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WATER STRESS AND K NUTRITION EFFECTS ON GROWTH INDICES AND SEED YIELD OF SUNFLOWER

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Abstract

In order to study the effect of water stress and potassium levels, growth indices and yield of sunflower a split plot experiment based on randomized complete block design(RCBD) was conducted with four replications during 2011 growing season in Bojnourd International Airport's field. Water stress was applied by irrigation regimes as main factor at three levels, 60, 90, 120 mm evaporation, from Class A evaporation Pan, and four K^+ levels (0, 70, 140, 210 kg/ha K^+ as potassium sulphate) as sub plots.
The important growth indices i.e. Leaf area index (LAI), total dry matter (DM), Crop growth rate (CGR), plus seed yield was determined. The highest seed yield was obtained from the interaction between $K_{210} \times I_{60mm}$ about 4.79 t/ha, and the lowest one in $K_0 \times I_{120mm}$ with 1.70 t/ha. The more potassium nutrition, the more compensation of moisture stress adverse effects and reduction of yield loss. There was a positive relationship between growth indices and seed yield, so increasing of K^+ nutrition resulted to higher DM, LAI and CGR, then seed yield. The highest quantities for these three indices were 4.5, 800 gr/m^2, and 15.5gr/ m^2.days, respectively.

***Key words**: Helianthus annuus, growth analysis, potassium, drought stress.*

INTRODUCTION

Iran has located between 25-38′ North latitude with arid and semi arid climatic conditions. So irrigation economy is very important for our farmers. Amongst oilseeds, more than 190000 ha of Iran's arable lands is under cultivation of sunflower, and most of them are subjected to deficit or supplementary irrigation. This plant has a good capability for drought tolerance but needs a very good and efficient agronomic management (Shekari, 2013). Yield formation of sunflower under water stress conditions is related to rapid phenological development, higher assimilate translocation and partitioning, and also achieving more biomass before ripening (Elizondo, 1991).
Growth analysis is a valuable method for studying the growth capabilities of plants in different climatic and management conditions (Hunt, 1991). LAI reduction especially in flowering time, is one of the obvious effects of water stress (Chimenti et al., 2002). Total dry matter (TDM), has a sigmoidal trend across the sunflower growth period, but any stress can decrease the TDM curve to a lower level. Crop growth rate (CGR), is very susceptible to water stress too. Deficit irrigation in mid flowering and after that, has significant effect on CGR and seed filling period of sunflower (Shekari, 2013). Erdem, et al. (2006), demonstrated the effect of water stress on 58% yield reduction of sunflower. It seems that the budding and flowering stages are more susceptible to water stress in relation to seed yield (Pankovic el al., 1999).
Maintenance of high K^+ levels for plants in water stress conditions has a important role for crop production. Potassium can compensate the adverse effects of moisture stress on yield. So application of K^+-based fertilizers is a key management factor for crop production in water limited areas (Azizi, 1998).

MATERIALS AND METHODS

In order to study the traits related to yield and growth indices of sunflower a split plot experiment based on randomized complete block design (RCBD) was conducted with four replications during 2011 growing season in Bojnourd International Airport's field.

Irrigation regimes arranged as main factor with three levels, ie. Irrigation after 60, 90 and 120 mm evaporation from Class A Pan, and four K levels comprised (0, 70, 140, 210 kg.ha^{-1} K^+, as potassium sulphate) as sub plots.

Traits under consideration were: Leaf area index (LAI), Total dry matter (TDM), Crop growth rate (CGR) plus seed yield of sunflower cv. Hysun25. For growth analysis 2-weekly plant sampling from 0.5 m^2 soil area was done. Leaves surface area and total dry biomass per unit area was determined. Then the best fitted curves for these three indices were estimated via regression methods. At the end of growing season economic seed yield was determined in each plots. Mean comparison was done based on least significant difference method (LSD).

RESULTS AND DISCUSSIONS

LAI trend was different for irrigation and potassium treatments (Figures 1 and 2).

The highest LAI (4.5) was achieved in I_{60}, but severe water stress forced it to significant reduction about 2.8.

This phenomenon is the result of reduction of leaves number, decline of leaf area, leaf abscission and changing the morphology of plant because of water stress (Shekari, 2013). Also the slope of decreasing the curve of LAI in water stress treatments after its peak was sharper than $I_{60,}$ the non stress treatment.

The more potassium application resulted to more LAI. So the K_{210}, had superiority in its leaf area trend compared to the least one ie. K_0.

Potassium deficiency, either due to soil shortage or due to its low availability because of water stress, is resulted to cessation of leaf expansion and reduced carbon exchange rate (Azizi, 1998). As leaf K^+ deficiency is increased the total photosynthetic area decreased (Ozbun et al., 1965).

TDM trend was different for irrigation and potassium treatments (Figures 3 and 4).

Increasing of water stress reduced the whole trend of TDM. But with more plant K consumption in each irrigation regime, dry matter was increased even in severe water stress. In I_{120} the maximum dry matter was decreased up to 30% compared to control. The highest TDM, about 800 g/m^2, was obtained in K_{210} and in non stress treatment. It seems that the compensatory effects of potassium in water stress conditions can balance the accumulation of dry mater for better seed yield (Azizi, 1998).

