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To Establish the Yield Response Factor (Ky) of Different Soybean Varieties in Northern Area 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. Relative yield response (Ky) were determined from relative yield decrease (1-Ya/Ym) and relative evapotranspiration deficit (1-ETa /ETm). Ky values on $I_1(I_{40})$ of variety V_1 (Swat 84) were recorded from 0.38 to 1.48 and Ky values on $I_1$of V_2(Malakand 96) were recorded from 0.82 to 2.78. Ky values on $I_2(I_{60})$of variety V_1 were recorded from 0.37 to 1.77, and Ky value on I_2 of V_2 were recorded from 0.79 to 3.23. Ky values on $I_3(I_{80})$ of variety V_1 were recorded from 0.30 to 1.52, and Ky values on I_3 of V_2 were recorded from 0.47 to 3.14. Ky values of variety V_1 ranged from 0.30 to 1.77, for V_2 it ranged from 0.47 to 3.23.Hence it is concluded that among both the varieties V_2 performed better on irrigation two (V_2I_2), thereforethis strategy is recommended for irrigated areas of Khyber Pakhtunkhwa, Pakistan

INTRODUCTION

The first domestication of soybean has been traced to the eastern half of North China in the eleventh century B.C. or perhaps a bit earlier. Soybean has been one of the five main plant foods of China along with rice, soybeans, wheat, barley and millet. According to early authors, soybean production was localized in China until after the Chinese-Japanese war of 1894-95, when the Japanese began to import soybean oil cake for use as fertilizer. Shipments of soybeans were made to Europe about 1908, and the soybean attracted world-wide attention. Europeans had been aware of soybeans as early as 1712 through the writing of a German botanist. Some soybean seed may have been sent from China by missionaries as early as 1740 and planted in France.

The first use of the word "soybean" in U.S. literature was in 1804. However, it is thought that soybean was first introduced into the American Colonies in 1765 as "Chinese vetches" . Early authors mentioned that soybeans appeared to be well adapted to Pennsylvania soil. An 1879 report from the Rutgers Agricultural College in New Jersey is the first reference that soybeans had been tested in a scientific agricultural school in the United States. For many years, most of the references to this crop were by people working in eastern and southeastern United States where it was first popular. Most of the early U.S. soybeans were used as a forage crop rather than harvested for seed. Most of the early introductions planted in these areas were obtained from China, Japan, India, Manchuria, Korea, and Taiwan.

A record 2.9 million bushel soybean crop was produced in 2001 on 74.1 million acres with an average per acre yield of 39.6 bushels. The leading soybean states are Iowa and Illinois. In 2003, Iowa had 10.6 million acres of soybeans while Illinois had 10.3 million. The highest state yield ever achieved was 50.5 bushels per acre produced by Iowa farmers in 1994.

To investigate the effects of the water deficit on yield and yield components of soybean in semi-arid conditionson clay soil, the irrigation treatments of 33% (I_{33}), 67% (I_{67}), 100% (I_{100}) and 133% (I_{133}) were taken. The ratios were found from the total irrigation water applied (I_W)/cumulative pan evaporation (CPE) with four days irrigation interval. The average amount of irrigation water applied to treatments ($I_{133,}I_{100}$, I_{67} and I_{33}) was 1058, 795, 533 and 263 mm and 1094, 823, 551 and 272 mm for Toyokomachi and Toyohomare cultivars, respectively. The maximum green pod yields were 20.6 and 29.1 t ha^{-1} with 997 and 922 mm water consumption for Toyohomare and Toyokomachi, respectively in I_{133} treatments. Yield response factor (k_y) values of I_{100}, I_{67} and I_{33} treatments were determined as 2.17, 0.92 and 0.59 for Toyohomare and 3.50, 0.61 and 0.61 for Toyokomachi, respectively. (Comlekcioglu*et al.*2011).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)

Objectives

Specific objectives of the study were to:

1) assessthe response factor to maximum reduction in irrigation
2) assessthe response factor to optimal reduction in irrigation
3) assessthe response factor to minimum reduction in irrigation

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 treatments were V_1(Swat 84) and V_2(Malakand 96). TheIrrigationsI_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.

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

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

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

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

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:

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

WhereDw 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.

$$t = \frac{A \times dw}{Q}$$ ……………………………………………………(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.

