are grown for oil and protein around the world. Cultivated primarily in warm and hot climates, soybeans were originally used as nitrogen fixers in early systems of crop rotation. The ancient farmers would plant a field of soybeans on an exhausted or depleted field and then plow the crop under to replenish the soil. Development of used technologies such as fermentation and processing for oil has led to many new applications of this useful plant.

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).

As the soybean plant ages from stage R1 (beginning bloom) through stage R5 (seed enlargement), its ability to compensate for stressful conditions decreases and the potentialdegree of yield reduction from stress increases (Foroud *et al*.1993)

Moisture stress in soybean reduced the number of nodes per plant, number of pod per plant, plant weight, number of seed per pod and seed weight. Additional irrigation application increased seed yield 1000-seed weight and seed weight per plant (Kolarik, 1990).

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)

The adverse effects of drought stress on growth, yield and endogenous phytohormones of soybean. Polyethylene glycol (PEG) solutions of elevated strength (8% & 16%) were used for drought stress induction. Drought stress period span for two weeks each at pre and post flowering growth stage. It was observed that soybean growth and yield attributes significantly reduced under drought stress at both pre and post flowering period, while maximum reduction was caused by PEG (16%) applied at pre flowering time. The endogenous bioactive GA and GA content decreased under elevated drought stress.. On the basis of current study, concluded that application of earlier drought stress severely reduced growth and yield attributes of soybean when compared to its later application (Hamayun *et al*.2010).

Objectives

Specific objectives of the study were to:

1) To assess the response of productive pods, non productive pods and yield of soybean in stressed conditions.
2) To investigate the harvest index of soybean crop in district swat pakistan

MATERIALS AND METHODS

An experiment on 'the response of different soybean varieties yield and yield component to different reduced irrigation levels in district swat of pakistan' 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.

$$\theta_m = (W_w - W_d/W_d) \times 100 \quad \text{.....(1)}$$

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.

$$\theta_V = (\rho_b/\rho_w) \times \theta_m \quad \text{.....(2)}$$

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:

$$MAD = RAW/AW \quad \text{.....(3)}$$

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

$$AW = D_{rz}(fc-pwp)/100 \quad \text{.....(4)}$$

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

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;

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

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.

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

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.

Yield and yield components

The yields and yield components includes the productive and non productive yield m^{-2}, biological yield (kg/ha), grain yield (kg/ha) and harvest index(%)

i. Productive Pods

The data on number of productive Pods m^{-2} was recorded in an area of one meter row length (one meter wide) along with its spacing on both sides in each plot at 3 places to be converted to averaged value for the plot specified.

ii. Non productive Pods

The data on number of non productive pods m^{-2} was recorded in an area of one meter row length in each plot at 3 places to be converted to averaged value for the plot specified.

iii. Biological yield

Biological yield was calculated after harvesting rows in each plot, dried and weighed and then was converted into kg ha^{-1}.

iv. Grain yield

Grain yield were collected for the whole sub plots plot after threshing and thoroughly cleaning these grain yield were then converted into kg ha^{-1} for each treatment.

v. Number of grain pod^{-1}

To determine the grain pod $^{-1}$ ten earmarked pods were randomly selected from each plot. These were then threshed and the grain were counted and then averaged**.**

vi. Harvest index (%)

Harvest index was estimated from the following relationship:

$$H.I\ \% = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100 \qquad \text{…………………………..(1)}$$

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 yield and yield component of Malakand 96 and Swat 84 soybean varieties during the Kharif 2012, at Agriculture Research Institute Swat. The data was collected on physiological parameter,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.

Yield and yield components

Productive pods

The productive pods mean of I_{40},I_{60} ,I_{80} and I_{100} irrigation were obtained 1078,1039,1237 and 1257 respectively. I_{80} and I_{100} showed best result for both varieties. Maximum productive pods was 1337 which was obtained from malakand 96 variety (V_2I_4). Mean of swat 84 variety was 1069.5 and malakand 96 was 1236.2 (Table 1). Statistical analysis showed significant difference in varieties .

Table 1 Productive pods of selected soybean varieties

Irrigation	**I_{40}**	**I_{60}**	**I_{80}**	**I_{100}**	**Mean**
$Variety_1$	861	1296	1153	1177	1069.5a
$Variety_2$	1087	991	1322	1337	1236.2b
Mean	1078b	1039b	1237a	1257a	

LSD value for variety of 5% level probability: 44.39

LSD value for irrigation of 5% level probability: 62.788

Non Productive Pods

The non productive pods of variety V_1I_{40},V_1I_{60} ,V_1I_{80} and V_1I_{100} varieties were obtained 12,14,13 and 18 respectively, and for variety V_2I_{40},V_2I_{60} ,V_2I_{80} and V_2I_{100} were obtained 16,15,20 and 18 respectively, and the mean of I_{40}, I_{60}, I_{80}, I_{100} were 14,14, 16, 18 respectively. Mean of non productive pods were 14 and 17 for swat 84 and malakand 96 respectively (Table 2). These results are in agreement with those obtained by Purmousavi et al., (2009) who found that deficit irrigation caused a significant decrease in yield and yield components of soybean. Furthermore statistical analysis showed significant difference in varieties.

