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EFFECT OF EXOGENOUS APPLICATION OF GLYCINEBETAIN ON CAPITULUM SIZE AND ACHENE NUMBER OF SUNFLOWER UNDER WATER STRESS

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ABSTRACT

Plants grown under stressful environments, accumulate many organic compounds thorough biochemical changes, which improve their growth and development. Among these, quaternary ammonium compounds, especially the glycinebetaine (GB) is very useful in conferring resistance against abiotic stresses. Exogenous application of GB is a novel approach used to minimize the adverse effects of environmental stresses on crop plants. The present study was carried out to assess whether exogenously supplied GB has any role in drought tolerance of sunflower. Two sunflower lines, Gulshan-98 and Suncross were subjected to water stress at the vegetative and reproductive stages of plant growth. Three levels of GB (0, 50 and 100 m*M*) were applied before sowing (seed treatment) and at the time of initiation of water stress at the vegetative or reproductive stages. Water deficit had a marked adverse effect on capitulum diameter and number of achenes per capitulum of both sunflower lines. The sunflower line, Suncross, performed better than Gulshan-98 for both above mentioned characteristics. Exogenous application of GB either in the form of seed treatment or foliar spray was, not effective in alleviating the adverse effect of water deficit on capitulum diameter. Water stress induced reduction in number of achenes per capitulm, however, significantly improved by the foliar application of GB. Pre-soaking of seeds with GB was not effective in preventing the adverse effects of water stress on yield components. Moreover, the effects of water stress and exogenous GB was more pronounced when applied at the vegetative stage than that at the reproductive stage. Foliar spray of 100 m*M* GB was found to be more beneficial in preventing the negative effects of water deficit on achene yield per plant as compared with 50 m*M* GB.

Key works: Water stress, glycinebetaine, sunflower, yield components.

INTRODUCTION

Plants have the capacity to adjust to environmental conditions, which are never stable. Among the various environmental factors, water stress is a major problem to plants, particularly grown in warm, arid and semi-arid climates (Boyer, 1982; Ashraf and Khan, 1990). Now-a-days many countries of the world are experiencing extreme scarcity of water due to its increasing demand for agriculture sector. The problem of shortage of water seems to be more severe for higher crop production (Chapin, 1991; Rachidi *et al.*, 1993), particularly in third world countries like Pakistan. Water stress affects various physiological and biochemical process in plants and different crop species (Brassica sp.) have varying responses to water stress (Ashraf and Mehmood, 1996), one finds a spectrum of responses within same species and may be classified as tolerant or sensitive to water stress. The productivity of a plant under water stress depends upon the intensity, timing of water deficit and sensitivity of crop to it.

Plants have evolved various biochemical and physiological mechanisms to combat to this problem. Among these the accumulation the certain organic metabolites such as glycerol, sucrose, trehalose, pinitol, proline and especially the glycinebetaine is the most important one (Yancey *et al.*, 1982; Rhodes and Hanson, 1993). Exogenous application of these metabolites for increasing stress tolerance in crop plants has been the subject of many green house and field studies from last few years (Makela *et al.*, 1996a; b; Agboma *et al.*, 1997a).

It is well reported that exogenous application of glycinebetaine improves stress tolerance in different plant species including both GB-accumulators and non-accumulators (Harinasut *et al.*, 1996; Hayashi *et al.*, 1998; Allard *et al.*, 1998). Application of glycinebetaine significantly alleviated the adverse effects of salinity and water stress on growth of rice (Rahman *et al.*, 2002). However, certain evidences suggest that exogenous application of GB is not effective for all crops (Suplice *et al.*, 1998; WeiBing and Rajashekar, 1999). Furthermore, even toxic effects of exogenously supplied glycinebetaine have been reported in rape plants (Gibon *et al.*, 1997), suggesting the view that it is not a compatible solute for higher plants.

