

Large variation in gravimetric TE exists in wild and cultivated groundnut germplasm

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Introduction

Transpiration efficiency (TE) is one component of the yield hierarchy ($Y = T \times TE \times HI$) (Passioura, 1977), in particular under water deficit.

TE has been often assessed using surrogate traits, such as SLA (specific leaf area) or SCMR (SPAD chlorophyll meter reading), that have shown good correlation with TE (Hubick et al., 1986; Nageswara Rao and Wright, 1994). However, a previous attempt to breed for TE using surrogate traits have failed (Nigam et al., 2005).

Wild and cultivated groundnut are genetically isolated from each other. There might be interesting variants for TE in the wild ancestors, these having evolved in a range of different environments.

Objectives of this work were to: (i) Evaluate TE in a large and representative set of groundnut genotypes; (ii) Compare TE in wild and cultivated accessions of groundnut; (iii) Assess the suitability of TE surrogates for phenotyping purposes

Materials and Methods

Gravimetric evaluation of TE.

Large screening for TE in cultivated groundnut. 440 genotypes, including the mini-core collection (184 accessions), were tested. TE was evaluated in both well-watered (WW) and water stressed (WS) conditions in 200 genotypes (group 1), and in WS conditions alone in the remaining 240 (group 2). Plants were grown in 10" pots containing 9 kg of soil, under WW conditions up to 30 days after sowing (DAS). For group 1 and 2, twelve and eight replicated pots per genotype were planted, respectively. Four replications per genotype were harvested at 30 DAS in both groups. Then, remaining pots were fully saturated with water and allowed to drain overnight. Early the next morning, pots were bagged around the plant stem to avoid soil evaporation, and weighed immediately after. In group 1, half of the plants were exposed to WS, whereas the other half was kept under WW conditions. In group 2, all plants were exposed to WS. Weighing was performed once in every 4 days (1 rep/day). For WW plants, re-watering to about 80% field capacity was done once in every 2 days. For WS plants, the exposure to stress was made progressive by letting plants to loose no more than 100 g day⁻¹, i.e. 400 g at each weighing, and transpiration in excess of this was added back. The experiment was terminated when most plants in the WS treatment were permanently wilted.

TE evaluation in wild and cultivated peanut. TE was assessed under well-watered conditions in 21 accessions of wild peanut and 10 accessions of cultivated peanut. The protocol used was similar to that above. Plants were grown on 8" pots containing 5 kg of soil. The weighing was done once in every 2 days, and plants were kept under WW conditions. In the wild accessions, the number of replicated plants varied between 3 and 6, whereas 6 replications were used in cultivated groundnut. To account for growth differences, the wild peanut were about 2 months old when the experiment was started, whereas the cultivated were about 30 days old. The experiment was terminated two weeks after bagging and initial weighing of pots.

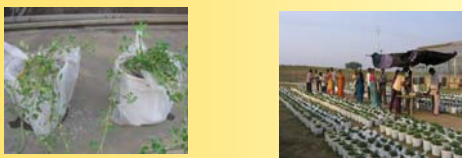


Figure 1. View of the wild Arachis during the experiment (left) and of the outdoor setup to measure TE in a large number of genotypes, weighing in progress (right).

TE calculation: Assessed in these trials, as the amount of biomass produced between the pre- and the post-treatment harvest, divided by the amount of water transpired during that period, in g biomass kg⁻¹ water transpired, such as:

$$TE = \frac{\text{Delta biomass (Post-treatment - Pre-treatment)}}{\text{Total water transpired (From bagging to harvest)}}$$

Delta biomass is the difference between biomass at 30 DAS and the biomass at harvest.

Total water transpired is the difference between the initial pot weight (after saturation and drainage) and the final pot weight plus water added during the experiment.

TE surrogates (SLA, SCMR):

- SLA was measured at the time of treatment imposition and at harvest
- SCMR was measured in 200 accessions (group 1) only, at 7 and 11 days after stress imposition

References

Hubick, K.T., Faruqar, G.D. and Shorter, R. 1986. Australian Journal of Plant Physiology. 13: 803-816.
 Nageswara Rao, R.C. and Wright, G.C. 1994. Crop Science 34: 98-103.
 Nigam, S.N., Chandra, S., Rupa Sriveti, K., Bhukta, M., Reddy, A.G.S., Rachaputi, N.R., Wright, G.C., Reddy, P.V., Deshmukh, M.P., Mathur, R.K., Basu, M.S., Vasundhara, S., Vindhya Varman, P. and Nagda, A.K. 2005. Annals of Applied Biology 146: 433-439.
 Passioura, J.B. 1977. J. Aust. Inst. Agr. Sci. 43: 21.