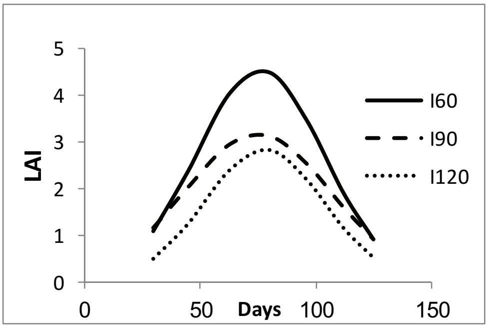

Figure 1. Comparison of LAI trend in different irrigation regimes (I_{60}….I_{120} means non to severe water stress)

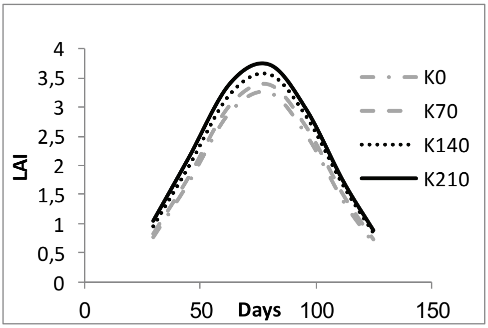

Figure 2. Comparison of LAI trend in different potassium Levels (K_0…K_{210} means non to high K application)

CGR trend was different for irrigation and potassium treatments (Figures 5 and 6).

Maximum CGR was obtained in I_{60}, 15.8 g.m^{-2} days^{-1}, and for potassium the maximum ones was about the same rate in higher K applied. It is concluded that potassium had more obvious effect on LAI and TDM than CGR. Turner and Sobrado (1987) were reported the reduction of crop growth efficiency and rate of sunflower with water stress.

With reduction of water consumption from I_{60} to I_{120}, interacted with all levels of potassium, kernel weight was decreased significantly. Economic yield of sunflower in I_{90} and I_{120} were reduced 24.3 and 58.4% compared to I_{60}. Potassium application in all levels of irrigation treatments increased the kernel yield. The highest kernel yield was achieved from the combination of $I_{60}\times k_{210}$ equal to 4.79 t.ha^{-1}, and the least one in $I_{120}\times k_0$ equal to 1.34 t.ha^{-1}.

Results showed, sunflower have a very good response to potassium nutrition especially in water stress conditions or in dryland farming.

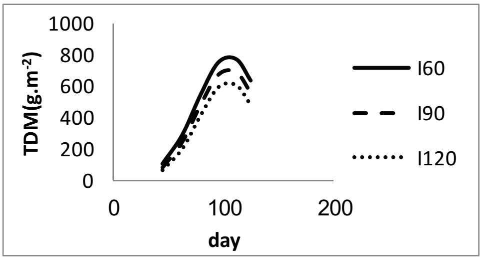

Figure 3. Comparison of TDM trend in different irrigation regimes (I_{60}…I_{120} means non to severe water stress)

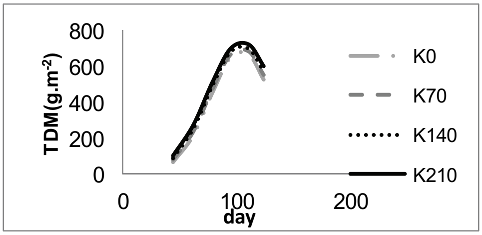

Figure 4. Comparison of TDM trend in different potassium Levels(K0…K210 means non to high K application)

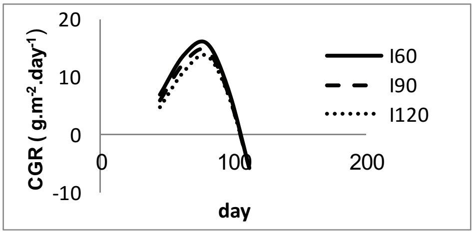

Figure 5. Comparison of CGR trend in different irrigation regimes (I60…I120 means non to severe water stress)

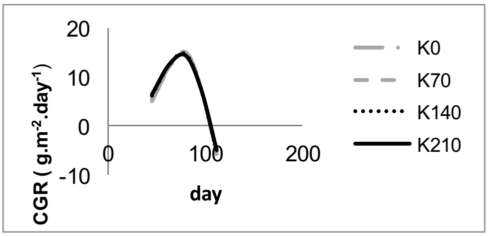

Figure 6. Comparison of CGR trend in different potassium Levels (K_0…K_{210} means non to high K application)

CONCLUSIONS

Adverse effects of water stress on kernel yield of sunflower are recoverable by using proper rates of potassium fertilizers like potassium sulphate. Potassium can modify photosynthetic apparatus in water stress conditions so that the reduction of growth indices responsible for yield formation is compensated for better drought tolerance.

Potassium increased total dry matter, leaf area index, crop growth rate, and kernel weight in all levels of irrigation treatments especially in severe water stress.

It seems that, application of potassium in dryland areas under cultivation of sunflower, is a key management strategy that prevent significant yield loss.

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