Leaf wettability and leaf angle affect air-moisture deposition in wheat for self-irrigation

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Introduction

Climate change and the ever-increasing world population affect the water sources and reduce irrigation water supply. Means of translating scarce water sources like air moisture has gained attention to be utilized for crop irrigation. The present study was designed to explore and architect the wheat plant for self-irrigation through exploiting the leaf surface structures like leaf hydrophilicity, leaf-stem angle supported by optimum leaf rolling.

Material and methods

Genotypes with all possible combinations of leaf angle selected from diverse germplasm (1796 genotypes).

Morpho-physiological characterization:

- Leaf traits: leaf angle and leaf rolling characterized at booting, and anthesis stages
- Physiological traits measured net photosynthetic rate (P), stomatal conductance (gs), photosynthetic water use efficiency (WUE), and transpiration rate (T).
- Morphological traits measured flag leaf attitude, flag leaf twist, plant height, days to heading and maturity, peduncle length, and yield parameters such as spike length, spike weight, spikelets per spike, seeds per spike and grain yield

Stem flow and leaf wettability:

- Stem-flow quantified using a collector apparatus (Fig 1).
- Soil moisture measured by portable soil moisture meter TDR 350
- Leaf wettability measured using the contact angle device (OCA 25, data-physics instruments GmbH, Germany). (Fig 2).

Statistical analysis: variability analysis, frequency distributions, genotype-trait biplot analysis, heat map based on clustering and Pearson correlation.

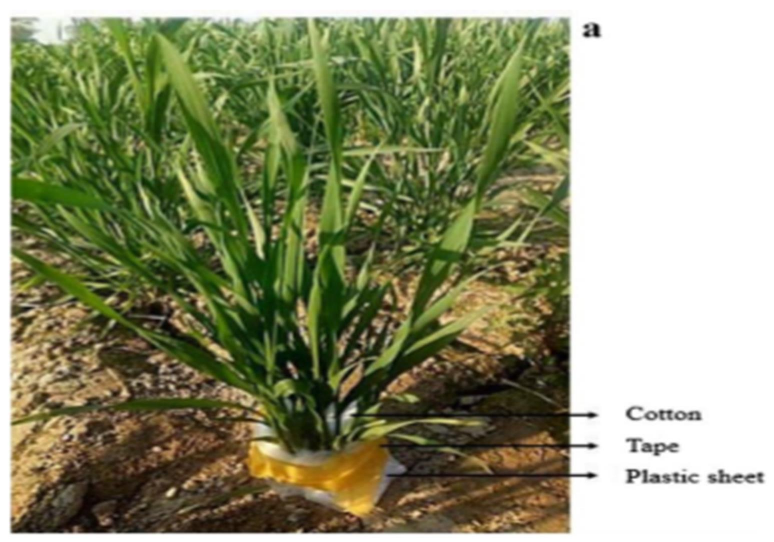

Fig 1. Collector setup under field conditions

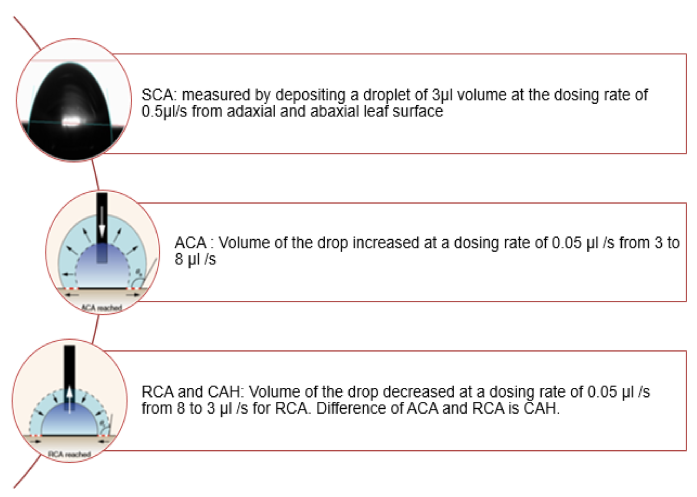

Fig 2. Contact angle measurements SCA: Static contact angle; ACA: Advancing contact angle; RCA: Receding contact angle

