Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.4, No.8, 2014

Determination of Crop Water Productivity of Different Soybean Varieties in District Swat of Pakistan

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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 determine the yield response factor on maximum, optimal and minimum irrigation levels of soybean varieties, using two varieties (swat 84 and malakand 96) having four replicates and four irrigation levels. Crop water prodcuctivity were were determined from crop yield divided Seasonal water applied. CWP was recorded minimum 0.58 kg m^{-3} for (swat 84) varieties V_1 and maximum 0.82 kg $m^{-3}$for V_2 (malakand 96) varieties (Table 1). Mean of I_{40}, I_{60}, I_{80}, I_{100} were 0.58,0.62, 0.71 and 0.75 respectively. Lower CWP values of V_1 and highest value for V_2 were determined.Hence it is concluded that among both the varieties V_2 performed better on irrigation two (V_2I_4), therefore this strategy is recommended for irrigated areas of Khyber Pakhtunkhwa, Pakistan
Keywords: Deficit irrigation, Irrigation levels, water productivity, soybean.

Objectives

- To find water productivity of soybean.
- To study the effect of different irrigation levels on crop water productivity of soybean varieties.

INTRODUCTION

Soybean posses a very high nutritional value. It contains about 20 per cent oil and 40 per cent high quality protein (as against 7.0 per cent in rice, 12 per cent in wheat, 10 per cent in maize and 20-25 per cent in other pulses). Soybean protein is rich in valuable amino acid lycine (5%) in which most of the cereals are deficient. In addition, it contains a good amount of minerals, salts and vitamins (thiamine and riboflavin) and its sprouting grains contain a considerable amount of Vitamin C, Vitamin A is present in the form of precursor carotene, which is converted into vitamin A in the intestine. A large number of Indian and western dishes such as bread, `chapati', milk, sweets, pastries etc., can be prepared with soybean. Wheat flour fortified with soybean flour makes good quality and more nutritious `chapati'. Soybean oil is used for manufacturing *vanaspati* ghee and several other industrial products. Soybean is used for making high protein food for children. It is widely used in the industrial production of different antibiotics. Soybean builds up the soil fertility by fixing large amounts of atmospheric nitrogen through the root nodules, and also through leaf fall on the ground at maturity. It can be used as fodder; forage can be made into hay, silage etc. Its forage and cake are excellent nutritive foods for livestock and poultry. Soybean being the richest, cheapest and easiest source of best quality proteins and fats and having a vast multiplicity of uses as food and industrial products is sometimes called a wonder crop.

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)

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)

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)

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.

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Experimental Design

The experiment was laid out in Randomized Complete Block Design having four replications. The treatments were V_1(Swat 84) and V_2 (Malakand 96). The Irrigations I_1, I_2, I_3 and I_4 were of 40%, 60%, 80% and 100% of full irrigation. The total number of treatments per replication were 8 which for the total number of treatments per experiment 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.

$$\theta_m = (W_w - W_d/W_d) \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

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.

$$\theta_V = (\rho_{b}/\rho_w) \times \theta_m \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

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:

$$MAD = RAW/AW \quad \ldots\ldots\ldots\ldots(3)$$

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

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

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

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;

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

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:

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

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.

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

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.

Crop Water Productivity

Seasonal water applied was determined by calculating the discharge of water applied to the field and then multiple it with the total number of irrigation applied to that crop during the whole season. Crop water productivity (CWP) in terms of Seasonal Water Applied (SWA) (irrigation and rainfall) to the fields as reported.

$$CWP_{(Water\ \mathrm{Applied})} = \frac{Crop\ \mathrm{Yield}}{\mathrm{SWA}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

Where Crop Water Productivity will be measured in Kg m^{-3}

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) crop water productivity and yield response factor and actual evapotranspiration (ETa) of malakand 96 and swat 84 of soybean varieties. The results of the study are presented and discussed in the following sections.

Water Productivity

Statistical results revealed that there was significant difference in crop water productivity (CWP) of both the varieties. There was not much difference in mean values of CWP of swat 84 and malakand 96 soybean varieties. CWP was recorded minimum 0.58 kg m^{-3} for (swat 84) varieties V_1 and maximum 0.82 kg $m^{-3}$for V_2 (malakand 96) varieties (Table 1). Mean of I_{40}, I_{60}, I_{80}, I_{100} were 0.58,0.62, 0.71 and 0.75 respectively. Lower CWP values of V_1 could be due to rainfall during growing period, as CWP is the function of grain yield and water applied including rainfall throughout growing season.

Table 1 Crop water productivity (kg m^{-3}) of selected soybean varieties

Irrigation	**I_{40}**	**I_{60}**	**I_{80}**	**I_{100}**	**Mean**
$Variety_1$	0.58	0.60	0.65	0.69	0.63b
$Variety_2$	0.58	0.65	0.77	0.82	0.70a
Mean	0.58s	0.62s	0.71s	0.75s	

Conclusions

Some of the conclusions of the study are as follows:

1) The maximum (I_{100}) and minimum (I_{40}) water productivity in irrigations for swat 84 variety were,0.69 and 0.58 respectivily.
2) The maximum (I_{100}) and minimum (I_{40}) crop water productivity in irrigations for malakand 96 variety were 0.82 and 0.58 respectivily.
3) The Malakand 96 shows best result in crop water productivity in irrigation (I_{100})

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