Consumptive use of water (ETa)

The consumptive use of water or actual evapotranspiration fo soybean was worked out by soil moisture depletion method. ETa were determined by adding water loss between successive soil sampling, rainfall, irrigation and actual evapotranspration estimated by detection from soil through oven. In case of heavy rainfall, deep percolation (Dp) was estimated by subtracting maximum water holding capacity of the soil just before rainfall from effective rainfall. Dividing the total water used between two samplings by the number of days, the consumptive use per day (ETa) was calculated as:

$$ETa = \frac{Drz\frac{(\emptyset i - \emptyset f)}{100} + Re + I + Dp}{\Delta t}$$ ………………….(9)

Where, ETa is actual evapotranspiration between two successive sampling periods(mmper day), Drz is depth of rootzone in (cm), θi is soil moisture content in (% by volume) at the time of first sampling, θf is soil moisture content in (% by volume) at the time of second sampling, Re is effective rainfall between the sampling periods in (cm),I is depth of irrigation in (cm), Dp is deep percolation in (cm) and Δt is time period in days

Yield response Factor (Ky)

The relation between crop yield reduction as caused by water deficit is expressed by the following basic equation

1-Ya/ Ym = ky*(1-ETa/ ETm) …………………………..(10)

1-Ya/ Ym is the relative yield decrease

1-ETa/ ETm is relative evapotranspiration deficit

Ym is the maximum yield, Ya is actual yield, ETm is maximum evapotranspiration, ETa is actual evapotranspiration and Ky is yield response factor.

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 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.

Yield response factor (Ky)

Yield response factor (Ky) of variety V_1 (swat 84) and V_2 (malakand 96) for I_1 (I_{40})

Ky values of $I_1$for variety V_1 were recorded from 0.38 to 1.48 (Figure 1), and Ky value of $I_1$for V_2 were recorded from 0.82 to 2.78.The highest value was recorded in the last week of august for V_2 and V_1 varieties (Figure 1).

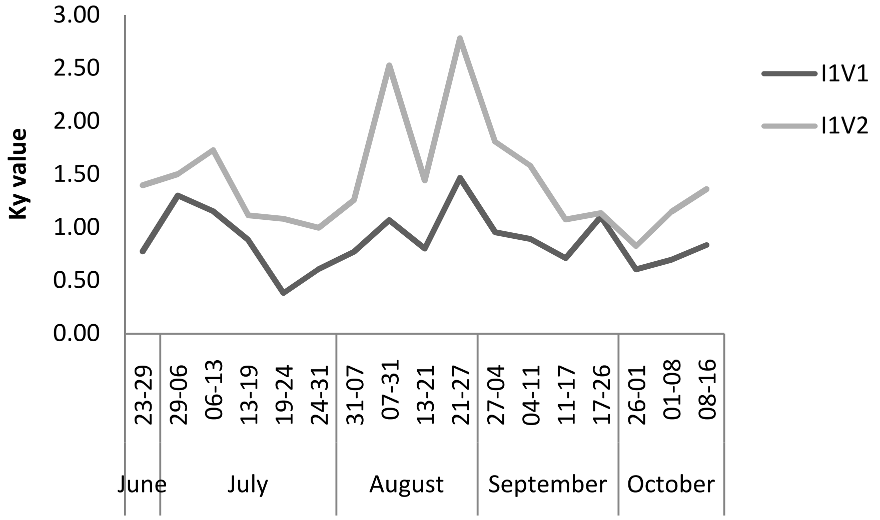

Figure 1 Ky values of soybean varieties for I_1during growing period

Yield response factor (Ky) of variety V_1 (swat 84) and V_2 (malakand 96) for I_2 (I_{60})

Ky values on $I_2$of variety V_1 were recorded from 0.37 to 1.77 (Figure 2), and Ky value on I_2 of V_2 were recorded from 0.79 to 3.23.The highest value was recorded in the last week of august for V_2 and highest value for V_1 was recorded in September (Figure 2).