Results

- Genotype 7 with features erect leaf angle, hydrophilic leaf surfaces, minimum contact angle hysteresis and maximum soil moisture content.
- Significant negative correlation among leaf wettability, stem flow water, and leaf angle

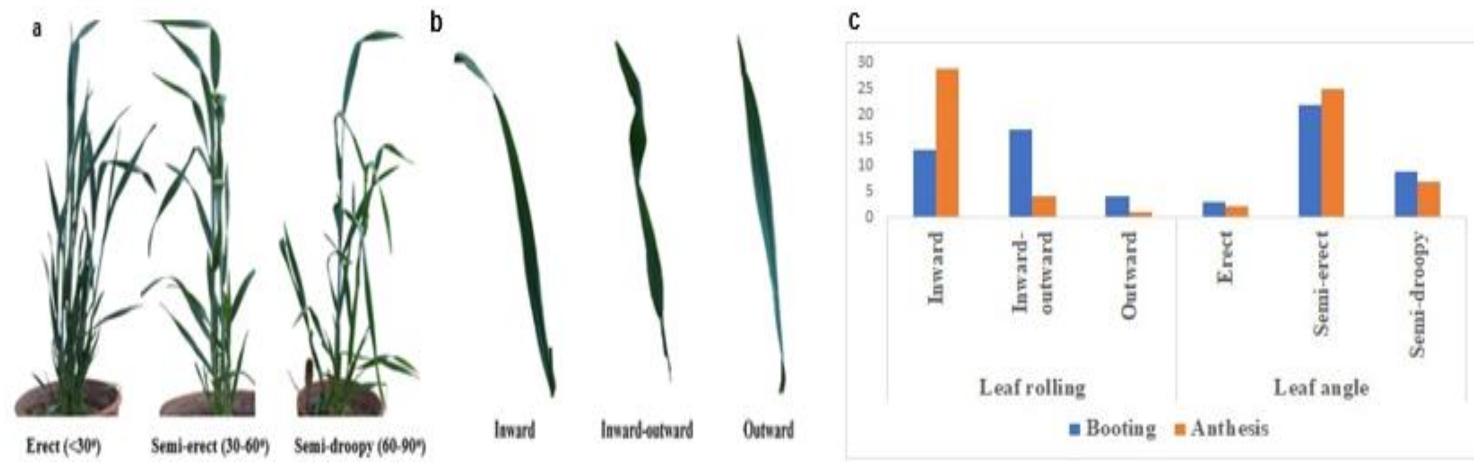

Fig 3. The dynamics of leaf angle across thirty-four wheat genotypes. **a.** Photographs of wheat genotypes categorized according to their a. leaf-stem angle. **b.** leaf rolling. **c.** Frequency distribution of the leaf angle and leaf rolling at the booting and anthesis stage.

