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PERFORMANCE OF SUNFLOWER IN RESPONSE TO EXOGENOUSLY APPLIED SALICYLIC ACID UNDER VARYING IRRIGATION REGIMES

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ABSTRACT

A field experiment was conducted to evaluate the performance of sunflower in response of exogenously applied Salicylic Acid (SA) under varying irrigation regimes at Agronomic Research Area, University of Agriculture, Faisalabad, during spring 2007. The experiment was laid out in randomized complete block design with split-plot arrangement and replicated thrice. Net plot size was 3 m x 5 m. Irrigation regimes were kept in main plots and foliar application of SA regimes in sub plots. Irrigation regimes comprised of I_1: control (Normal irrigations), I_2: Irrigation missing at vegetative stage (drought stress at vegetative stage), and I_3: Irrigation missing at flowering stage (drought stress at flowering), where as exogenous SA application comprised of F_0: Control (no application), F_1: Foliar application of 100 ppm SA at vegetative stage, F_2: Foliar application of 100 ppm at flowering stage. It was observed that among various irrigation regimes, maximum number of achenes head^{-1} (1164.67), achene yield (2857.11 kg ha^{-1}), biological yield (11412.00 kg ha^{-1}), harvest index (25.18 %), and achene oil (41.48 %), was noted when crop was grown under normal irrigation regimes, where as minimum achene protein content (22.63 %) was recorded when crop was irrigated normally. The minimum values of above parameters were recorded, when crop was missed irrigation at flowering stage. Correspondingly, among different treatments of exogenous application of SA, maximum number of achenes head^{-1} (986.11), achene yield (2601.00 kg ha^{-1}), biological yield (10822.56 kg ha^{-1}), harvest index (25.43 %), and achene oil (40.72 %), and minimum achene protein content (22.92 %) was recorded, when foliar application of SA (100 ppm) was done at vegetative stage. Likewise, the minimum values of above parameters were recorded, when foliar application of SA (100 ppm) was done at flowering stage. It may be concluded that maximum achene yield would be obtained when crop was irrigated normally. Drought stress both at vegetative and flowering stage badly affected the crop growth and yield components but stress at flowering stage was more damaging. Exogenous application of SA significantly ameliorated the negative effects of drought stress at both stages.

Key words: Sunflower, Irrigation regimes, Exogenous application of Salicylic Acid, growth, yield, oil, protein contents, achene.

INTRODUCTION

The shortage of edible oil in Pakistan is still persisting although the country has made an impressive improvement in agriculture. Pakistan spends a huge foreign exchange on the import of edible oil. The import bill of edible oil was about Rs. 28.02 billions in 2002-03 and has risen up to Rs. 52.13 billions in 2006-07 for the import of edible oil and Rs. 15.68 billions for oilseeds (Govt. of Pakistan, 2007).

The oilseed production can be increased by two means, either by horizontal or by vertical expansion. At present, the horizontal expansion in oilseed crops is difficult, thus vertical expansion is the only option. There fore, emphasis must be given on non conventional crops. For this purpose, sunflower and soybean are promising crops. Sunflower (*Helianthes annus* L.) is high yielding, non conventional oilseed crop. It is a short duration crop (90-120 days) and can be grown twice a year. It fits well in existing cropping systems and can be grown with out replacing any major crop (Ahmad *et al*., 2009).

Sunflower seed contains 25-48 % oil and 20-27 % protein. Its oil contains high percentage of poly-unsaturated fatty acids (60 %), accepted largely in diet to reduce cholesterol in blood and prevents heart diseases (Rathore *et al*., 2001). Sunflower oil is quite palatable and contains soluble vitamins A, D, E and K. It is used in manufacturing of margarine. Sunflower cake is used as cattle feed (Hussain *et al*., 2000).

Among the package of production technology of sunflower, irrigation management plays an important role because water has direct relationship with the yield of crop. But during last two decades, country is facing the shortage of irrigation water. Drought stress or drought badly affects the yield of different crops. It has been suggested that in many crops differences in sensitivity to drought stress occur at different growth stages.

Normal irrigations are essential for bumper crop production, but when there is scarcity of water, it becomes imperative to differentiate the critical growth stages of the crop where irrigation could be missed, without reducing the grain yield significantly. Irrigation missing at flowering drastically reduces achene yield (Demir *et al*., 2006) and biological yield (Petchu *et al*., 2003) than for achene yield (El-Tayeb, 2005) and biological yield (De-Guang *et al*., 2001) obtained by irrigation missing at vegetative stage (Laghrab *et al*., 2003) on account of reduction in number of achenes head^{-1} (Kadayifei and Yildrim, 2000). However, it improves achene protein content (Reddy *et al*., 2003).

