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Full Length Research Paper

Physiological growth indices in winter rapeseed (*Brassica napus* L.) cultivars as affected by drought stress at Iran

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This experiment was carried out to study the effect of drought stress on physiological growth indices of winter rapeseed cultivars in Karaj, Iran using split-plot design with three replications to study the effect of drought stress on oil yield of winter rapeseed cultivars. The main-plot factors included: Four levels of irrigation regimes (control = no drought stress, irrigation interrupted during the flowering stage, irrigation interrupted during the silique formation stage and irrigation interrupted during the seed filling stage) while the sub-plot factor included three cultivars (Zarfam, Okapi and Licord) of winter rapeseed (*Brassica napus* L.). The results showed that total dry matter (TDM), leaf area index (LAI), relative growth rate (RGR) and crop growth rate (CGR) were highly significantly different among the rapeseed cultivars, whereas, drought stress had effects of practical significance on TDM, LAI, RGR and CGR. The results also showed that the highest TDM, LAI, RGR and CGR were obtained from the cultivar, Zarfam under no-drought condition. The findings firmly established that the drought stress sorely reduces physiological growth indices of winter rapeseed cultivars under conditions of Karaj in Iran.

Key words: Drought stress, physiological growth indices, winter rapeseed cultivars.

INTRODUCTION

Drought stress is very important in areas where crop production is essentially rain-fed (Boyer, 1982; Ludlow and Muchow, 1990). Drought stress causes an increase in solute concentration in the soil and root-zone of the plant leading to an osmotic flow of water out of plant cells. This in turn causes the solute concentration inside plant cells to increase, thus lowering water potential and disrupting membranes along with essential processes like photosynthesis. These drought-stressed plants consequently exhibit poor growth and yield. In worst situations, the plants completely die. Certain plants have devised mechanisms to survive such low soil moisture conditions. These mechanisms have been classified as tolerance, avoidance or escape (Kramer and Boyer, 1995; Neumann, 1995). Drought tolerance is the ability of crops to grow and produce seeds or propagules under conditions of water deficit. A long-term drought stress effects on plant metabolism vary with plant growth stage, water storage capacity of the soil and physiological aspects of plant. Drought tolerance of cultivated crop plants is different from that of wild plants. When crop plants get encountered with severe water deficit, they often die or seriously lose yield while conversely wild plants face similar conditions of drought, they survive well with often little/no yield loss. Because of water deficit in most of the arid regions, tolerance of crops to drought has always been of great importance for the plant breeders (Alizadeh, 2004). According to Lessani and

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Mojthaedi (2006), one of the main aspects of drought tolerance is the ability of plant cells to survive severe water loss without being affected by deleterious damages. When the plant cell dries up, usually the vacuole crumples more than the cell wall and thus results in tearing up of the protoplasm. Plant yield losses under insufficient water have always been an important issue for plant breeders to improve using drought tolerance indices to select genotypes (Mitra, 2001). Investigations by Champolivier and Merrien (1996) revealed that yield and yield components of rapeseed were affected by water shortage occurring from flowering to the end of seed set. Most number of seeds per plant was affected, although some compensation occurred when the water supply was restored. The thousand seed weight was only affected by low water stress even if it occurs during the period when siliques were swelling to seeds coloring. The results also demonstrated that a marked reduction in oil concentration was evident when water deficit occurred from anthesis to maturity. Furthermore, they found that oil and protein concentrations were inversely related. Therefore, the aim of the present investigation is to determine the effects of drought stress on physiological growth indices of winter rapeseed cultivars in Karaj Region, Iran.

MATERIALS AND METHODS

This study was conducted on the experimental field of the Seed and Plant Improvement Institute, Karaj at Iran (35°58' N, 51°06' W; 1313 m above sea level) in 2004. The experiment was laid out in a split-plot design with three replications. The main-plot factors included: Four levels of irrigation regimes (control=no drought stress (NDS), irrigation interrupted during the flowering stage (IIFS), irrigation interrupted during the silique formation stage (IISFS1) and irrigation interrupted during the seed filling stage (IISFS2)) while the sub-plot factor included three cultivars (Zarfam, Okapi and Licord) of winter rapeseed (*Brassica napus* L.). Phosphorus and potassium were applied each at the rate of 100 kg ha^{-1} in the form of triple super phosphate (TSP) and K_2O. While the former was applied at planting, the latter was applied right just cultivation. Nitrogen fertilizer was added in three splits, whereby the first application (50% of 100 N ha^{-1}) was made at the time of cultivation while the second and third, applications, each constituting 25% of the total rate, were respectively made at the stages of stem elongation and beginning of flowering. In order to the determination of TDW, from 20 days after cultivation to harvesting time, 10 plants were selected randomly in all plots each 15 days regularly. Samples were placed under 75°C in oven for 48 h and were weighed by scale and then TDW was determined in sampling stages. To determine LAI, leaves area upon samples were estimated by leaf area meter before placing in oven and then determined LAI in each sampling stage. Finally, RGR and CGR were determined by the following formulas (Aliabadi et al., 2009):

