Evidence for significant, genotype-dependent and circadially-controlled nocturnal transpiration among maize NAM parents

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INTRODUCTION

Recent studies have shown that nocturnal transpiration (TR_N) in plants is non-negligible and can represent a substantial amount of overall daily water use, dependently on the nighttime environmental conditions. TR_N can represent up to 55% of daytime transpiration in wheat when nighttime vapor pressure deficit (VPD) is high (2kPa, Schoppach et al 2014). In maize, there are conflicting reports regarding the existence of TR_N which might be an indication of strong genetic variability of the trait. Therefore, this study was undertaken to explore the extent and magnitude of TR_N among 25 maize diversity panel (Nested Association Mapping parents) along with B72 and Mo17.

A study on *Eucalyptus* (Resco de Dios et al. 2016) suggested that circadially regulated pre-dawn stomata conductance improves overall fitness under water scarcity conditions. However, such observation was not made on crops. Here a second goal of this study was to investigate potential circadian control of the TR_N trait and the resulting physiological tradeoffs in maize.

METHODS

- Three independent experiments were carried out on maize NAM parents (McMullen et al 2009).
- Plants were phenotyped using the GPS platform (see poster 100 for details on the platform) for TR_N.
- During the nighttime period which spanned between 2100 to 0700 hrs, the temperature, VPD and PPFD were maintained at approx. 20 °C, 0.9 kPa and 0 µmol m^{-2} s^{-1}, respectively.
- Time courses for TR_N were smoothed using moving averages calculated over 5 consecutive observations.

Table 1. Environmental conditions imposed inside growth chambers during TR_N measurement for each experiment.

Experiment	Nighttime conditions	
	Temperature (°C) ± S.E.	VPD (kPa) ± S.E.
E1	20.2 ± 0.1	0.8 ± 0.02
E2	20.1 ± 0.1	1.0 ± 0.02
E3	20.1 ± 0.1	0.8 ± 0.10

RESULTS

1. Maize exhibits non- null, genotype-dependent TR_N

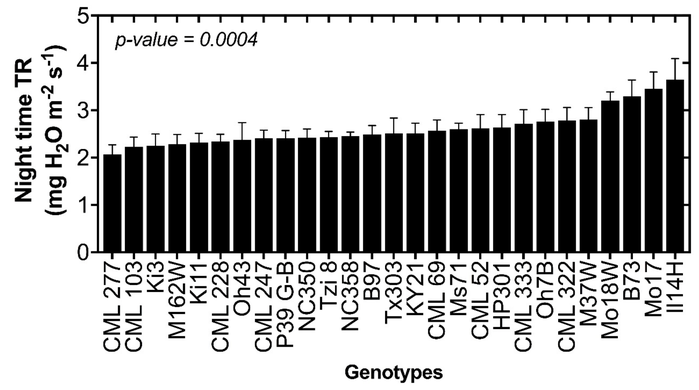

Figure 1. Average rate of nocturnal transpiration among studied 27 maize genotypes. Names of genotypes corresponding to each bars are reported. Each bar represents average values from three experiments (n = 11-12, ± S.E.).

2. Maize TR_N represents up to 18% of daytime TR measured under low VPD

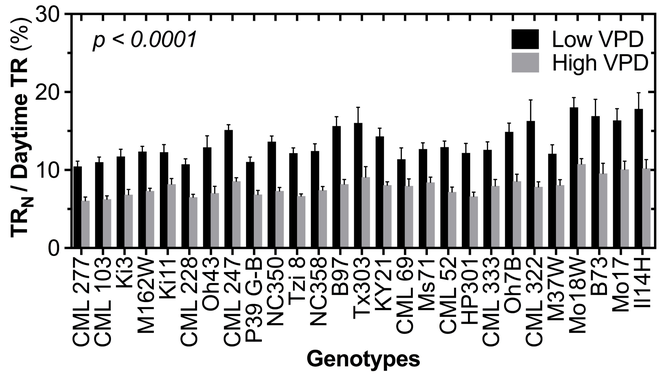

Figure 2. Ratio of nocturnal transpiration rate to daytime TR calculated for the lowest (1.7 kPa, black bars) and the highest (3 kPa, grey bars) daytime vapor pressure deficit conditions. Names of genotypes corresponding to each pair of bars are reported. Each bar represents average values from the three experiments (n = 11-12, ± S.E.).