Foliar applied glycinebetaine reduces yield losses by environmental stresses. Diaz–Zorita *et al.* (2001) found that under shortage of water, foliar application of glycinebetaine at the vegetative stage enhanced grain yield by increasing number of grains per spike in wheat. Exogenous application of glycinebetaine also increased grain yield in some other crop plants like maize and sorghum (Agboma *et al.*, 1997a) under varying levels of water stress. Agboma *et al.* (1997b) suggested that foliar application of glycinebetaine increase the yield components of tobacco. However, rate and timing of glycinebetaine application affect the outcome, and different crop species respond differentially to soil water status and glycinebetaine application (Agboma *et al.*, 1997a; b; c). Hence the present study was conducted to assess whether exogenously supplied glycinebeataine has any role in reducing the negative effects of water stress on capitulum diameter and achene number in two sunflower lines.

MATERIALS AND METHODS

Seeds of two sunflower lines, Suncross and Gulshan-98 were obtained from the regional office of Pakistan Seed Council, Faisalabad. The study were conducted at the experimental area of Dept. of Botany, University of Agriculture, Faisalabad. Water stress were applied at the vegetative and reproductive stages of plant growth. There were three treatments of glycinebetaine (0, 50 and 100 mM) applied before sowing (seed treatment), at vegetative stage and reproductive stage. The experiment was laid out in a split plot design with 8 replications for each experimental unit. The soil texture was determined with the hygrometer method (Dewis and Freitas, 1970). Electrical conductivity, pH and ions of saturation extract were determined according to Jackson (1962). The saturation percentage of the soil was 31 with pH 8.1 and electrical conductivity of 2.1 dS m^{-1}. The phosphorus, potassium and calcium contents of the soil were 5.6, 187 and 109 mg/kg dry soil, respectively.

The plants were harvested at maturity and capitulum diameter (cm) and number of achenes per capitulum was recorded. Analysis of variance of the data from each attribute was computed using the MSTAT Computer Program (MSTAT Development Team, 1989).The Duncan's New Multiple Range test at 5% level of probability was used to test the differences among mean values (Steel and Torrie, 1980).

RESULTS AND DISCUSSIONS

Highly significant (P>0.001) effects of water deficit treatments were found on capitulum diameter of two sunflower lines (Fig.1). Water deficit at the vegetative stage caused a 32% reduction in capitulum diameter of stressed plants as compared with normally irrigated plants. Imposition of water deficit at the reproductive stage caused only 15% reduction in capitulum diameter of water stressed plants with respect to non-stressed ones.

