Exogenous selenium as a potent modulator of antioxidants, osmo-protectants, lipid peroxidation and wheat grain yield under terminal heat stress

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ABSTRACT

Purpose: The coincidence of terminal heat stress and late grain filling stage is a major constraint in wheat. The objectives of this study were to determine the thermo-sensitivity of reproductive stages of wheat, optimize the application of exogenous selenium to wheat and explore the correlation of biochemical and agronomic attributes of wheat under heat stress.

Methods: A 3 x 5 factorial experiment was laid out in a randomized complete block design with split arrangement and replicated thrice. The main plots were comprised of 3 levels of heat stress, viz. H_0 = No heat stress; H_1 = Heat from spike to grain filling. H_2 = Heat from flowering to grain filling, while subplots included 5 levels of foliar selenium, Se_0 = Control (water spray); Se_{25} = 25 mg L^{-1}; Se_{50} = 50 mg L^{-1}; Se_{75} = 75 mg L^{-1} and Se_{100} = 100 mg L^{-1}.

Results: More detrimental responses were observed under H_1 compared to H_2. Under H_0, the application of Se at 75 mg L^{-1} and 100 mg L^{-1} significantly increased superoxide dismutase, peroxidase, soluble proteins, and osmotic potential, while reduced malondialdehyde compared to other doses of Se. Under H_1 and H_2, Se treatment (100 mg L^{-1} Se) resulted in a significant increase in the recorded biochemical attributes and a significant reduction in malondialdehyde. Similar and higher plant height, spike length and grain yield were observed at 75 mg L^{-1} Se and 100 mg L^{-1} Se, compared to other doses.

Conclusion: Our findings suggest that wheat spike initiation was more sensitive to heat stress than flowering. While the application of 75 mg L^{-1} Se was beneficial to plants under ambient environmental conditions, its responses were more promising under heat stress. The recorded biochemical attributes were closely related to the agronomic traits of wheat.

Keywords: antioxidants, osmo-protectants, water relations, thermos-sensitivity, reactive oxygen species, lipid free radicals, correlation

INTRODUCTION

Incessant rise in temperature is a serious menace around the globe to accomplishing the potential productivity of field crops. Anthropogenic activities mediated emission of radiative force of 2.72 W m^{-2} was recorded in the year 2019 compared to the 0.43 W m^{-2} observed in 2011. Whereas, the average rate of heating of the earth was enhanced from

0.50 W m^{-2} during 1976-2006 to 0.79 W m^{-2} during 2006-2018. Wheat production is not immune to these global climate changes and continually rising temperatures. Therefore, there is an urgent need to tackle heat stress in wheat to achieve global food security.