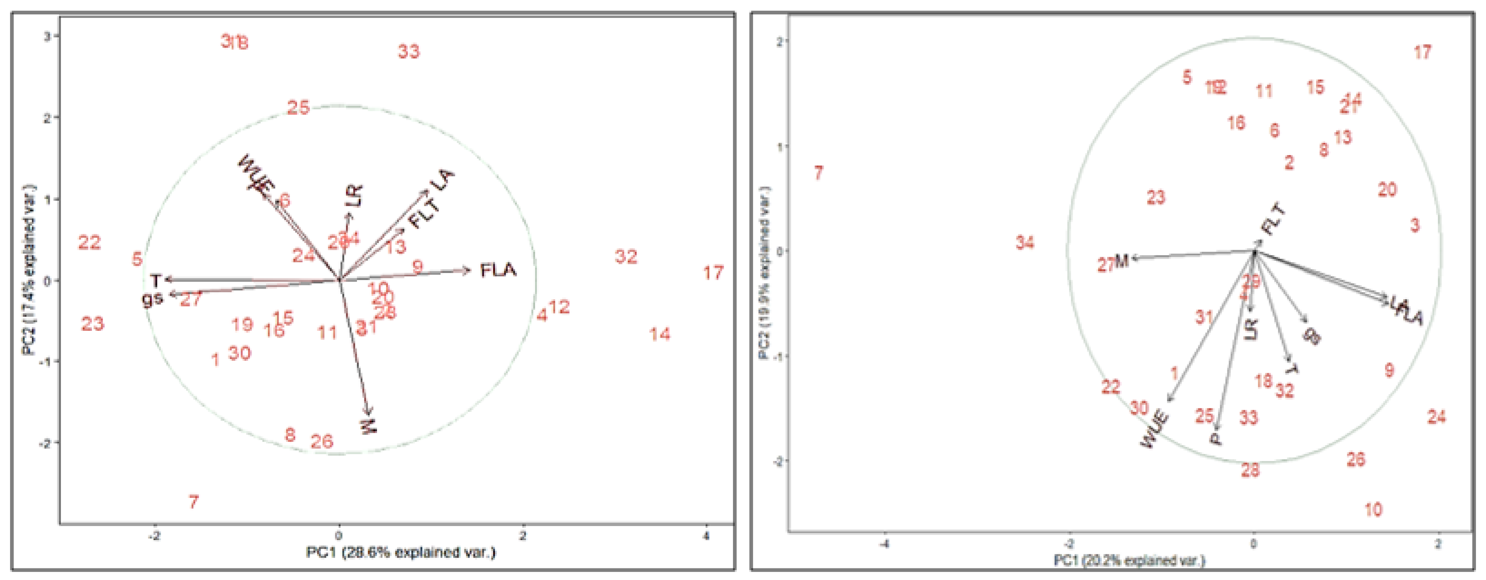

Fig 4. Biplot analysis of thirty-four wheat genotypes for leaf angle, leaf rolling, soil moisture content and physiological parameters at the booting stage (left side) and the anthesis stage (right side).