One of the possible solutions for ameliorating the drought stress at critical growth stages of sunflower is the exogenous application of SA (He *et al*., 2005). Exogenous application of SA where helps in the activation of a range of plant defense genes, increases resistance to infection, decreases damages caused by exposure to ultra violet light, and ozone it improves drought tolerance in plants (Rasmussen *et al*., 1991). SA application at vegetative stage tends to increase achene yield (Fariddudin *et al*., 2003), number of achenes head^{-1}, harvest index (He *et al*., 2005), and biological yield (De-Guang *et al*., 2001) to the application of SA at flowering stage ameliorated drought stress due to increase in number of achene head^{-1} (Sharma and Kaur, 2003).

The present study was, therefore, chalked out to monitor the impact of exogenous application of SA on the growth behavior of sunflower under drought stress conditions.

MATERIALS AND METHODS

The experiment was conducted on a sandy clay loam soil to see the effect of foliar application of salicylic acid against drought on hybrid sunflower at Agronomic Research Station, University of Agriculture, Faisalabad, during 2007. The experiment was laid out in randomized complete block design with split plot arrangement and replicated thrice. Net plot size was 3 m x 5 m. Irrigation regimes were kept in main plots and foliar application regimes in sub plots. Irrigation regimes comprised of I_1: control (4 irrigations), I_2: Irrigation missing at vegetative stage (drought stress at vegetative stage), and I_3: Irrigation missing at flowering stage (drought stress at flowering), where as exogenous SA application comprised of F_0: Control (no application), F_1: Foliar application of 100 ppm SA at vegetative stage, F_2: Foliar application of 100 ppm at flowering stage.

At the time of seed bed preparation, pre-soaking irrigation of 10 cm was applied. When the soil obtained optimum moisture level then seed bed was prepared by cultivating the field for 2-3 times with tractor mounted cultivator each followed by planking. Sunflower was sown with the help of dibbler by using the seed rate of 8 kg ha^{-1} maintaining row to row distance of 75 cm and plant to plant 25 cm. Fertilizers were applied @ 150-100 kg NP ha^{-1}. Half of the N and whole P_2O_5 were applied at sowing, while remaining N was applied at 1st irrigation. Appropriate plant protection measures were adopted to keep crop free of weeds, insects and diseases. All agronomic practices (seed bed preparation, method and time of sowing, hoeing and fertilization) were kept normal and uniform for all the treatments except the ones (irrigation regimes) under study.

After harvesting the plants at maturity, the heads were separated, sun dried, threshed manually from each plot, seed was cleaned and yield was recorded on the plot basis and then converted to kilogram hectare^{-1}. Similarly, for biological yield weight of harvested air dried plants (stalk + head) was recorded on plot basis and then converted into kg ha^{-1}. Harvest Index (HI) indicates the ratio of achene yield to biological yield. It was calculated by the formula. HI= achene yield/ biological yield x 100 (Hunt, 1978).

Achenes of ten randomly selected plant heads were threshed separately and the number of achenes was counted and then averaged per head to get number of achenes head^{-1}. Achene oil yield was determined as Soxhlet Fat Extraction method, while achene protein content was determined by micro-Kjeldhal distillation method (A. O. A. C., 1990).

Data on yield and quality parameters were analyzed statistically by using Fisher ‘s analysis of variance techniques, when a significant F- value was obtained, the comparison among treatments means was done by using least significant difference (LSD) test at 5 % probability level (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Number of achenes head^{-1}: Irrigation regimes significantly influenced number of achenes head^{-1} as shown in Table 1. The maximum number of achenes head^{-1} (1164.67) was recorded in control, when crop was given normal irrigations, followed by number of achenes head^{-1} (925.89), when irrigation was missed at vegetative stage, where as minimum number of achenes (778.11) was observed when irrigation was missed at flowering stage. These results are in line with findings of Kadayifei and Yildirim (2000) and Petcu *et al*., (2003), who stated that irrigation missed at flowering stage significantly, reduced number of achenes head^{-1}. Similarly, although foliar application of SA significantly produced higher number of achenes head^{-1} (986.11) than number of achene (902.67) with no application of SA (F_0), yet number of achene head^{-1} (986.11) was at par with foliar application of SA at flowering stage. These results are in line with the findings of Sharma and Kaur (2003) who suggested that foliar application of SA increased the number of grains pod^{-1} in soybean. Interactive effects of irrigation regimes and SA application on number of achenes head^{-1} were non significant.