METHODOLOGY

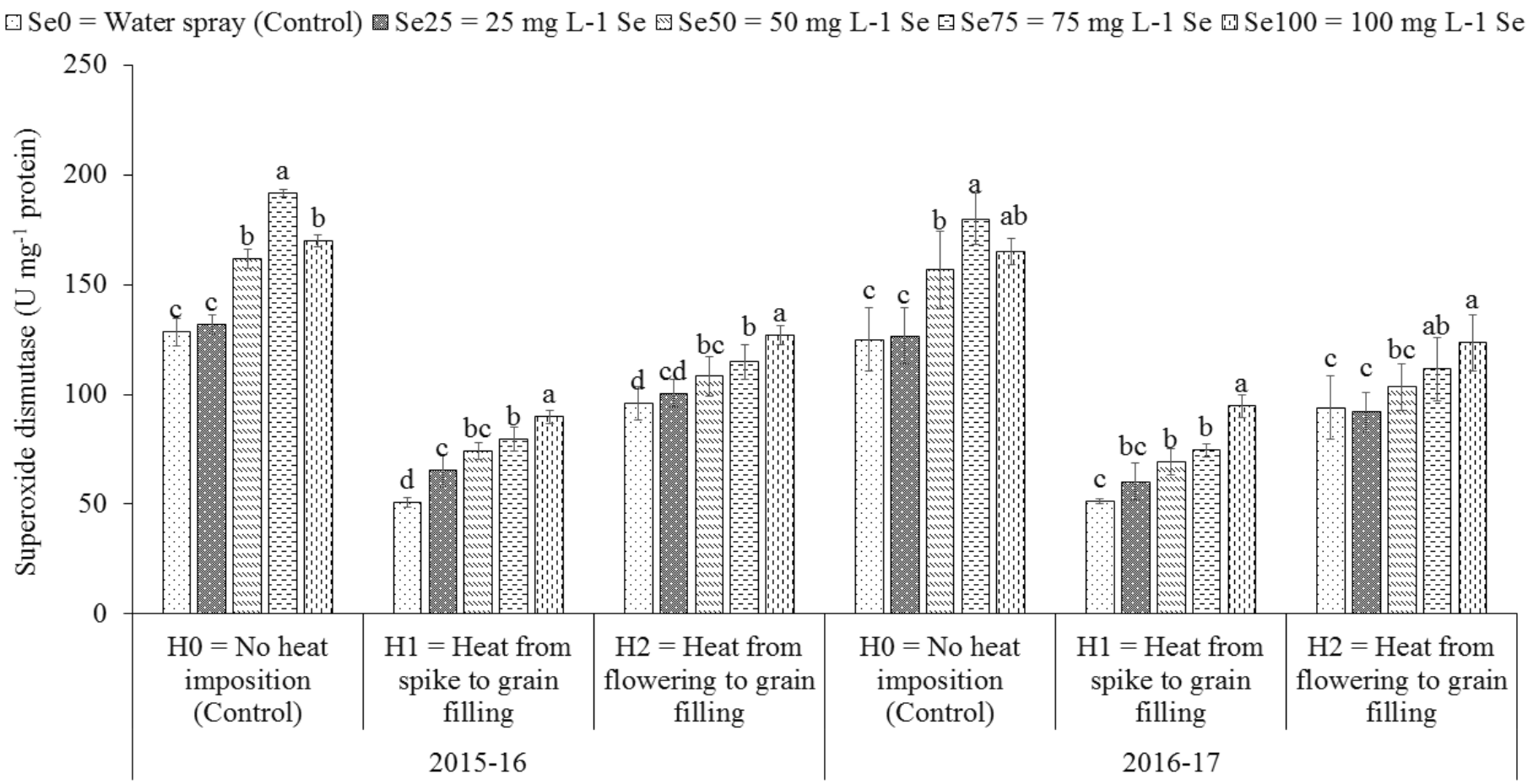
The field trials were conducted for two years at the Agronomic Research Area, University of Agriculture, Faisalabad (31° - 26'N; 73°- 06'E; 184.4 m). Heat stress was applied by making walk-in tunnels (height 4 m) using perforated polythene sheets. The study was conducted in a randomized complete block design (RCBD) under split arrangement with three blocks. Heat stress was applied in the main plot and selenium in sub-plot.

Superoxide dismutase was measured as SOD units inhibiting the photochemical reduction of nitro blue tetrazolium (NBT). Peroxidase content was quantified as POD units leading to oxidation of guaiacol.

Observations were recorded using standardized procedures and subjected to analysis of variance to determine significance of different sources of variation. Once the ANOVA showed a significant treatment effect ($P \leq 0.05$), Tukey's Honestly Significant Difference (Tukey's HSD) ($p \leq 0.05$) test was used to compare treatment means for different response variables.