Table 2 Non productive pods of the selected soybean varieties

Irrigation	I_{40}	I_{60}	I_{80}	I_{100}	Mean
Variety $_1$	12	14	13	18	14b
Variety$_2$	16	15	20	18	17a
Mean	14a	14a	16a	18a	

Number of Grain per Pod

There were no much difference in grain per pod of the varieties. Number of grain per pod mean of I_{40}, I_{60}, I_{80} and I_{100} were 2, 3, 3 and 3respectiviely. Mean of number of grain per pod for swat 84 was 2.53 and malakand 96 was 2.65 (Table 3). statistical analysis showed significant difference in varieties.

Table 3 Number of grain per pod of the selected soybean varieties

Irrigation	I_{40}	I_{60}	I_{80}	I_{100}	Mean
Variety$_1$	2	3	3	3	2.53b
Variety$_2$	2	3	3	3	2.65a
Mean	2c	3b	3a	3a	

LSD value for variety of 5% level probability: 0.048
LSD value for irrigation of 5% level probability: 0.068

Grain Yield Kg/ Hectare

Grain yield of variety V_1I_{40},V_1I_{60},V_1I_{80} and V_1I_{100} were obtained 2719,2854,3052 and 3250 respectively, and for malakand 96 variety V_2I_{40},V_2I_{60} ,V_2I_{80} and V_2I_{100} were obtained 2729,3073,3583 and 3823 respectively. Mean of grain yield kg/ha of swat84 was 2969 and grain yield kg/ha for malakand 96 was 3302 (Table 4). Mean of I_{40}, I_{60}, I_{80} and I_{100} for both varieties were 2724, 2963, 3317 and 3536 respectively and I_{100} showed best results. Malakand 96 showed best result in grain yield kg/ha of soybean varieties. These result are the contrast with (Abayomi, 2008) that growth and yield components of soybean were significantly affected by various irrigation frequencies. These results are in agreement with those obtained by Purmousavi et al., (2009), Ruhul Amin et al., (2009) and Ibrahim and Kandil. (2007), who found that deficit irrigation caused a significant decrease in yield and yield components of soybean. Statistical analysis showed significant difference in varieties.

Table 4 Grain yield kg/ha of the selected soybean varieties

Irrigation	I_{40}	I_{60}	I_{80}	I_{100}	Mean
Variety$_1$	2719	2854	3052	3250	2968b
Variety$_2$	2729	3073	3583	3823	3302a
Mean	2724d	2963c	3317b	3536a	

LSD value for variety of 5% level probability: 50.251
LSD value for irrigation of 5% level probability: 71.061

Biological Yield

The biological yield of swat 84 variety V_1I_{40},V_1I_{60} ,V_1I_{80} and V_1I_{100} varieties were obtained 5743,5908,5972 and 6221 respectively, and malakand 96 variety V_2I_{40},V_2I_{60} ,V_2I_{80} and V_2I_{100} were obtained 6341,6354,6813 and 6896 respectively. Mean of the biological yield of soybean variety swat84 was 5960 and malakand 96 was 6600 (Table 5). I_{80} and I_{100} showed best result for both varieties and variety V_2 was best. Statistical analysis showed significant difference in the varieties.

Table 5 Biological yield of the selected soybean varieties

Irrigation	I_{40}	I_{60}	I_{80}	I_{100}	Mean
Variety$_1$	5743	5908	5972	6221	5960b
Variety$_2$	6341	6354	6813	6896	6600a
Mean	6042b	6131ab	6392a	6558a	

LSD value for variety of 5% level probability: 182.22
LSD value for irrigation of 5% level probability: 257.69

Harvest Index

There were no much difference in harvest index of both the varieties of soybean. The harvest index mean of I_{40}, I_{60} ,I_{80} and I_{100} irrigation were obtained 43,44,44 and 47 respectively for both varieties. Mean of harvest index were 44 and 45 for swat 84 and malakand 96 of soybean varieties respectively (Table 6). These results are in accordance with the findings of Ahmad (1984) and Pandey *et al.*, (1984). Statistical analysis showed significant difference in varieties.

Table 6 Harvest index of the selected soybean varieties

Irrigation	**I_{40}**	**I_{60}**	**I_{80}**	**I_{100}**	**Mean**
$Variety_1$	**43**	**43**	**45**	**47**	**44a**
$Variety_2$	**43**	**46**	**44**	**47**	**45b**
Mean	**43c**	**44c**	**44b**	**47a**	

LSD value for variety of 5% level probability: 1.51
LSD value for irrigation of 5% level probability: 2.13

Conclusions

Some of the conclusions of the study are as follows:

lower grain yield kg/ha (2719) was observed for I_1V_1 and Higher grain yield kg/ha (3823) for I_4V_2.
Highest productive pods (1337) was observed for I_4V_2 and Lowest (861) for I_1V_1.
Highest biological yield (6896) was observed for I_4V_2 and lowest (5743) for I_1V_1.
Highest harvest index (47) was observed for I_4V_2 and I_4V_1 and Lowest (43) for I_1V_1.

Recommendation/ Suggestions

Among both the varieties variety V_2 performed best on I_4 (I_{100}) with regard grain yield kg/ha, biological yields, productive pods,and harvest index

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