Results

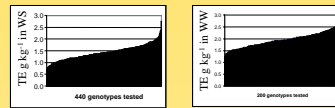


Figure 1. Range of variation in TE values under WS (left) and WW (right) conditions in 440 and 200 genotypes respectively

- Large range of variations in both WS and WW conditions, i.e. 4-fold under WS conditions
- The range of variation was higher under WS than under WW

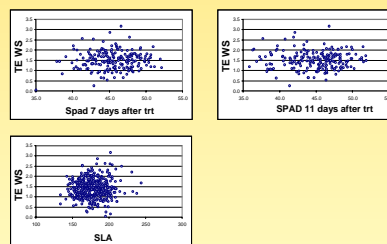


Figure 3. Relation between TE and SCMR values measured under WS conditions at 7 (top left) and 11 days after imposing the stress (top right), and between TE and SLA (bottom left)

- No relation was found between TE and the surrogates under WS

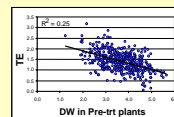


Figure 5. Relation between TE in WS plants and the DW of plants harvested before starting the experiment (pre-treatment plants)

- A negative correlation was found between TE and the DW of pre-treatment plants, showing that genotypes having poorer early vigor tend to have lower TE values

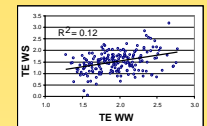


Figure 2. Relation between the TE data obtained under WW conditions (X-axis) and those under WS (Y-axis)

- Significant relation was obtained, though poorer than previously reported.

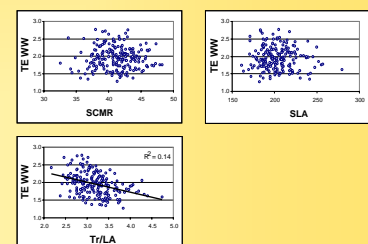


Figure 4. Relation between TE and SCMR values measured under WW (top left), between TE and SLA (top right), and between TE and the transpiration divided by the leaf area

- No relation was found between TE and the surrogates under WW
- An interesting negative relation was found between the rate of water loss per unit of leaf area and TE

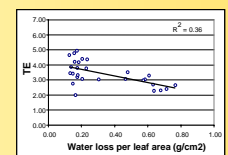


Figure 6. Relation between the TE and the rate of water loss per unit of leaf area across wild and cultivated accessions of groundnut

- There was a negative relation between the two parameters, showing that genotypes having a conservative use of water had higher TE

Accession number	Species	TE (g kg ⁻¹)	Tr cm ⁻¹
Wild Peanut			
ICG-1499	Duramenis	3.43 ± 0.46	0.15 ± 0.02
ICG-8124	batuicoi	3.80 ± 0.52	0.17 ± 0.01
ICG-1154	Valda	4.59 ± 0.86	0.21 ± 0.02
ICG-8059	Mecadoi	4.66 ± 0.59	0.15 ± 0.01
ICG-11552	Duramenis	4.38 ± 1.18	0.23 ± 0.05
ICG-1228	Hochnei	3.20 ± 0.64	0.18 ± 0.02
ICG-8137	Sonoopema	4.23 ± 1.30	0.16 ± 0.03
ICG-4983	Dipoi	3.04 ± 0.71	0.20 ± 0.05
ICG-1256	Valda	4.80 ± 1.31	0.16 ± 0.03
ICG-1236	Sonoopema	3.44 ± 1.27	0.15 ± 0.04
ICG-8123	Duramenis	1.99 ± 1.25	0.16 ± 0.03
ICG-8216	Cudonasi	3.07 ± 0.57	0.20 ± 0.02
ICG-11558	Cudonasi	2.75 ± 0.60	0.15 ± 0.04
ICG-11559	Cudonasi	3.86 ± 1.09	0.14 ± 0.04
ICG-8125	Sonoopema	4.93 ± 0.82	0.17 ± 0.01
ICG-1230	Valda	3.34 ± 0.48	0.18 ± 0.03
ICG-8211	batuicoi	4.20 ± 1.15	0.18 ± 0.02
ICG-11160	batuicoi	3.77 ± 1.07	0.21 ± 0.04
ICG-5195	Hypogea	2.41 ± 0.65	0.35 ± 0.06
ICG-0809	Hypogea	2.27 ± 0.19	0.25 ± 0.09
ICGV 87187	Hypogea	2.32 ± 0.46	0.31 ± 0.07
ICGV 86155	Hypogea	2.70 ± 0.14	0.31 ± 0.07
ICGV 86156	Hypogea	2.65 ± 0.24	0.29 ± 0.09
ICG-2777	Hypogea	3.06 ± 0.43	0.23 ± 0.06
ICGV 87923	Hypogea	3.04 ± 0.56	0.29 ± 0.08
ICG-156 C	Hypogea	3.50 ± 0.52	0.24 ± 0.04
ICG-2773	Hypogea	2.97 ± 0.26	0.30 ± 0.04
ICGV 86699	Hypogea	3.30 ± 0.53	0.31 ± 0.11

Table 1. TE and rate of water loss per unit of leaf area in 21 accessions of wild groundnut and 10 accessions of cultivated groundnut. The rate of water loss per unit of leaf area was calculated as the transpiration over the last 4 days of the experiment, divided by the leaf area of plants at harvest.

- TE was generally higher and more varied in the wild groundnut
- The rate of water loss per unit of leaf area was higher in the cultivated groundnut

Conclusions

- We found a large range of variation for TE in cultivated groundnut.
- Surrogate traits of TE, SCMR and SLA showed no relation with TE across a large set of genotypes, and suggest that care should be taken to use these for phenotyping.
- TE appeared to vary more in the wild than in the cultivated groundnut.
- TE values were generally higher in the wild groundnut.
- TE was negatively related to the rate of water loss per unit of leaf area, a proxy for stomatal conductance, suggesting that stomatal conductance is likely to have a lot more influence on TE than previously reported in the literature.

Prospects:

- Develop new populations between contrasting genotypes for TE.
- Repeat the experiment.