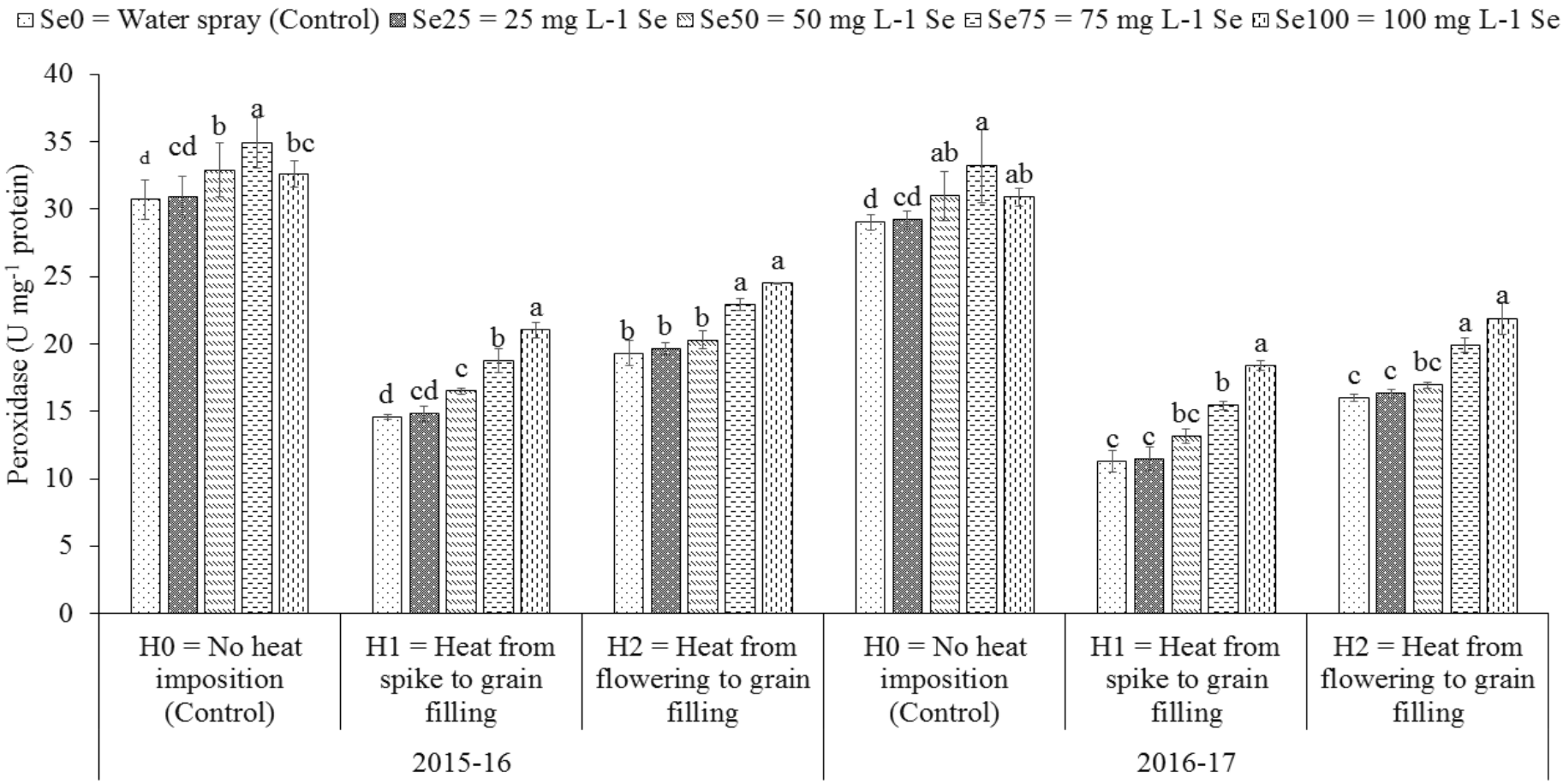
RESULTS

Fig. 1: Effect of foliar applied selenium on superoxide dismutase contents of heat stressed wheat