Biological yield (Kg ha^{-1}): Irrigation regimes significantly influenced biological yield as indicated in Table 1. Biological yield (11412.00 kg ha^{-1}) was significantly higher in control, when crop was given normal irrigations, than biological yield (10146.11 kg ha^{-1}), when irrigation was missed at vegetative stage and biological yield (9853.33 kg ha^{-1}) were observed, when irrigation was missed at flowering stage with no significant variation between them. Similar observations were noted by Petcu *et al*., (2003). Correspondingly, foliar application of SA significantly influenced biological yield. Foliar SA application at vegetative stage produced higher biological yield (10822.56 kg ha^{-1}) than biological yield (10318.33 kg ha^{-1}) of foliar SA application at flowering stage and biological yield (10270.56 kg ha^{-1}) in control.

Interactive effects of irrigation regimes and SA application on biological yield were significant. The maximum biological yield (12190.67 kg ha^{-1}) was noted when normal irrigations were given (I_1) with foliar SA application at vegetative stage, where as irrigation missing at flowering (I_3) with foliar application of SA at flowering stage produced minimum biological yield (9713.67 kg ha^{-1}). These results are in line with the findings of De-Guang *et al*., (2001) who concluded that the foliar application of SA had obvious drought resistance and yield increasing effect on maize.

Achene yield (Kg ha^{-1}): Irrigation regimes significantly influenced achene yield. The maximum achene yield (2857.11 kg ha^{-1}) was recorded in control, when crop was given normal irrigations, followed by achene yield (2443.00 kg ha^{-1}), when irrigation was missed at vegetative stage, where as minimum achene yield (2179.44 kg ha^{-1}) were observed, when irrigation was missed at flowering stage (Table 1). These results are in line with the findings of Laghrab *et al*. (2003) and Demir *et al*. (2006) also stated that drought condition occurred at flowering stage badly reduced achene yield. In the same way, foliar application of SA significantly influenced achene yield. Although higher achene yield (2601.00 kg ha^{-1}) of sunflower were recorded in control, when no SA was applied, than achene yield (2337.33 kg ha^{-1}) by foliar application of SA at vegetative stage, yet it was par with achene yield (2541.22 kg ha^{-1}) by foliar application of SA at flowering stage. These results are in line with the findings of Fariddudin *et al*. (2003) who stated that exogenously applied SA significantly increased the achene yield in sunflower. The possible reason might be the increased photosynthetic efficiency; stabilization of chlorophyll and translocation of assimilates from source to sink. Interactive effects of irrigation regimes and SA application on grain yield were non significant.

Harvest Index (%): Irrigation regimes were statistically similar regarding HI. Similar observations were noted by Reddy *et al*., (2003). Correspondingly, foliar application of SA was also statistically similar regarding HI. However, interactive effects of irrigation regimes and SA application on HI index were significant. Irrigation regimes at control (I_1) and irrigation missing at vegetative stage (I_2) with foliar application of SA at vegetative stage (F_2) produced the highest HI 27.73 % and 27.73 %, respectively. Irrigation missing at flowering (I_3) with foliar application of SA at flowering stage (F_2) produced minimum HI (21.57%). These results are in line with the findings of He *et al*., (2005), who stated that foliar application of SA at vegetative stage increased HI, but reduced HI for foliar application of SA at flowering stage.

Achene oil content (%): Irrigation regimes were statistically similar regarding achene oil content (as shown in fig.). Similar observations were noted by Demir *et al*., (2006). Correspondingly, foliar application of SA was also statistically similar regarding achene oil content. However, interactive effects of irrigation regimes and SA application on achene oil content were non significant. These results are in line with the findings of Gharib (2006) who stated that exogenously applied SA did not increase oil yield by enhancing photosynthesis and nutrient up take.

Achene protein content (%): Irrigation regimes significantly influenced achene protein content. Achene protein content (24.44 %) was significantly higher in irrigation missing at flowering stage than achene protein content (23.49 %) in control, when crop was given normal irrigations, and achene protein content (22.63 %), when irrigation was missed at vegetative stage (as shown in fig.). Similar observations were noted by Reddy *et al*., (2003). Likewise, foliar application of SA significantly influenced achene protein content. Although achene protein content recorded in control (24.30 %), significantly differed with achene protein content (22.92 %) by foliar application of SA at vegetative, yet achene protein content (23.34 %) was at par with SA application at flowering stage. Interactive effects of irrigation regimes and SA application on achene protein content were significant. Irrigation missing at flowering stage (I_3) with no foliar application of SA (F_0) produced maximum achene protein content (25.45 %), where as normal irrigations (I_1) with foliar application of SA at vegetative stage produced minimum achene oil content (21.91 %).These results are in line with the findings of Gharib (2006) who stated that foliar application of SA at vegetative stage increased achene protein content, but reduced achene protein content for foliar application of SA at flowering stage.