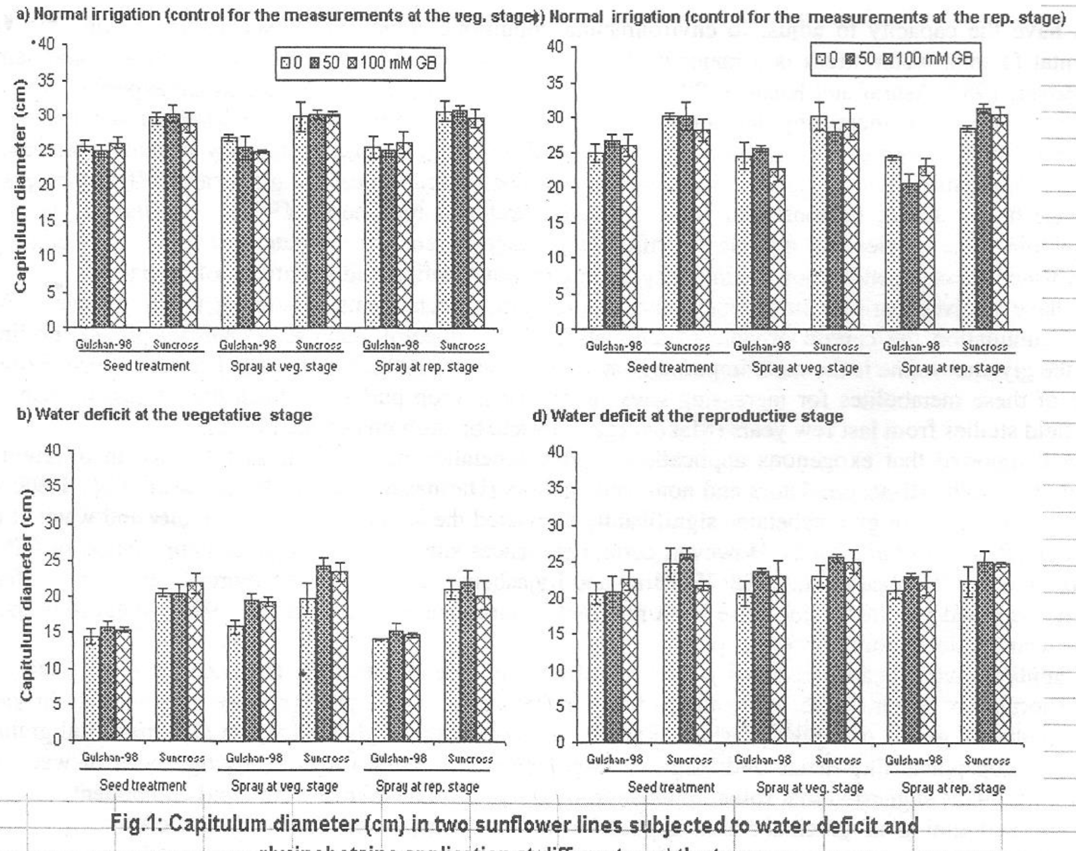

Fig.1: Capitulum diameter (cm) in two sunflower lines subjected to water deficit and glycinebetaine application at different growth stages.

Exogenous application of GB at all growth stages showed almost similar effects on capitulum diameter (Fig.3a). The three levels of GB did not differ significantly with respect to this variable (Fig.3b).

The two sunflower lines exhibited highly significant (P>0.001) differences regarding capitulum diameter. Suncross had 17% higher capitulum diameter than that of Gulshan-98. Interactions were significant only for water deficit treatments x sunflower lines. Suncross showed 29% reduction in capitulum diameter of water stressed plants as compared to well-watered plants due to the imposition of water deficit at the vegetative stage, whereas a 37% reduction in capitulum diameter of stressed plants of Gulshan-98 over control was recorded under the same conditions. In contrast, when the water deficit was applied at the reproductive stage, the sunflower line Gulshan-98 showed less reduction (9%) in capitulum diameter of stressed plants than that of Suncross (18%) when compared with normally irrigated plants.

Analysis of variance of the data for the number of achenes per capitulum showed highly significant (P > 0.001) differences among water deficit treatments. The number of achenes per capitulum decreased by 39% when water deficit was applied at the vegetative stage, whereas, a 22% reduction in this variable was recorded due to the application of water deficit treatment at the reproductive stage (Fig.2).