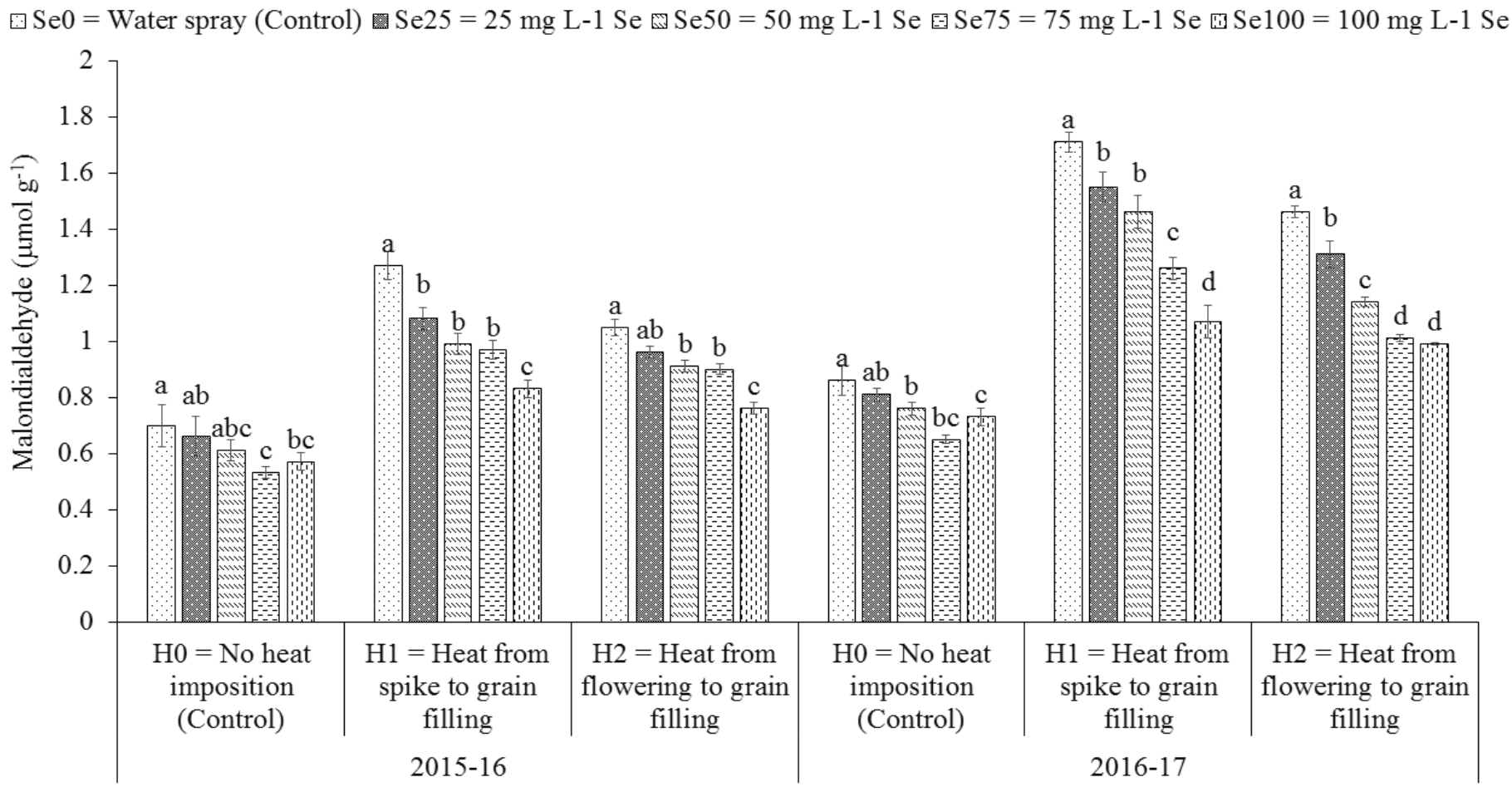
Vertical bars above means represent standard error

Fig. 2: Effect of foliar applied selenium on peroxidase contents of heat stressed wheat



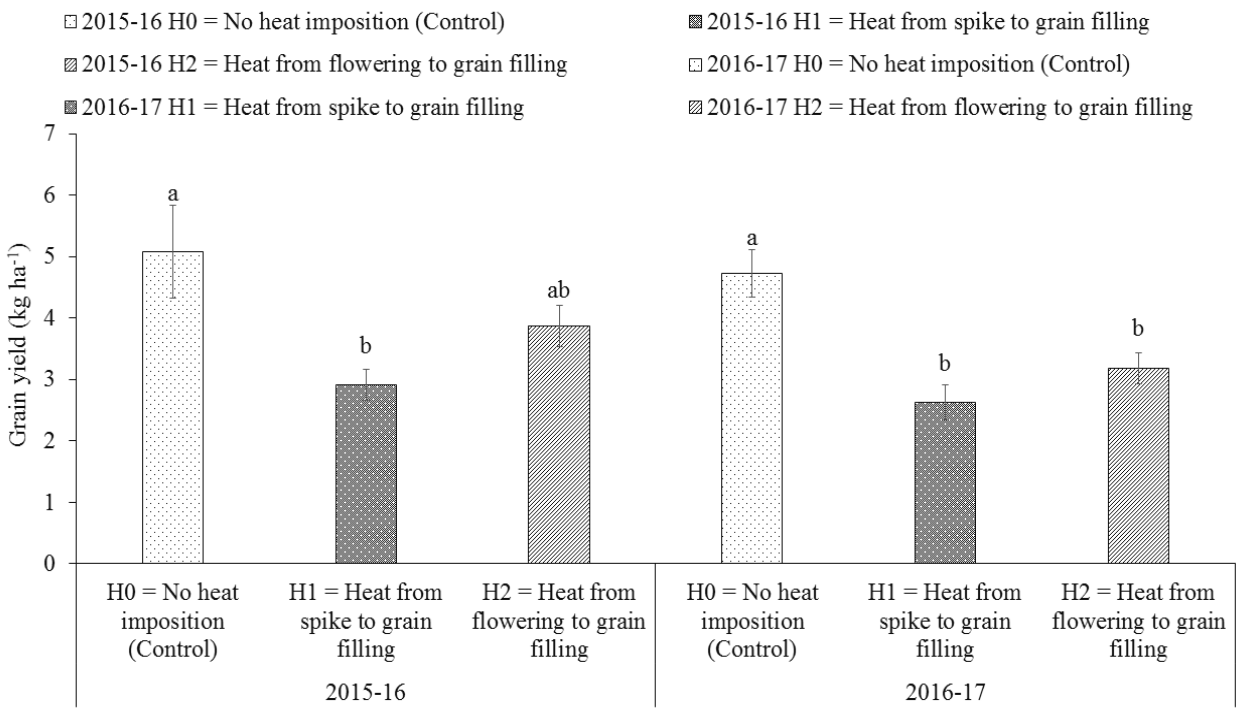
Vertical bars above means represent standard error