$$RGR = \frac{LnW_2 - LnW_1}{T_2 - T_1}$$

$$CGR = \frac{W_2 - W_1}{T_2 - T_2} \times GA$$

RESULTS

The results showed that total dry matter (TDM), leaf area index (LAI), relative growth rate (RGR) and crop growth rate (CGR) were all highly significantly different among the rapeseed cultivars, whereas drought stress had effects of practical significance on TDM, LAI, RGR and CGR. The results also showed that the highest TDM, LAI, RGR and CGR were obtained from Zarfam cultivar under no-drought condition (Figures 1 - 4).

DISCUSSION

As the results of this study indicated that drought stress has negative effects on physiological growth indices of winter rapeseed. This implies that rapeseed plants use different mechanisms to resist drought stress. Plant's photosynthesis reduces under drought stress because the leaf area, plant height and lateral stem number reduce under this condition. Under drought stress, stomata become blocked or half-blocked and this leads to a decrease in absorbing Co_2 and on the other hand, the plants consume a lot of energy to absorb water, these cause a reduction in producing photosynthetic matters. Drought stress reduced the amount of the oil, because in case of stress, more metabolites are produced in the plants and their substances prevent it from oxidization in the cells. It was also seen that as the increase of drought stress, its height, stem diameter and stem yield decreased. Shoot reduction could be due to the reduction in the area of photosynthesis, drop in chlorophyll production, the rise of the energy consumed by the plant in order to take in water, increase the density of the protoplasm, change respiratory paths and the activation of the path of phosphate pentose, or the reduction of the root deploy, etc. The physiological growth indices were decreased in winter rapeseed cultivars under drought stress.

Conclusion

The investigation showed that physiological growth indices were reduced under drought stress. This condition can be the most important environmental factor for the increase of TDM by control of irrigation. Therefore, the selection of cultivars that perform well over a wide range of environments can increase quantity and quality yields of winter rapeseed under drought stress. Consequently, our findings can help farmers and