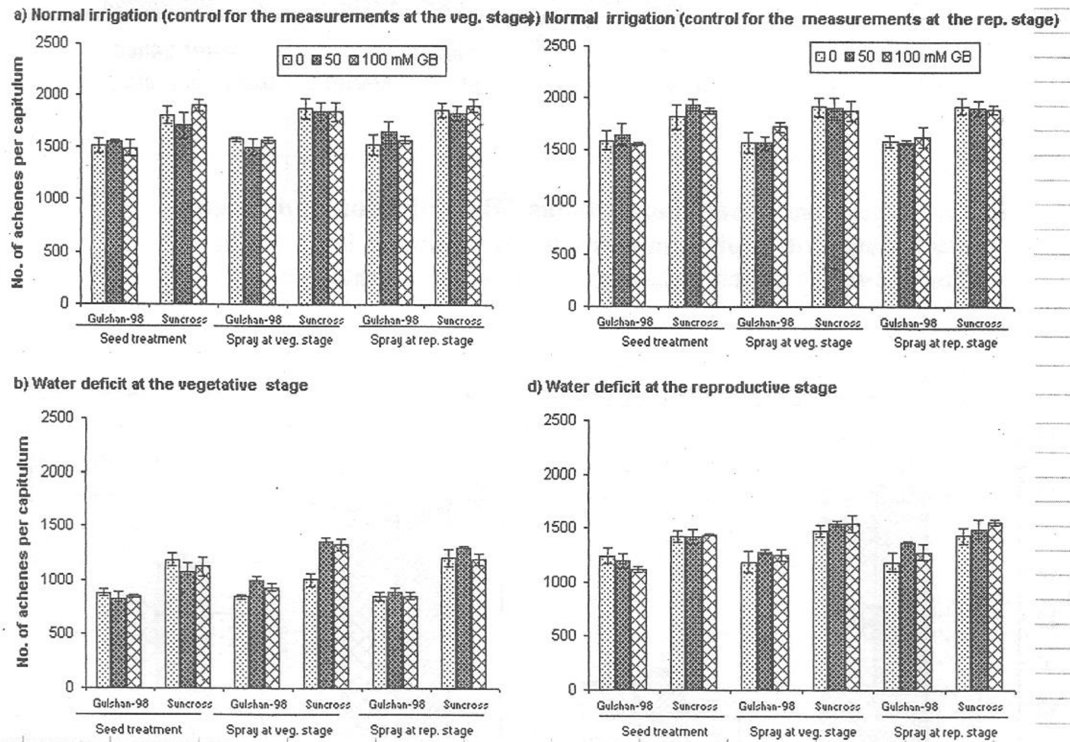

Fig.2: Number of achenes per capitulum in two sunflower lines subjected to water deficit and glycinebetaine application at different growth stages.

Exogenous GB application was found to be effective in reducing the adverse effects of water deficit treatments on number of achenes per capitulum in both sunflower genotypes (Fig.4a). Seed treatment with GB was not effective in alleviating the inhibitory effect of water deficit on number of achenes per capitulum, imposed at the vegetative or reproductive growth stage(Fig.4a). Foliar application of GB at the time of the initiation of water deficit at the vegetative stage produced 8% greater number of achenes per plant in water stressed plants with regard to GB untreated ones. In contrast, a 5% increase in number of achenes per capitulum of water stressed GB treated plants was recorded by the application of GB at the time of initiation of water stress at the reproductive stage (Fig.4a). Application of GB before the initiation of water stress, at any growth stage, showed no effects on number of achenes per plant. The three levels of GB did not differ significantly regarding this variable (4.b).

The sunflower lines differed significantly (P>0.001) regarding number of achenes per capitulum. Suncross produced higher number of achenes per capitulum (1603) than that of Gulshan-98 (1316). Interactions among different factors were statistically non-significant.