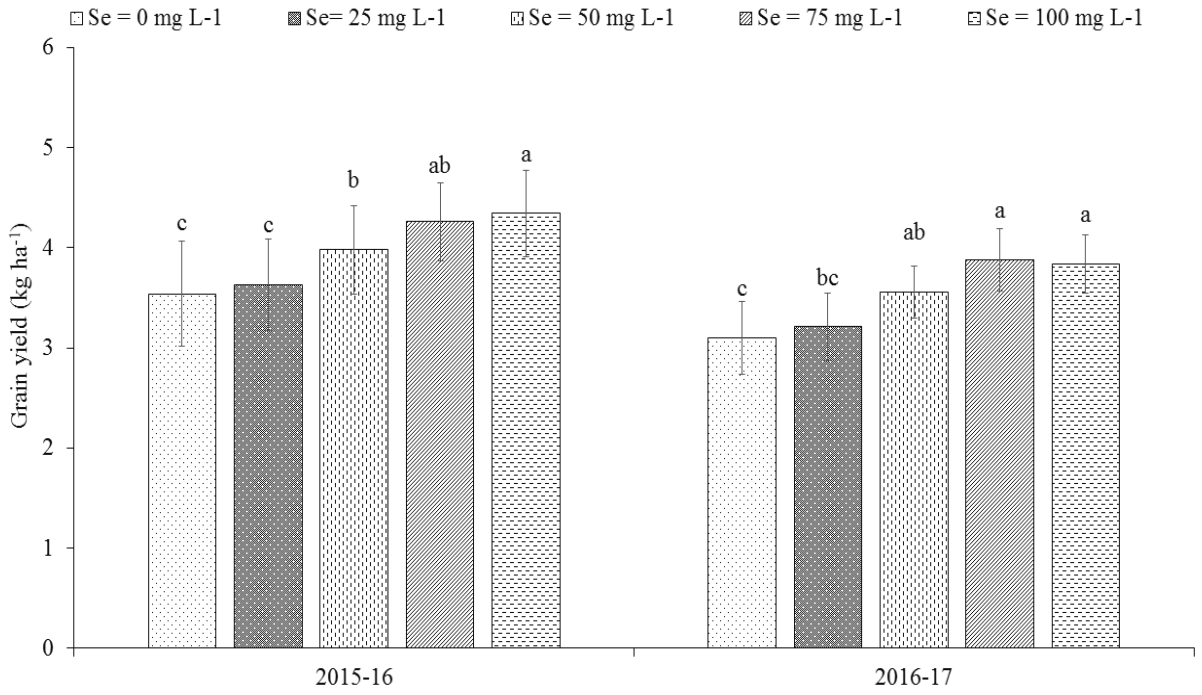
Fig. 3: Effect of foliar applied selenium on malondialdehyde contents of heat stressed wheat



Vertical bars above means represent standard error

Fig. 4: Effect of heat stress on grain yield of wheat





Vertical bars above means represent standard error

CONCLUSION

Wheat spike initiation was more sensitive to heat stress than flowering. While the application of 75 mg L^{-1} Se was beneficial to plants under ambient environmental conditions, its responses were more promising under heat stress. The recorded biochemical attributes were closely related to the agronomic traits of wheat.

REFERENCE

Muhammad Shahid, Muhammad Farrukh Saleem, Amna Saleem and Haroon Zaman Khan. 2022. Exogenous selenium as a potent modulator of antioxidants, osmo-protectants, lipid peroxidation, and wheat grain yield under terminal heat stress. Journal of Soil Science and Plant Nutrition. https://doi.org/10.1007/s42729-022-00959-w.