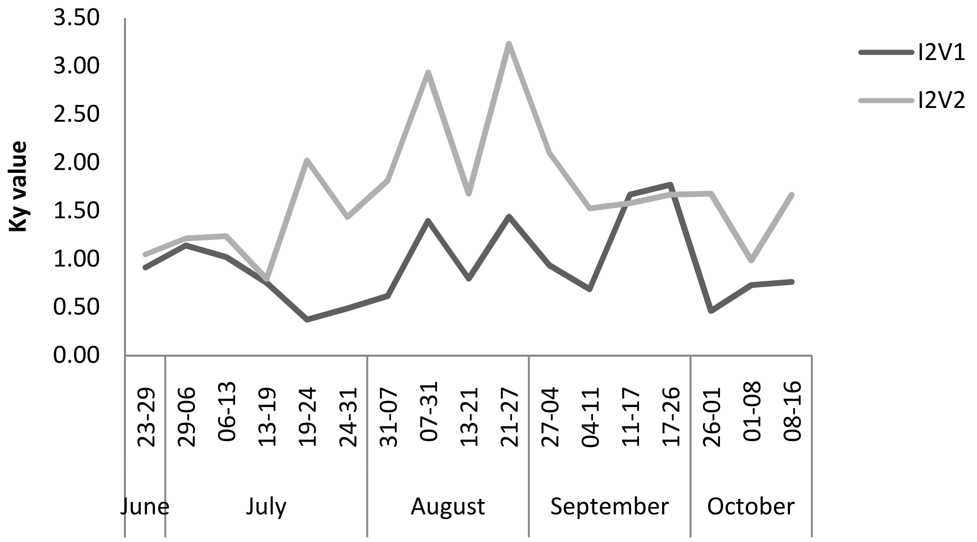

Figure 2 Ky values of soybean varieties on I_2 during growing period

Yield response factor (Ky) of variety V_1 (swat 84) and V_2 (malakand 96) for I_3 (I_{80})

Ky values on I_3 of variety V_1 were recorded from 0.30 to 1.52 (Figure 3), and Ky value for $I_3$of V_2 were recorded from 0.47 to 3.14.The highest value was recorded in the month of july for V_2 and highest value for V_1 was recorded in august (Figure 3).

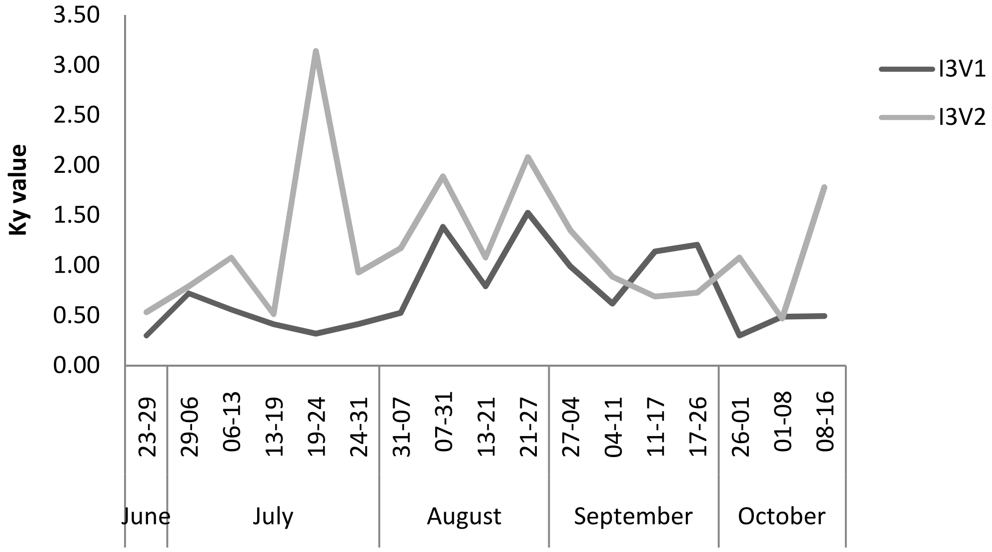

Figure 3 Ky values of soybean varieties for I_3 during growing period

Yield response factor (Ky) of variety V_1 (swat 84)

Ky values of variety V_1 was recorded from 0.30, to 1.77, (Figure 4.3). Maximum value was recorded 1.77 in the last week of september whereas, minimum value of 0.30 was found in the last week of June at crop initial stages (Figure 4.3). The fluctuation in Ky value could be due to abrupt change in weather conditions.