Conclusion: The maximum achene yield was obtained when crop was irrigated normally. Drought stress both at vegetative and flowering stage badly affected the crop growth and yield components but stress at flowering stage was more damaging. Exogenous application of SA significantly ameliorated the negative effects of drought stress at both stages.

Table 1. Production potential of sunflower in response to exogenously applied Salicylic Acid under varying irrigation regimes

Treatment	No. of achenes head^{-1}	Achene yield (Kg ha^{-1})	Biological yield (Kg ha^{-1})	Harvest Index (%)	Achene oil content (%)	Achene protein content (%)
A-Irrigation regimes (I)						
I_1 : Control (Normal irrigations)	1164.67a	2857.11a	11412.00a	25.18	41.48	22.63b
I_2: Irrigation missing at vegetative stage	925.89b	2443.00b	10146.11b	24.97	40.30	23.49ab
I_3: Irrigation missing at flowering stage	778.11c	2179.44c	9853.33b	23.75	39.29	24.44a
LSD (a)	64.38*	81.56*	881.0*	N.S	N.S	1.257*
B- Exogenous Salicylic Acid application (F)						
F_0: Control (No application)	902.67b	2337.33b	10270.56b	24.17	39.75	24.30a
F_1: Foliar application 100 ppm at vegetative stage	986.11a	2601.00a	10822.56a	25.43	40.72	22.92b
F_2: Foliar application 100 ppm at flowering stage	979.89a	2541.22a	10318.33b	24.30	40.60	23.34ab
LSD (b)	75.26*	85.08*	267.5*	N.S	N.S	1.011*
C-Interaction (I x F)						
I_1 x F_0	1106.00	2605.67	11160.67b	23.41bc	42.01	22.25de
I_1 x F_1	1164.67	2969.00	12190.67a	24.39bc	40.83	21.91e
I_1 x F_2	1223.33	2996.67	10884.67b	27.73a	41.59	23.73abcd
I_2 x F_0	875.00	2322.67	9988.67cd	23.59bc	39.28	25.18ab
I_2 x F_1	960.33	2538.00	10093.00cd	27.73a	40.85	23.18cde
I_2 x F_2	942.33	2468.33	10356.67c	23.59bc	40.79	22.10de
I_3 x F_0	727.00	2083.67	9662.33d	25.51ab	37.85	25.45a
I_3 x F_1	833.33	2296.00	10184.00c	24.17bc	40.49	23.66bcde
I_3 x F_2	774.00	2158.67	9713.67d	21.57c	39.43	24.20abc
LSD (c)	N.S	N.S	463.4*	3.057*	N.S	1.7511*

Any two means not sharing common letter differ significantly with each other at 5 % level of probability
N.S= Non significant

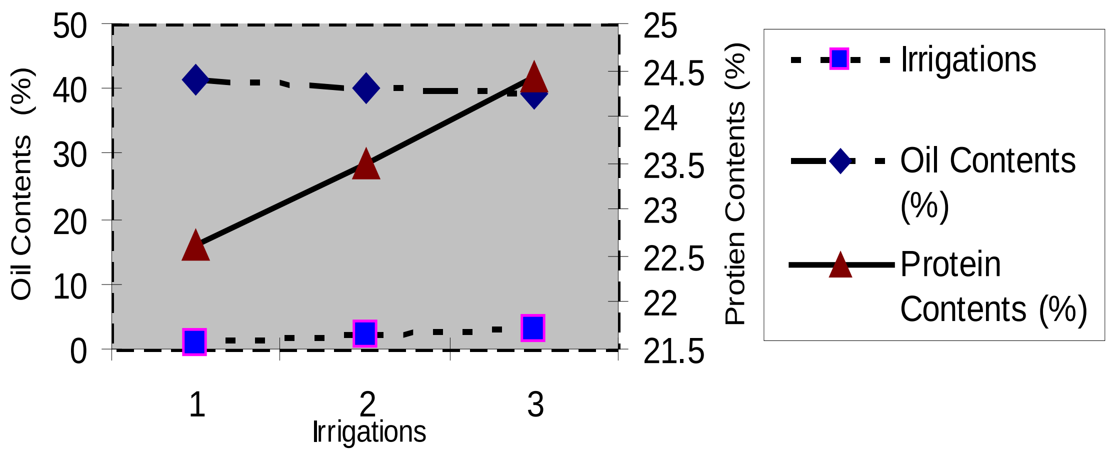

Figure Effect of different irrigation regimes on oil and protein contents in Sunflower achene.

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