Crop Water Stress as Estimated by Water Deficit Index and Some Popular Drought Indices

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Drought index is a measure to quantify drought, which basically results from precipitation shortage. Currently, many drought indices/models are being used to quantify agricultural drought, such as Palmer Drought Severity Index (PDSI), Palmer Z-index (ZI), Standardized Precipitation Index (SPI), Lawn and Garden Moisture Index (LGMI), Keetch and Byram Drought Index (KBDI), and Decision Support Systems for Agro-technology Transfer (DSSAT). While some of these indices have not been designed basically for agricultural purpose; others have limited value as they do not quantify water stress for all the crops in general. To fill this gap, a new index – Water Deficit Index (WDI) – has recently been developed for the reference crop, grass, as a generic index for quantifying crop water stress for various crops. As this is a new index, it is yet to be explored how reliable its water stress estimations would be for various crops. The basic purpose of this study was to explore the potential of using WDI as an agricultural drought index through comparing its water deficit estimations with those of the above indices. Two locations, Lee, south Florida and Blairsville, north Georgia, each with 56 years of historical weather data, were selected for the study. While the values of WDI, LGMI, and DSSAT were simulated using the weather data, the values of PDSI, ZI, SPI, and KBDI for the corresponding years and locations were collected from the internet. These simulated and collected values were used to compare WDI with the other indices. The LGMI showed significantly more water stress in both the locations than that estimated by WDI, which was because of more evapotranspiration (ET) loss calculated by the less realistic ET function of LGMI. In terms of estimating crop water stress at full canopy, WDI showed a good agreement with DSSAT, a reliable and popular model. While PDSI reflected only long-term droughts - 1 in every 3 to 4 years and of 3 to 4 years' duration, WDI reflected short-term droughts, monthly or seasonal – a characteristic of agricultural drought. Unlike PDSI, ZI made short-term predictions like WDI, but was controlled by precipitation only. However, WDI did not just depend on precipitation but was also influenced by additional factors such as temperature. For instance, WDI did not show deficit even at low rainfall in January due to low temperature; but showed some stress in summer even at high rainfall because of high temperature, which seems obvious. The SPI behaved exactly like ZI as both indices are based on monthly precipitation anomalies. Although KBDI and WDI showed a similar water stress trend, the response of WDI was quicker than that of KBDI. Also, KBDI values were always greater than those of WDI, which was because KBDI does not allow 5 mm of daily precipitation to fall on the ground when the canopy is dry. In conclusion, WDI estimations are more realistic than those of LGMI and as reliable as those of DSSAT when the canopy is full. The WDI is more reliable for crops than is PDSI as the former reflects short-terms spells and the latter does not. WDI is more suitable to crops than are SPI and ZI because the former accounts for essential crop factors. Compared to WDI, KBDI is less applicable to agriculture because it assumes that a considerable amount of precipitation is intercepted by the dry tree canopy, which might be true for forest but is less realistic for crops. These results indicate that WDI has a good potential to be used as a reliable tool for quantifying agricultural drought.

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