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Research Application Summary

Drought stress effect on the leaf relative water content and proline content of safflower genotypes

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Abstract

Drought stress reduces the productivity of many crops especially in arid and semi-arid areas. In such areas the use of tolerant genotypes becomes ideal for increased growth and yield. A greenhouse experiment was conducted to study the effects of drought stress on the leaf relative water content (LRWC) and proline accumulation of various safflower genotypes. Factors under study were drought (stressed and non-stressed plants), three developmental stages, and five safflower genotypes. The results showed that drought stress significantly reduced LRWC and increased accumulation of leaf proline content. However, there were no genotypic differences regarding leaf proline accumulation with increase in stress level. The genotype 'Turkey' was the earliest to experience the highest level of water loss and accumulation of leaf proline content, irrespective of phenological stage. On the contrary, the genotypes 'Gila' and 'Kenya-9819' had the lowest percentage of leaf water loss and no signs of proline accumulation during the early stages of stress induction. These results suggested that the genotype 'Turkey' was more likely to be drought sensitive compared to the genotypes 'Gila' and 'Kenya-9819' which were the most drought tolerant.

Key words: Botswana, drought tolerance, proline accumulation, safflower

Résumé

Le stress hydrique réduit la productivité de nombreuses cultures, en particulier dans les zones arides et semi-arides. Dans ces régions, l'utilisation de génotypes tolérants devient idéale pour une croissance et un rendement accrus. Une expérience en serre a été menée pour étudier les effets du stress hydrique sur la teneur en eau relative des feuilles (LRWC) et l'accumulation de proline de divers génotypes de carthame. Les facteurs étudiés étaient la sécheresse (plantes stressées et non stressées), trois stades de développement et cinq génotypes de carthame. Les résultats ont montré que le stress hydrique réduisait considérablement le LRWC et augmentait l'accumulation de la teneur en proline des feuilles. Cependant, il n'y avait pas de différences génotypiques concernant l'accumulation de proline foliaire avec l'augmentation du niveau de stress. Le génotype « Turquie » a été le premier à subir le plus haut niveau de perte d'eau et d'accumulation de la teneur en proline des feuilles, quel que soit le stade phénologique. Au contraire, les génotypes 'Gila' et 'Kenya-9819' avaient le plus faible pourcentage de perte d'eau foliaire et aucun signe d'accumulation de proline pendant les premiers stades de l'induction du stress. Ces résultats suggèrent que le génotype « Turquie » était plus susceptible d'être sensible à la sécheresse que les génotypes « Gila » et « Kenya-9819 » qui étaient les plus tolérants à la sécheresse.

Mots clés: Botswana, tolérance à la sécheresse, accumulation de proline, carthame

Introduction

Drought stress is one of the most recurring events in the arid and semi-arid regions which hinders crop productivity. The challenges posed by drought stress prompted crop scientists to select drought tolerant plants that can produce economic yields even under water deficit conditions. Some strategies that plants use to cope with drought stress involve a combination of avoidance and tolerance which vary with genotype (Chaves *et al*., 2002). Safflower (*Carthamus tinctorius*) is one of the most drought tolerant among oilseeds crops and can produce a substantial yield in semi-arid areas (Weiss, 2000). It is a multipurpose crop and its cultivation may help diversify the economy and help to improve the socioeconomic status of many smallholder farmers. Although safflower is known to be a drought tolerant crop, its genotypes have a varying degree of tolerance to drought stress. This necessitates the selection of the most drought tolerant genotypes. Therefore, the objective of this study was to evaluate the leaf relative water content (LRWC) and proline content of safflower genotypes under drought stress.

Methodology

A greenhouse experiment was undertaken at Botswana University of Agriculture and Natural Resources, Sebele during 2019/2020 planting season. The experiment was arranged in a 2 x 3 x 5 factorial design. Factors under study were drought levels (stressed and non-stressed plants), three developmental stages (rosette, branching, and flowering), and five safflower genotypes (Gila, Kenya-9819, PI-537636, Turkey and Sina). Drought stress was initiated at the beginning of the rosette, branching, and flowering stages, respectively, by withholding water. In the non-stressed treatment, plants were irrigated throughout the crop cycle to satisfy plant water need. The data was collected weekly. The dependent variables collected were LRWC and proline content. Data collected was subjected to three-way analysis of variance (ANOVA) using Sigmaplot programme version 11.0. Treatment means were compared using the Fisher's least significant difference (LSD) procedure at significance level of 5%.

Results and Discussions

There was no genotypic difference in the LRWC and proline accumulation. At the rosette and branching stages, the genotype 'Gila' showed lower signs of water loss while the genotype 'Kenya-9819' exhibited lower water loss during the flowering stage, which demonstrated drought tolerant at those stages. Drought stress increased the accumulation of proline content of safflower as compared to the control which had less than 1 µmole/g of proline (Figure 1). At the rosette stage, the proline content increased with the stress duration among all the genotypes. Plants of the genotype 'Turkey' wilted before they reached day 28 of stress induction during the branching stage. A decline in the proline content of stressed turkey at day 21 explained why the genotype 'Turkey' was not able to reach day 28 compared to other genotypes. Leaf relative water content was reduced by drought stress at all the developmental stages studied but the effect was more pronounced during flowering (Figure 2). In the current study genotypes, which exhibited a lower proline content a week after stress induction also had higher LRWC and a negative correlation of -0.62. A similar indirect correlation between LRWC and proline was also reported by Slabbert and Krüger (2014). This may imply that a reduction in LRWC stimulated the accumulation of leaf proline content.