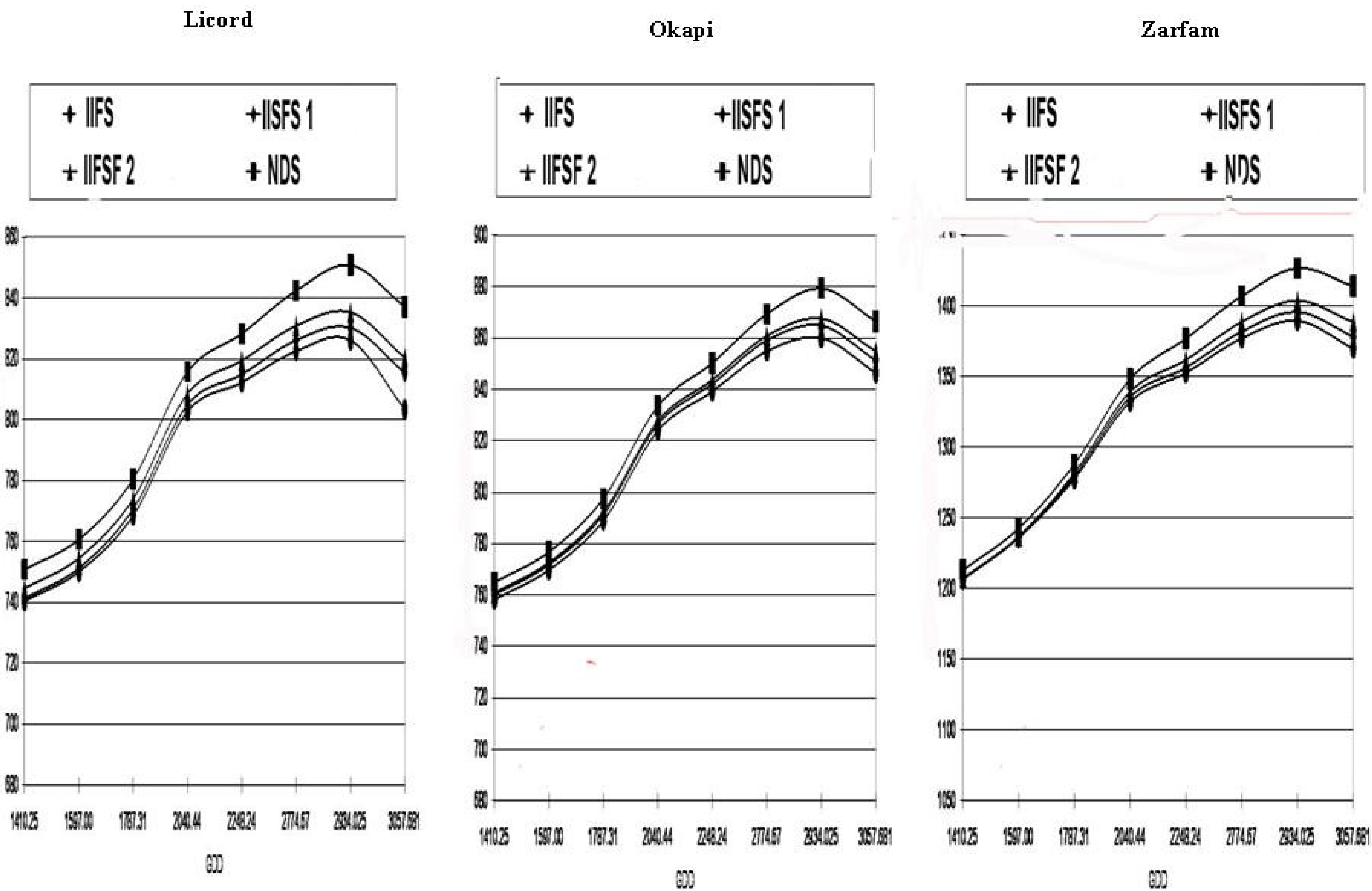

Figure 1. TDM variations in winter rapeseed cultivars under drought stress conditions.