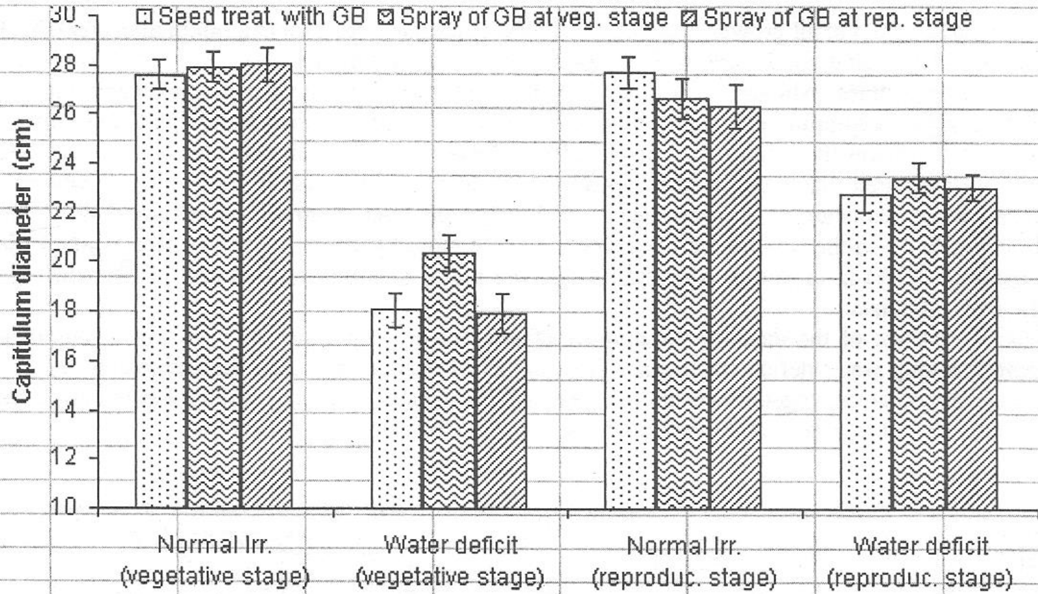

Fig.3a: Cumulative effect of exogenous GB application at different growth stages on capitulum diameter of sunflower lines under different water deficit treatments (time of GB x water deficit)

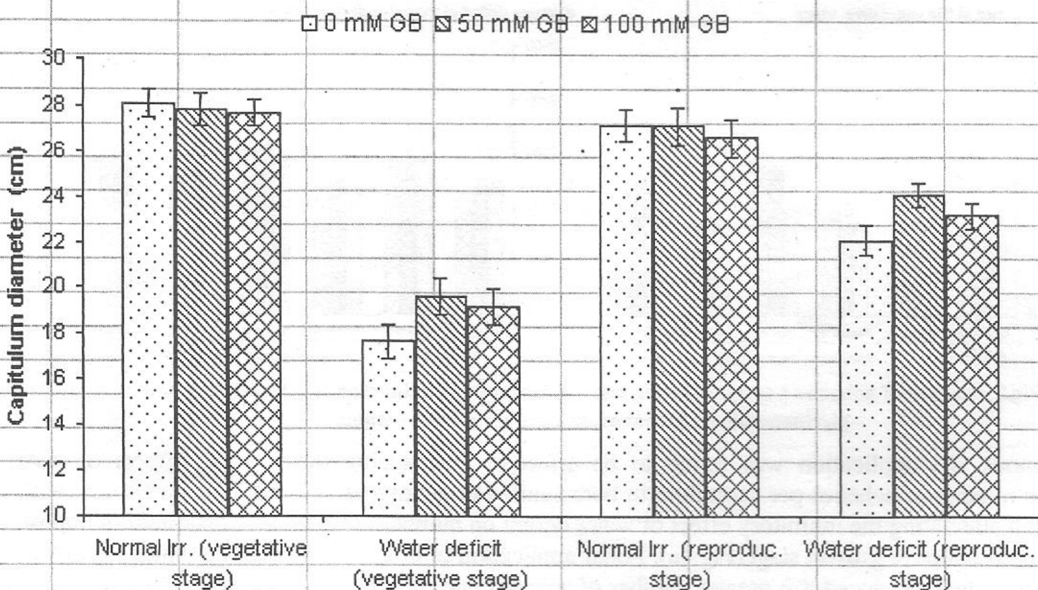

Fig.3b: Effect of different levels of GB on capitulum diameter of sunflower lines under different water deficit treatments (GB levels x water deficit)

There is no denying the fact that the yield of the yield of the crop plants in drying soil reduces even in the tolerant genotypes (Reddy *et al.,* 1998; Tahir and Mehdi 2001). The achene yield in sunflower depends on capitulum diameter and number of achenes per capitulum. It is clear form the results of present experiment that both of the above mentioned characteristics were decreased due to the water stress treatments at both vegetative or the reproductive growth stages. However, the less reduction in yield components of Suncross under water stress as compared to Gulshan-98 points towards its stress tolerance ability. Tahir and Mehdi, (2001) and Tahir *et al.,* (2002) also reported that tolerant lines of sunflower showed less reduction in yield and yield components than that of susceptible ones.