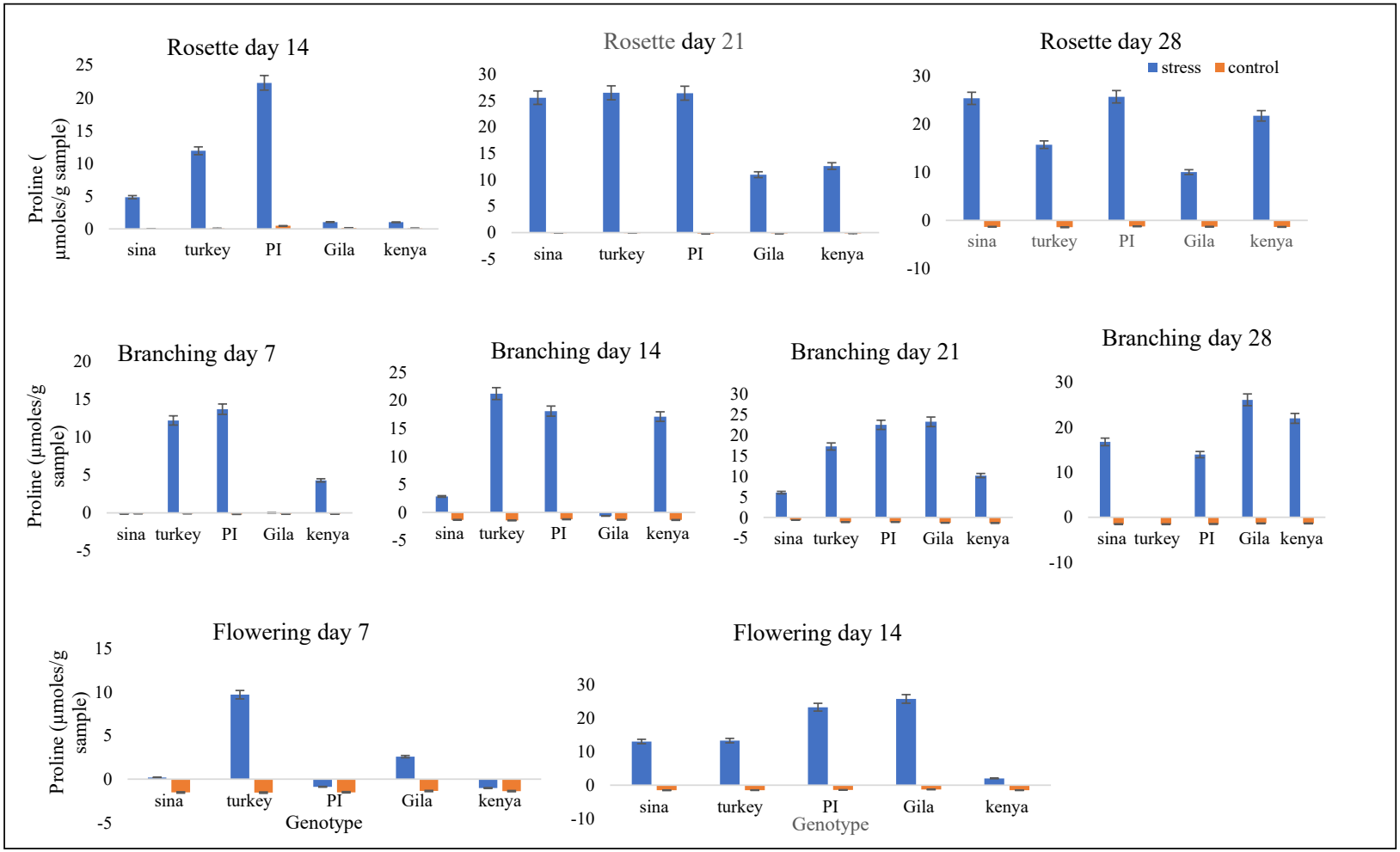

Figure 1. Drought stress effect on proline content of different Safflower geneotype at different growth stages

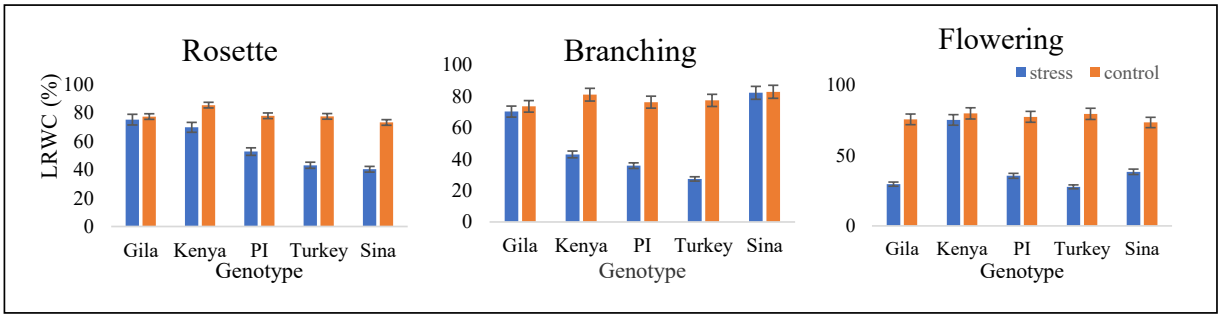

Figure 2. Drought stress effect on LRWC of safflower genotypes at different developmental stages

Conclusions and Recommendations

Drought stress caused a reduction in LRWC and increased proline content of safflower irrespective of genotype or stage of development. The genotype 'Turkey' was found to be drought sensitive while the genotypes 'Kenya-9819' and 'Gila' were the most drought tolerant. It was recommended that this study be tested under field conditions and more antioxidants be elucidated to help in the selection of drought tolerant genotypes.

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