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EVALUATION OF CHLOROPHYLL CONTENT INDEX AND NORMALIZED DIFFERENCE VEGETATION INDEX AS INDICATORS FOR COMBINE EFFECTS OF DROUGHT AND HIGH TEMPERATURE IN BREAD WHEAT GENOTYPES

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ABSTRACT
Wheat (*Triticum aestivum* L.) a staple food crop, is of great commercial importance. Its production is restricted due to multiple environmental stresses. The aim of this study was to investigate the effect of high temperature, drought and their combination effect on biomass and yield in addition to the stress adaptive traits like canopy temperature (CT), chlorophyll content (SPAD) and normalized difference vegetative index (NDVI). This study was conducted during winter season of mid-November to April, 2015-16 and 2016-17 with eight selected wheat genotypes *viz*. AKAW-3717, C-306, DHTW-60, HD-2967, HTW-11, Kundan, WH-730 and WH-1105. In control (irrigated) and drought-stressed experiments, genotypes were sown at optimum planting date, while for heat-stressed experiment sowing date was delayed. Experiments were conducted in randomized complete block design with five replications. Chlorophyll provide an assessment of leaf nitrogen, an essential plant nutrient, due to the close relationship between leaf chlorophyll and leaf nitrogen. Combine effects of these stress dramatically increased canopy temperature and reduced chlorophyll content and normalized difference vegetation index in sensitive genotypes (WH-1105 and HD-2967) whereas in tolerant genotypes (DHTW-60 and C-306) higher SPAD and NDVI under drought and heat stress conditions was observed. Genotypes found tolerant against stress has cooler canopy by maintaining the canopy temperature. The findings form this study showed that wheat genotypes higher in SPAD and NDVI also had higher yield, DHTW-60 and C-306 could be used as genetic stock to develop wheat tolerant varieties in breeding programs.

KEYWORDS: Wheat, drought, high temperature, chlorophyll and NDVI.

INTRODUCTION

High-throughput remote sensing phenotyping tools are a rapid and non-destructive methods to plant screening in both field and controlled conditions for high temperature and drought (White *et al.* 2012; Araus and Cairns, 2014) with important consequences for crop improvement. Three recent advanced and non-distractive commonly used traits for high-throughput screening are the normalized difference vegetation index (NDVI), chlorophyll content index (SPAD) and canopy temperature (CT) (Hao *et al.* 2015). NDVI is calculated using wavelengths within the NIR (near infrared) and VIS (visible) regions of the electromagnetic spectrum. NDVI relates to leaf chlorophyll content, leaf nitrogen and ultimately the photosynthetic capacity of the plant (Tattaris *et al.* 2016). CT, which is measured from emitted infra- red radiation, can be used as a tool to indirectly evaluate the transpiration rate, water status and stomatal conductance of a plant (Peñuelas *et al.*1992) while NDVI can estimate relative crop biomass at different growth stages (Babar *et al.* 2006) as well as N deficiency and crop senescence rate (Olivares-villegas *et al.* 2007).

The heat and drought tolerance of wheat can be determined through evaluation of yield performance and physiological traits under individual and combine stress conditions (Reynolds *et al.* 2001; Zhao *et al.* 2007). Chlorophyll content, normalized difference vegetation index (Reynolds *et al.* 1994; Fischer *et al.* 1998) and canopy temperature (Reynolds *et al.* 1994; Amani *et al.* 1996) has also been used as a measure of stress tolerance (Mason *et al.* 2011). Chlorophyll content, normalized difference vegetation index and stay-green trait has also been reported to be associated with heat and drought tolerance in wheat (; Feng *et al.* 2014; Cao *et al.* 2015). The visual observation of stay-green trait has been associated with maintenance of leaf chlorophyll and photosynthetic capacity (Fokar *et al.* 1998). The relationship between NDVI, SPAD and CT under stress conditions and grain yield is well established (Singh *et al.* 2003; Quiring *et al.* 2010). High chlorophyll content, cooler canopy temperature (CT) and maximum normalized difference vegetation index is associated with both drought and heat tolerance (Ramya *et al.* 2015: Munjal and Dhanda, 2016). The aim of present study was to screen the wheat genotypes under independent and combined effects of drought and high temperature on greenness of plant and grain yield under timely, late and very late sown condition.