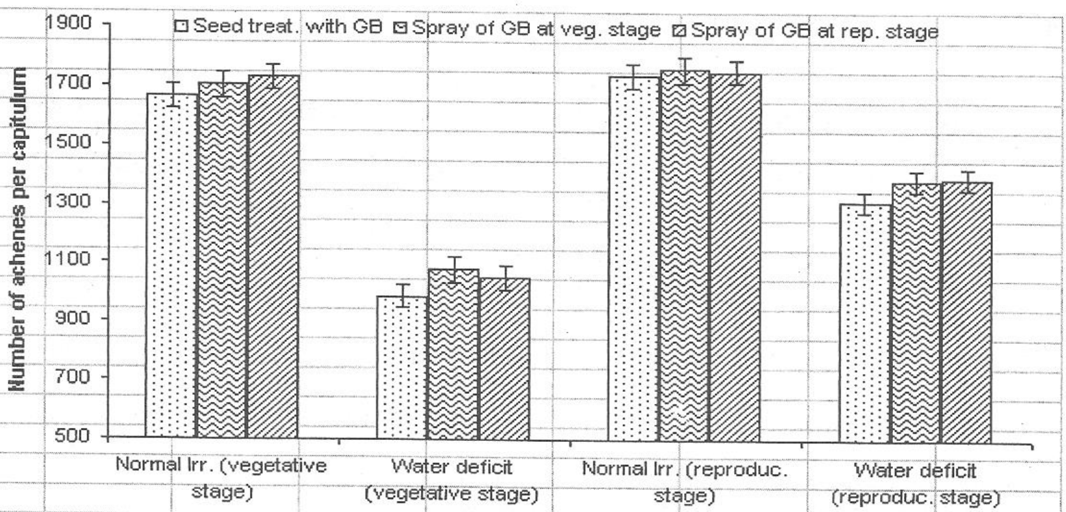

Fig.4a: Cumulative effect of exogenous GB application at different growth stages on number achens per capitulum of sunflower lines under different water deficit treatments (time of GB x water deficit)

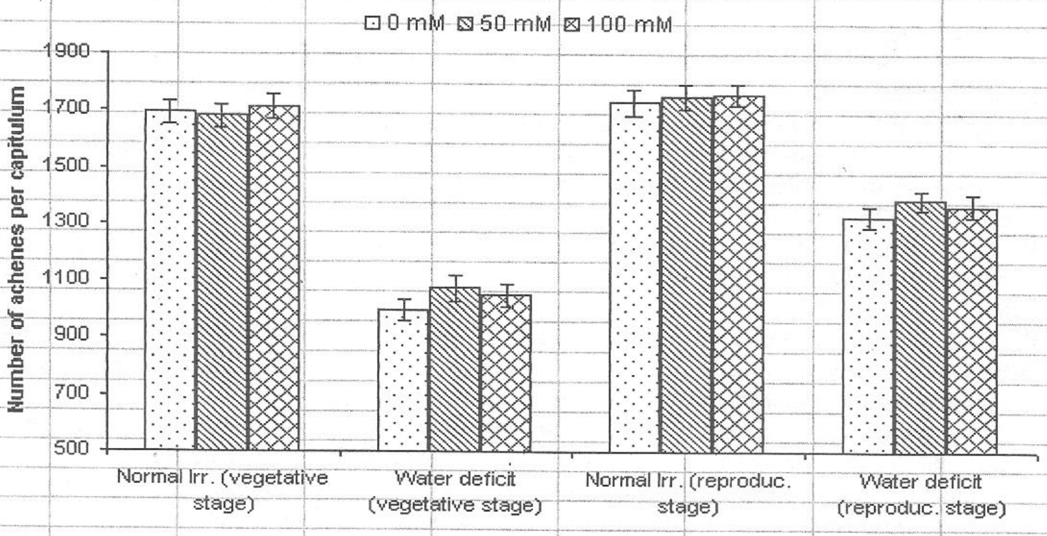

Fig.4b: Effect of different levels of GB on number of achenes per capitulum of sunflower lines under different water deficit treatments (GB levels x water deficit)

scientists also reported an increase in yield and yield components of cotton (Naidu *et al.,* 1998; Gorham *et al.,* 2000) and tomato (Makela *et al.,* 1998a). Some scientists (Meek *et al.,* 2003) however, are of the view that exogenous supply of GB had no role in increasing the yield and yield components.