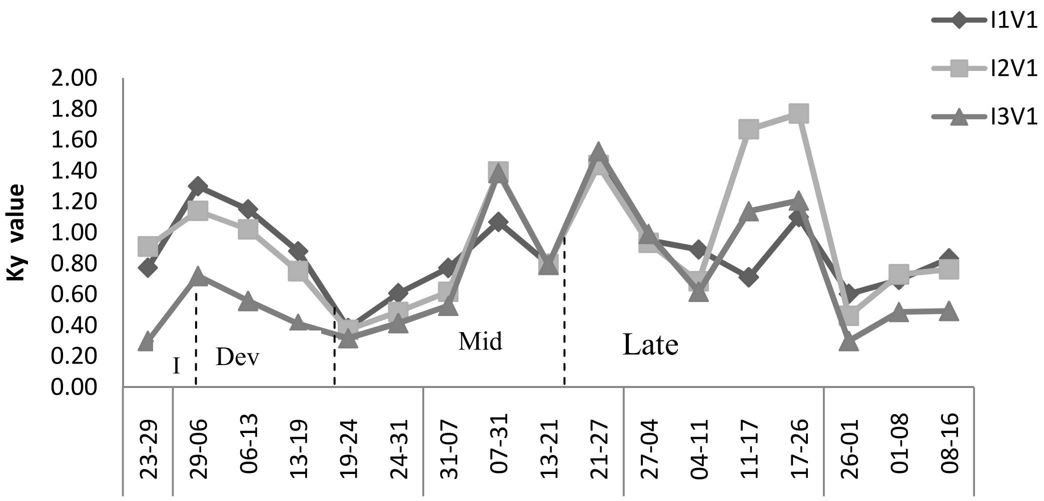

Figure 4 Ky values of Swat 84 variety of soybean during growing period

Yield Response Factor (Ky) of Malakand 96

Ky values of variety V_2 were recorded from 0.47 to 3.23 (Figure 4.4). The highest value was recorded in the last week of august and the lowest value in October (Figure 4.4). These results are in agreement with those of Comlekcioglu et al. (2011) who reported that ky value differed due to the deficit irrigation which effect yield and yield component of the varieties.

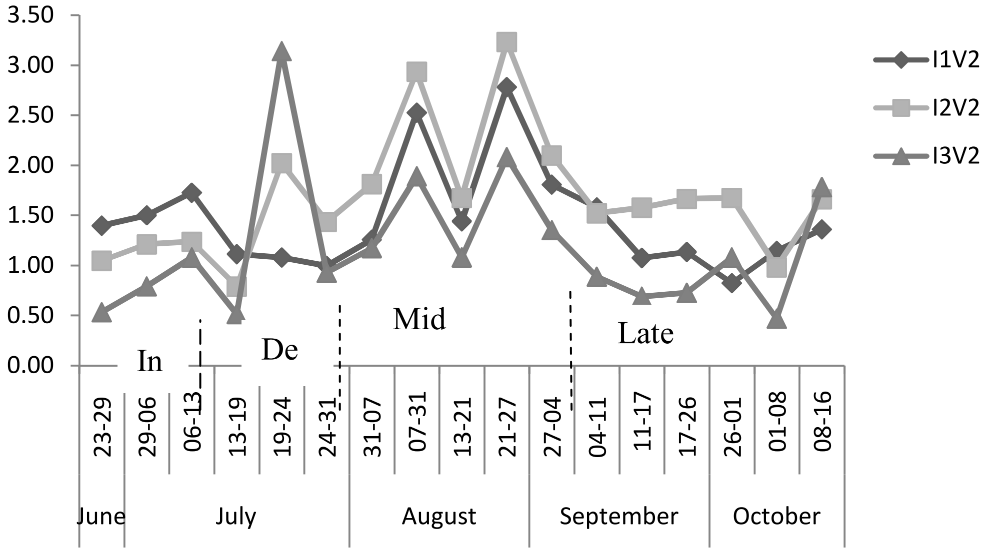

Figure 5 Ky values of Malakand 96 variety of soybean during growing period

Conclusions

Some of the conclusions of the study are as follows:

1) Themaximum (I_{80}) and minimum (I_{40}) reduction in irrigations for swat 84 variety reduce the crop response factors (Ky) by 14% and 15% respectivily when compared to the optimal irrigation (I_{60}) applied.
2) The maximum (I_{80}) and minimum (I_{40}) reduction in irrigations for malakand 96 variety reduce the crop response factors (Ky) by 10% each when compared to the optimal irrigation (I_{60}) applied.
3) There were in increase in the crop response factors(Ky)of malakand 96 over swat 84 variety by 48%, 46% and 50% for I_{40},I_{60} and I_{80}respectivily.
4) For optimal irrigation with malakand 96 variety there was high increase in the crop response factors (Ky) over other variety and irrigations.

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