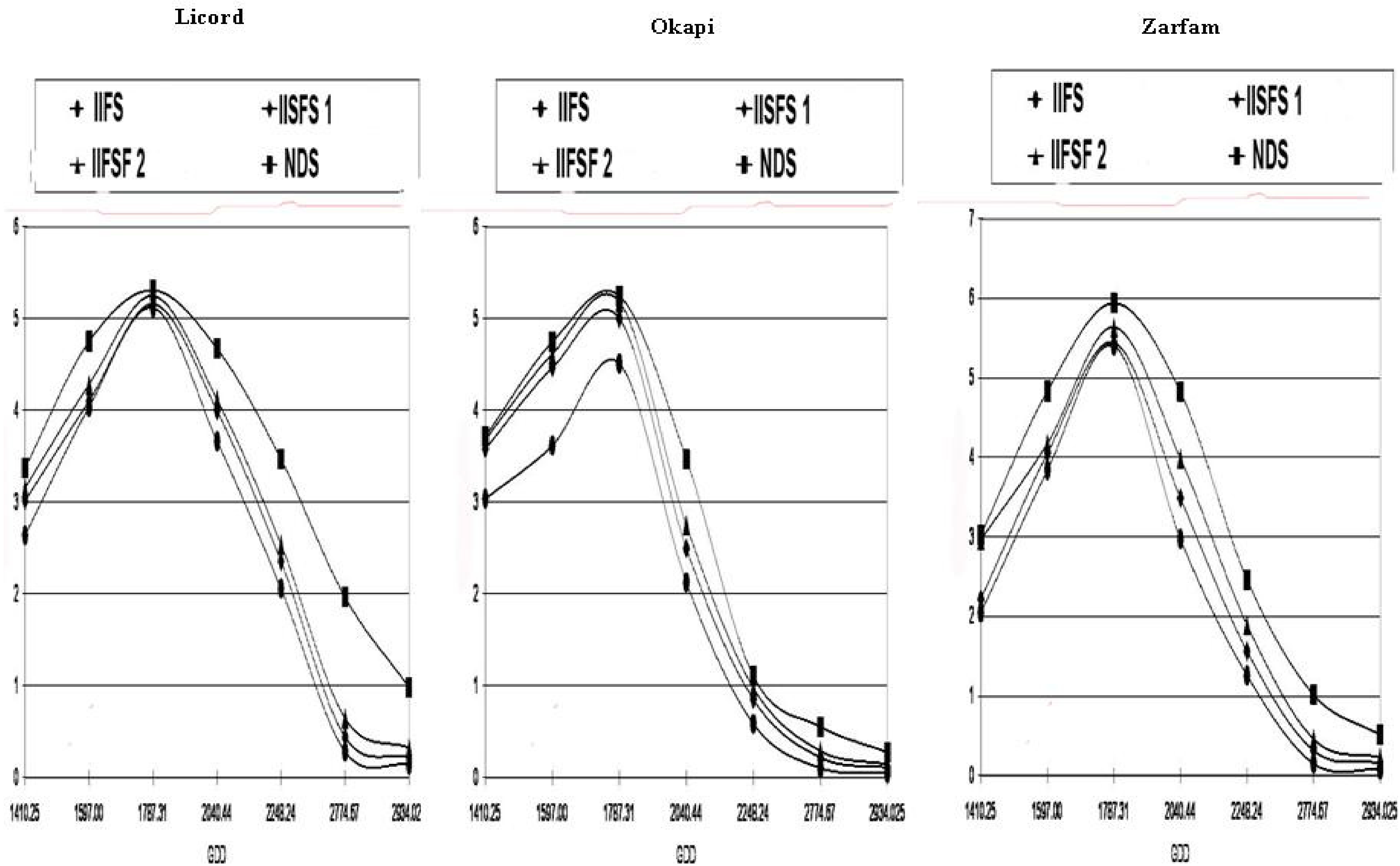

Figure 2. LAI variations in winter rapeseed cultivars under drought stress conditions.