The role of exogenous GB in increasing the yield and yield components of different crop plants under both normal and steressful environments is however, contradictory. For instance, in the present experiment, number of achene per capitulum increased due to the exogenous GB application under water stress. Similarly, some other

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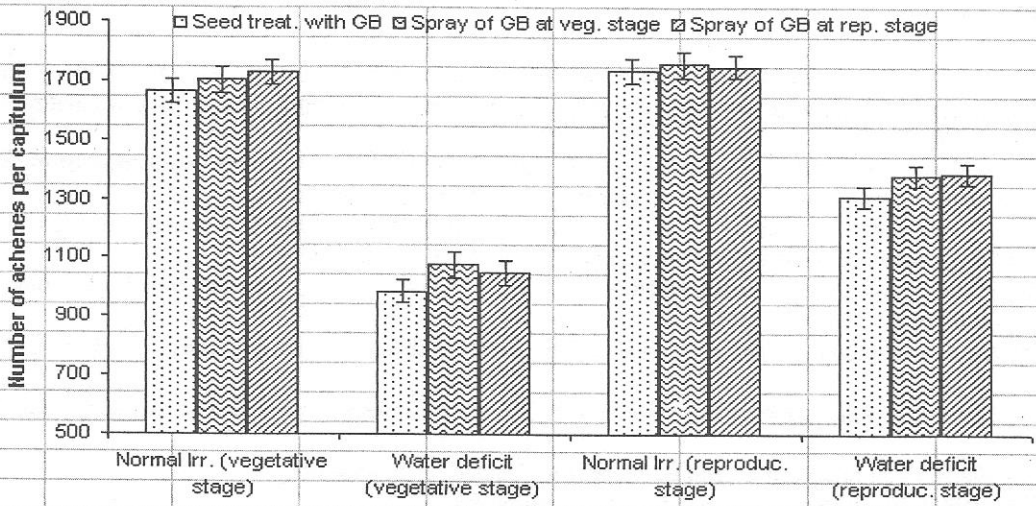

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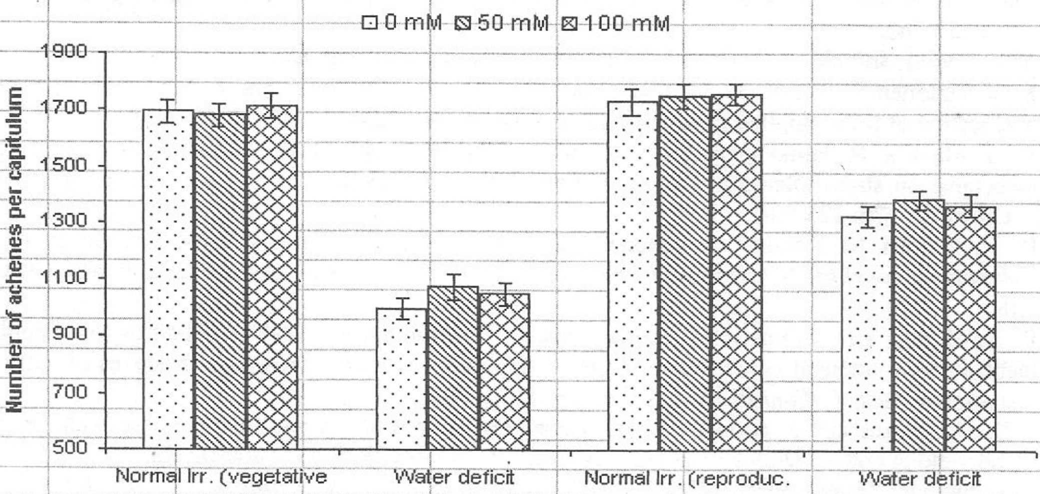

Fig.4b: Effect of different levels of GB on number of achenes per capitulum of sunflower lines under different water deficit treatments (GB levels x water deficit)

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