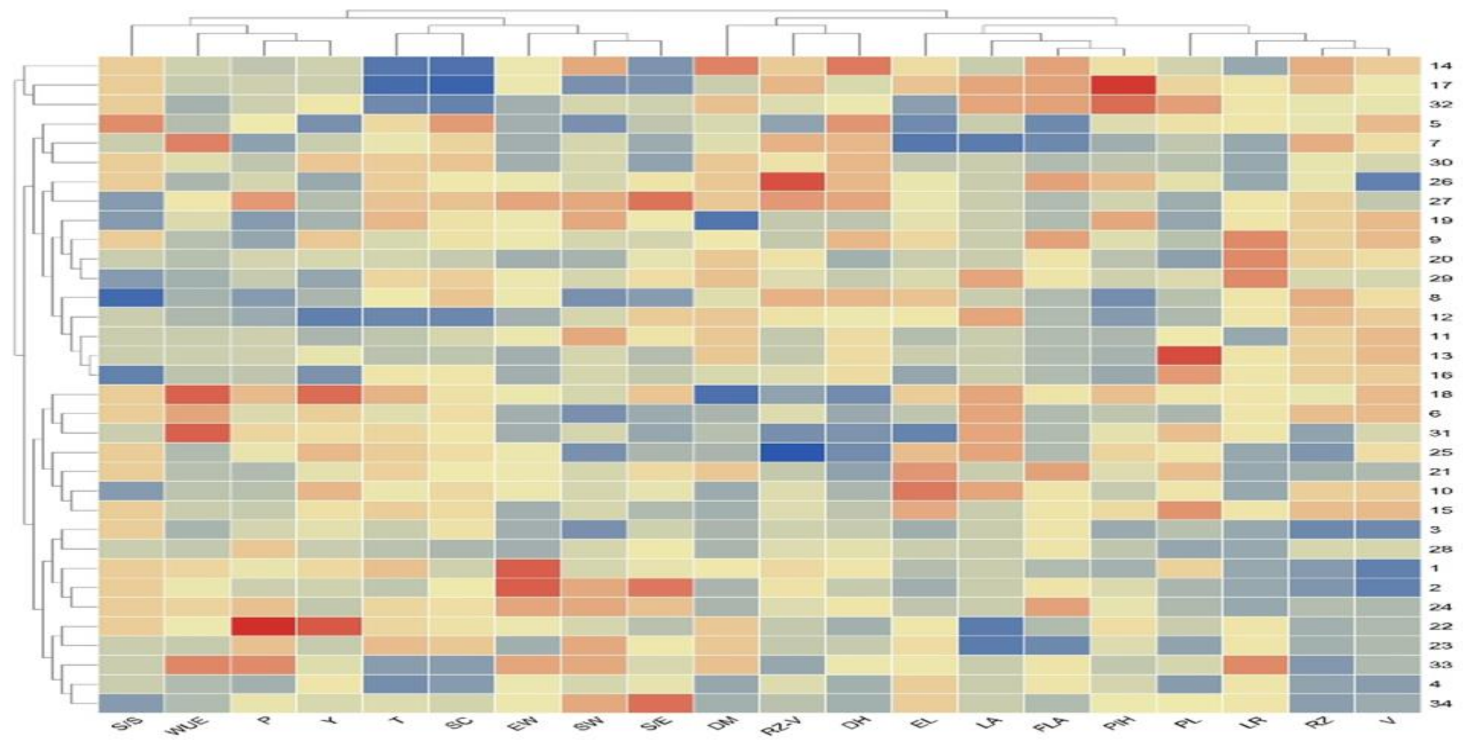

Fig 5 Heat map for morpho-physiological and yield traits for thirty-four wheat genotypes.

Results

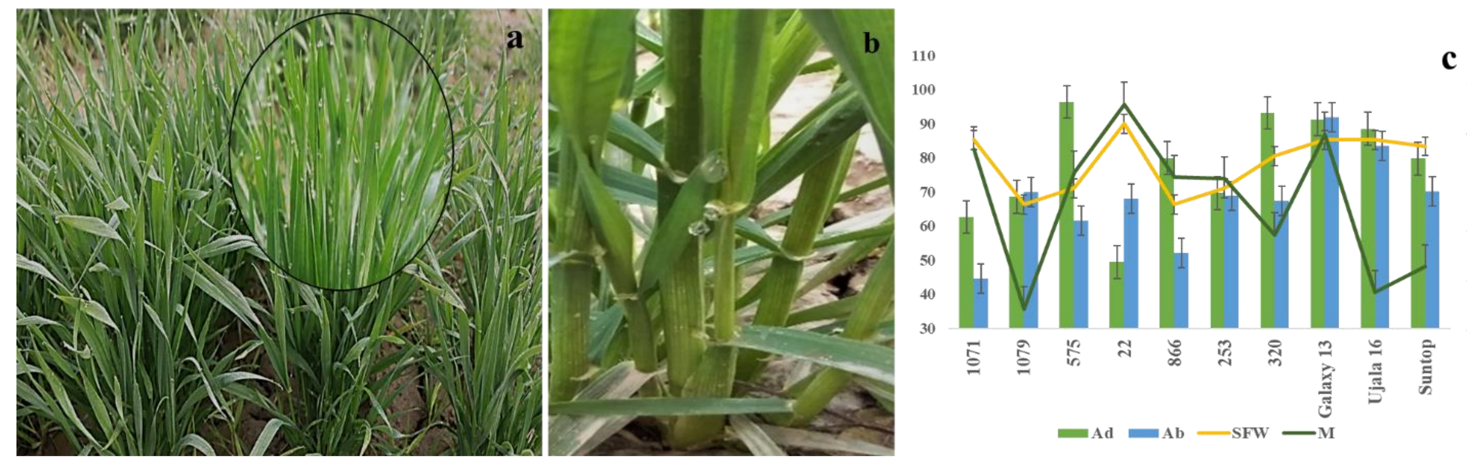

Fig 6. Stem flow mechanism of water channeling in wheat genotypes under natural field conditions. **a.** Water captured by the wheat genotype in a plot under natural environment, the circle shows zoom-in picture of the leaves bearing water droplets. **b.** Movement of water droplets along the stem towards the base wetting the root zone. **c.** Quantified water collected through stem flow

