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Peanut leaf area index, light interception, radiation use efficiency, and harvest index at three sites in Texas

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Abstract

Stability of parameters describing crop growth of peanut (*Arachis hypogaea* L.) is important because of the diversity of climatic conditions in which peanuts are grown and is valuable when developing simulation models for this species. In contrast, variability in the same parameters is desirable for plant breeders working to develop improved cultivars. This study seeks to quantify key parameters for biomass and yield production of some common peanut cultivars at three sites in Texas. We measured leaf area index (LAI), light extinction coefficient (k) for Beer's law, and harvest index (HI) for four cultivars at Stephenville, TX and one cultivar near Gustine, TX, and for LAI and biomass on four cultivars at Seminole, TX. Mean radiation use efficiency (RUE) values were 1.98 g MJ^{-1} at Stephenville, 1.92 at Gustine, and 2.02 at Seminole. Highest RUE values were for the Low-Energy Precise Application (LEPA) irrigation treatment at Seminole. Maximum LAI values ranged from 5.6 to 7.0 at Stephenville, from 5.0 to 6.2 at Seminole, and was 5.3 at Gustine. Mean k values ranged from 0.60 to 0.64 at Stephenville and was 0.77 at Gustine. The overall mean HI was 0.36, with a mean of 0.33 for Stephenville, 0.44 for Gustine, 0.53 for spray irrigation at Seminole, and 0.58 for LEPA irrigation at Seminole. Values of RUE, k, and HI for the cultivars in this study and similarities between this study and values reported in the literature will aid modelers simulating peanut development and yield and aid breeders in identifying key traits critical to peanut grain yield improvement.
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1. Introduction

Peanut production in the U.S. occurs from humid areas of Georgia and Florida to arid areas of the southern High Plains of Texas. Peanut production in the semi-arid region of western Texas near Seminole offers an opportunity to test the stability of parameters describing plant growth that were developed in more

Abbreviations: FIPAR, fraction of photosynthetically active radiation intercepted by plants; GROWTH, plant growth rate, g per plant per day; HI, harvest index; IPAR, photosynthetically active radiation intercepted by plants, MJ per plant per day; k, light extinction coefficient for Beers Law; LAI, leaf area index; LEPA, low-energy precise application; PAR, photosynthetically active radiation, MJ m^{-2} per day.

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humid, high rainfall areas such as the southeastern U.S. This western environment has high evaporative demand, high vapor pressure deficit, low rainfall, and high yield potential when irrigated. Parameters and functions that are stable in this environment as well as in more humid regions can be accepted as more fundamentally sound for peanut modeling internationally. Likewise, when measured in this arid environment, if parameters and functions diverge from accepted norms, then additional research will be needed to determine causes of such difference. In contrast to researchers involved in crop modeling, plant breeders working to develop improved peanut cultivars desire variability in such parameters.

As discussed by Amthor and Loomis (1996), mechanistic models simulating cropping systems at one level are best described by processes at a lower level. Likewise, Sinclair and Seligman (2000) discussed how crop level simulation models should simulate processes at the whole-plant level and whole-plant simulation should be simulated at the organ level. Such process-based simulation models have been developed and applied for peanut by Boote et al. (1986), Hammer et al. (1995), Meinke and Hammer (1995), and Kaur and Hundal, (1999).

These models rely on accurate, robust functions for plant growth and development. All crops produce leaves, intercept light, and partition biomass into grain. By better quantifying parameters that describe these processes, peanut models can be developed that accurately simulate leaf area index, biomass, and seed production. However, despite the fact that peanut is a prominent crop species in parts of Texas, there is a paucity of information from this state to allow its simulation by such process-based models.

Peanut *k* values from the literature are similar to those of other common crops while maximum seasonal LAI tends to be greater than for most crops. Reported values for LAI (Table 1) range from 3 to greater than 8. The mean LAI from these eight studies was near 6. Likewise, realistic values for *k* provide accurate simulation of light interception using LAI. The mean *k* (±S.D.) from eight studies was 0.60 ± 0.13 (Table 1).

Reported RUE values for peanut (Table 2) are lower than for many common grain crops (Kiniry et

Table 1
Maximum LAI values during the season, mean light extinction coefficient (*k*) for the Beer's Law equation (see Section 2), and harvest index (HI) values from the literature

Location (source)	LAI	*k*	HI
Florida (Gardner and Auma, 1989)	3	0.80	–
Florida (Jaaffar and Gardner, 1988)	6.13 and 6.75	0.65	–
Florida (Bennett et al., 1993)	4.2	–	0.40 and 0.48
Florida (Jones et al., 1982, *k* calc. from results)	4.5–5.9	0.57	–
Florida (Pixley et al., 1990)	7.1 and 5.2	–	0.49
Florida (Duncan et al., 1978)	7	–	0.38
Florida (Selamat and Gardner, 1985)	7	–	–
Florida (Hang et al., 1984)	–	–	0.49
North Carolina (Wells et al., 1991)	–	–	0.46
Virginia (Coffelt et al., 1989)	–	–	0.47
Argentina (Collino et al., 2001)	4.2 and 6	0.74	0.44
India (Nageswara Rao et al., 1988)	5–6	–	–
India (Dwivedi et al., 1998)	–	–	0.40
Australia (Chapman et al., 1993a, *k* calc. from results)	7.0–8.5	0.37	–
Australia (Bell et al., 1994)	–	0.50	0.43
Australia (Bell et al., 1992)	–	0.53	–
Australia (Bell et al., 1993)	–	–	0.62
Australia (Wright et al., 1991)	–	–	0.46
Australia (Chapman et al., 1993b)	–	–	0.46
Indonesia and Australia (Bell and Wright, 1998)	–	–	0.41
Japan (Awal and Ikeda, 2003)	–	–	0.52
Mean ± S.D. using above values	5.9 ± 1.5	0.60 ± 0.13	0.45 ± 0.04