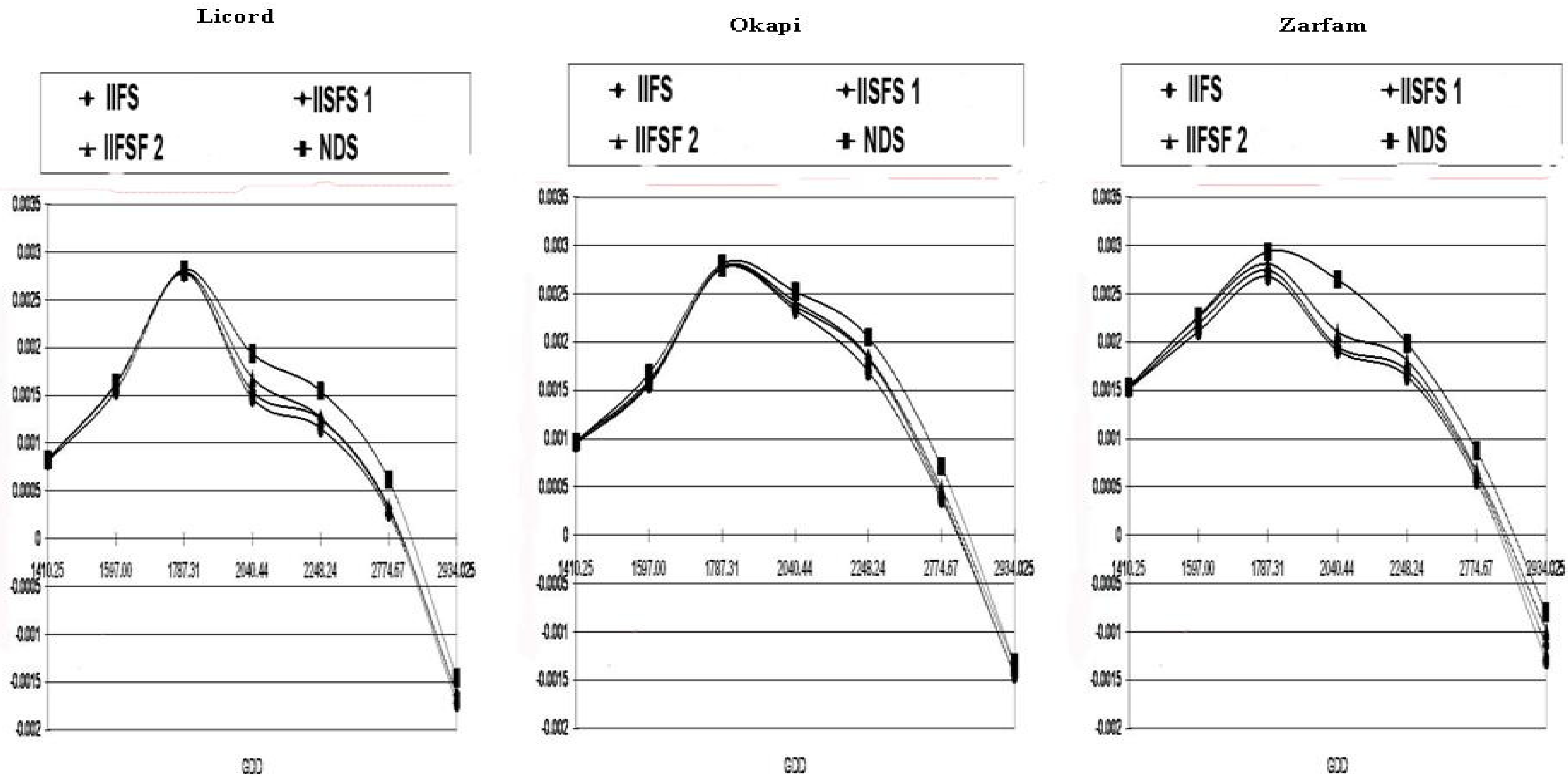

Figure 3. RGR variations in winter rapeseed cultivars under drought stress conditions.

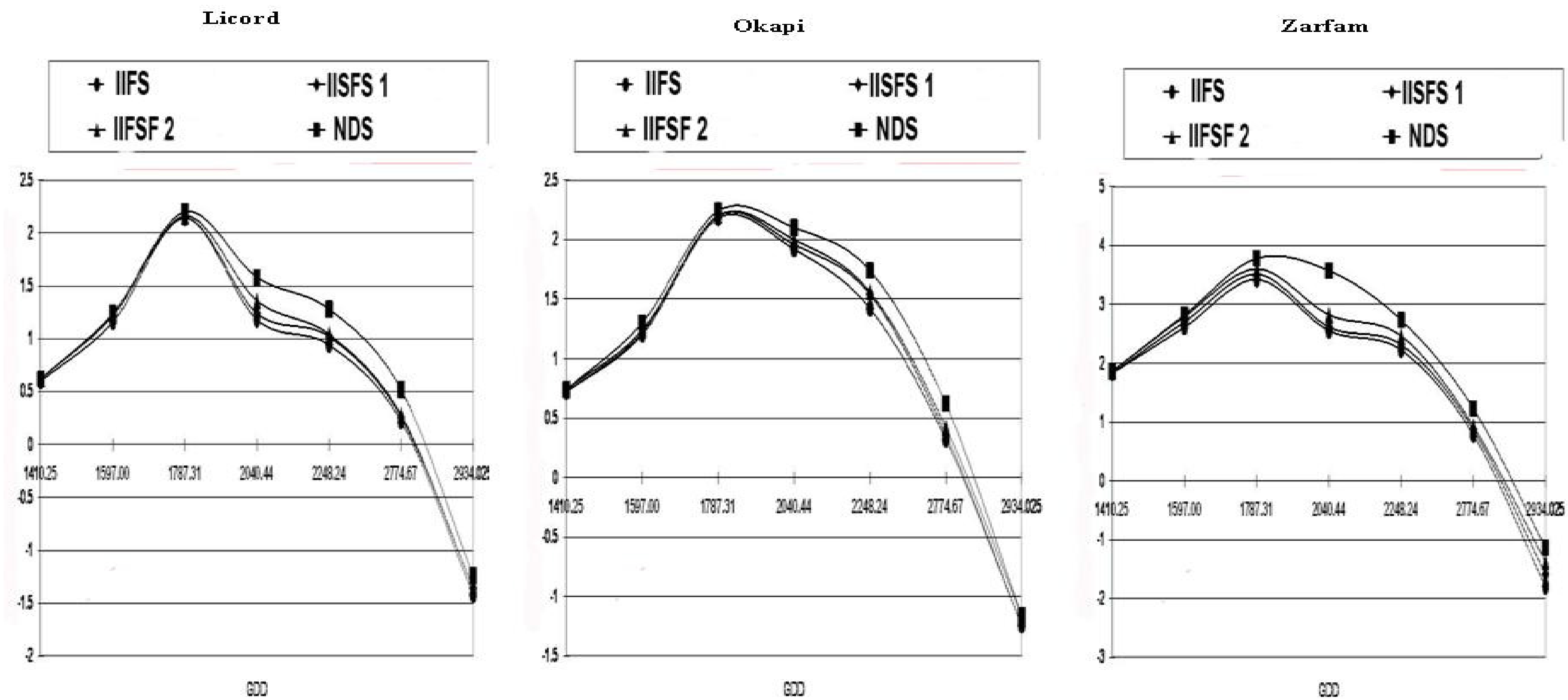

Figure 4. CGR variations in winter rapeseed cultivars under drought stress conditions.

agricultural researchers for management and proper use of irrigation in farming of winter rapeseed under drought stress.

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