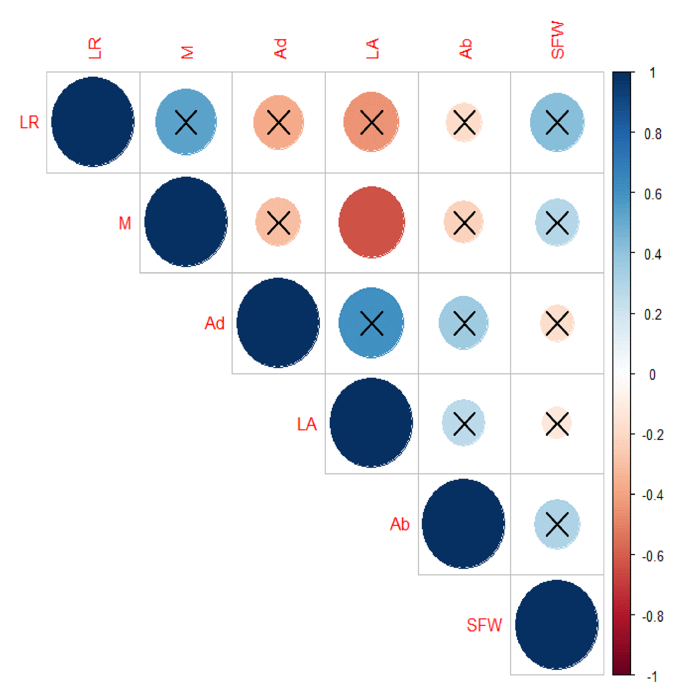

Fig 7. Association between the leaf traits (leaf angle and leaf rolling), surface wettability (adaxial and abaxial surface), soil moisture content and stem flow water.

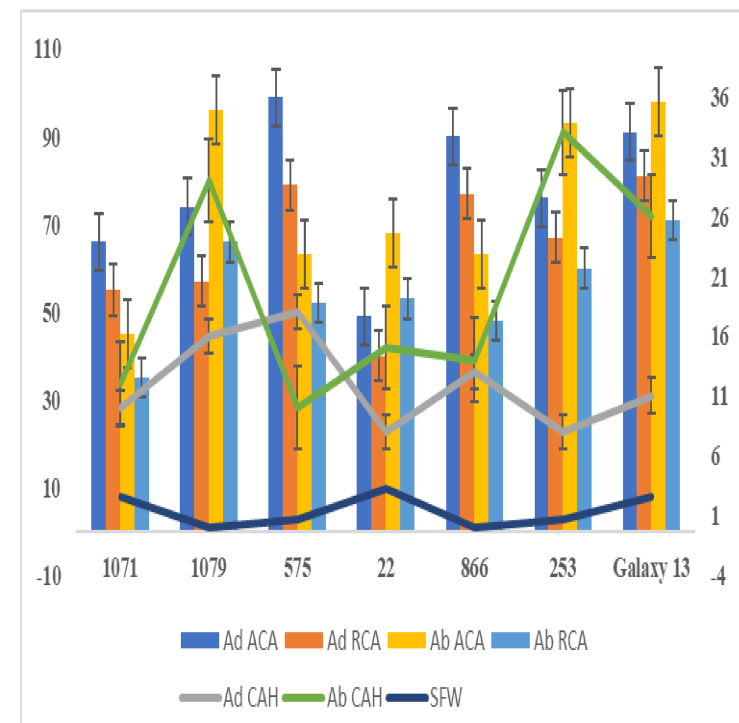

Fig 8. Advancing, receding contact angle of abaxial and adaxial leaf surface, contact angle hysteresis and stem flow water for the selected seven genotypes.

Conclusion

- Leaf hydrophilicity increase the surface wettability and droplet coalition
- Erect leaf to stem angle enhances the stem flow of water drops
- This mechanism can be engineered in wheat and other cereal crops for self-irrigation as a drought tolerance strategy against climate change

Acknowledgments

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