3. TR_N is in part controlled by an endogenous, circadian rhythm in a genotype-dependent fashion

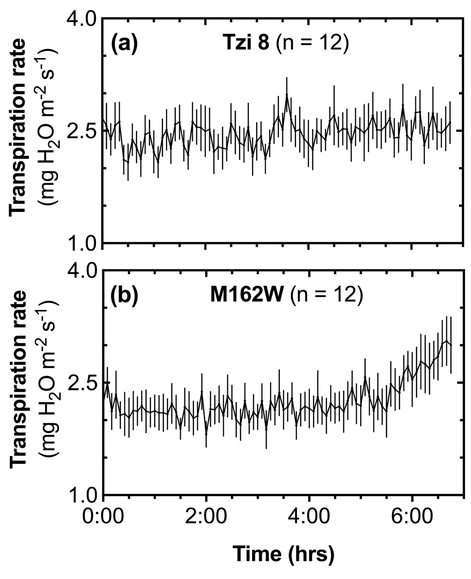

Figure 3. Representative TR_N time courses of two contrasting maize genotypes (Tzi 8, panel (a) and M162W, panel (b)) measured every 5 min. Error bars (mean ± S.E.) are calculated on the basis of 12 observations for all panels. The x-axis represents the time window between mid-night (00:00) and 07:00 (just before lights were turned on inside the chambers). The slope of pre-dawn increase in TR_N was observed for 7 genotypes in this panel which ranged from 0.34 to 1.34 mg H_2O m^{-2} s^{-1} min^{-1}.

4. The circadian control of TR_N is associated with higher TR_N and lower leaf construction costs with no consequences on leaf areas

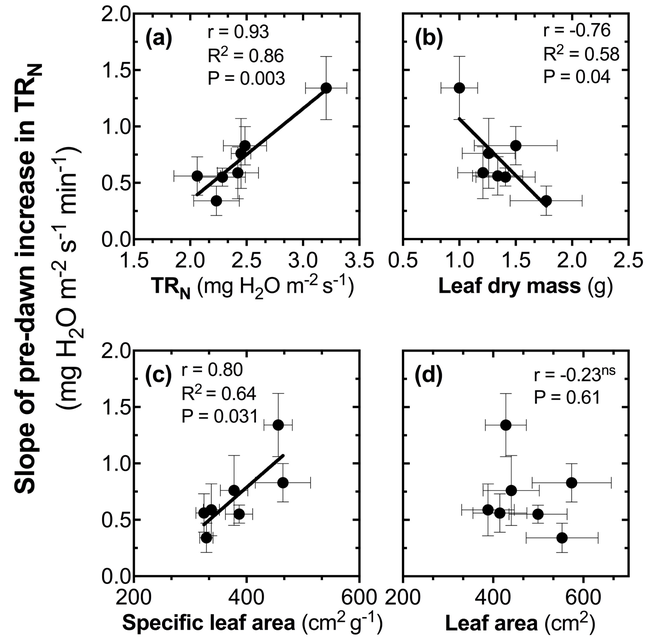

Figure 4. Correlations between the slope of the pre-dawn, endogenous increase in TR_N and whole-night transpiration rate (TR_N, panel (a)), leaf dry mass (panel (b)),specific leaf area (panel (c)) and leaf area (panel (d)). The slope of the pre-dawn TRN increase was calculated on the basis of data measured during the last hour of the night. Pearson's r, coefficients of determination (R^2) and significance levels of the linear regression fits are indicated. Error bars reflect standard errors (± S.E.). ns: non-significant correlation at $P < 0.05$.

CONCLUSIONS

- Maize exhibits non-negligible, genotype-dependent differences in TR_N and this TR_N represent significant amount of daily water use in maize.
- Genotype-dependent circadian control of TR_N exists in maize.
- Correlations exhibited by rate of pre-dawn increase in TR_N indicate that maize possessing such trait has lower leaf construction costs which might lead to enhanced productivity and overall fitness.

REFERENCES

- Schoppach et. al., 2014. Genotype-dependent influence of night-time vapour pressure deficit on night-time transpiration and daytime gas exchange in wheat. Funct. Plant Biol. 41: 963-971.
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- Resco de Dios et. al., 2016. Genetic variation in circadian regulation of nocturnal stomatal conductance enhances carbon assimilation and growth. Plant Cell Env. 39: 3-11.

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