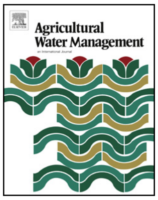
Agricultural Water Management 166 (2016) 70–76

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat



Assessment of drought tolerance of peanut cultivars based on physiological and yield traits in a semiarid environment

Jacqueline Wanessa de Lima Pereira[a], Manoel Bandeira Albuquerque[b], Péricles Albuquerque Melo Filho[a], Rejane Jurema Mansur Custódio Nogueira[c], Liziane Maria de Lima[d], Roseane Cavalcanti Santos[d,*]

[a] Universidade Federal Rural de Pernambuco/UFRPE, Departamento de Agronomia, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos, Recife, Pernambuco, Brazil
[b] Universidade Federal da Paraíba, Departamento de Fitotecnia e Ciências Ambientais, Centro de Ciências Agrárias, 231, 58397-000, Areia, Paraíba, Brazil
[c] Universidade Federal Rural de Pernambuco/UFRPE, Departamento de Biologia, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos, Recife, Pernambuco, Brazil
[d] Empresa Brasileira de Pesquisa Agropecuária, Rua Oswaldo Cruz, 1143 Campina Grande, Paraíba, Brazil

ARTICLE INFO

Article history:
Received 13 April 2015
Received in revised form 7 December 2015
Accepted 12 December 2015

Keywords:
Arachis hypogaea L.
Stomata resistance
Semiarid adaptation
Breeding

ABSTRACT

The regular water supply during life cycle is essential to determine the yield in the legumes. In semiarid environments, the irregular rainfall and high temperature influence the phenology of crops impairing the yield. Peanut is an oleaginous crop with broad adaptation to tropical and semiarid climates, but yield is often harmed when plants face water irregularities during reproductive phase. The recommendation of cultivars tolerant to environments with water—limitation is indispensable to farmers in order to ensure reasonable production when drought settles down. Here, we evaluating peanut bred lines in order to assess drought tolerance based on physiological and yield traits, in greenhouse and field assays. In greenhouse experiment, 2 genotypes (BR 1, drought tolerant and the sensible LViPE-06) and 2 descendant bred lines (earliness-LBM Branco and a mid-runner, LBR Branco) were submitted to 21 days of total water supression. Diffusive resistance, transpiration and leaf water potential were measured by porometer (LI 1600), from fully expanded leaves at mid canopy. Root length was also measured at final period of water stress. Further, in a 2-year field experiment carried out in semiarid environment (Barbalha, CE, Brazil), the genotypes were evaluated under rainfed and irrigation, aiming to estimating the yield trait and the efficiency of drought tolerance. Physiological and yield traits of all genotypes were altered under water stress and significant responses were observed. Both top lines showed physiological ability to tolerance to drought, but LBM Branco, an earliness and upright line, was classified as drought tolerant showing behavior near to BR 1. The losses in pod and seed yield were low, comparing to runner parent (LViPE-06). LBR Branco showed an intermediary performance between parents and was classified as moderately tolerant. Based on physiological and agronomic performances, LBM Branco can later be recommended for management in semiarid environment.

1. Introduction

Drought stress has been the major environmental factor responsible to yield losses in several crops worldwide. The losses are highly variable depending on timing, intensity, and duration coupled with other location-specific environmental stress factors such as high irradiance, temperature and salinity (Graciano et al., 2011; Kambiranda et al., 2011). At cell level, drought often leads to devastating effects in plant metabolism, with direct actions in thylakoid electron transport, phosphorylation and carboxylation (Bhagsari et al., 1976; Lauriano et al., 2000). The membrane permeability and solute synthesis are increased in water-stressed plants, leading to membrane disruption as well as reduction in photosynthesis, depending on stress level.

Plants have several mechanisms for adaptation to water stress including stomatal conductance and osmotic adjustments. The combination of these traits, associated with lower oxidative damage in cells will reflect in the adaptive response of the plant to

---

* Corresponding author. Fax: +55 8331824367.
E-mail addresses: jacquelinewlp@gmail.com (J.W. de Lima Pereira), manoel@cca.ufpb.br (M.B. Albuquerque), periclesmf@gmail.com (P.A. Melo Filho), rjmansur1@gmail.com (R.J. Mansur Custódio Nogueira), liziane.lima@embrapa.br (L.M. de Lima), roseane.santos@embrapa.br (R.C. Santos).

http://dx.doi.org/10.1016/j.agwat.2015.12.010
0378-3774/

survive in situations of extended drought (Azevedo Neto et al., 2009; Clavel et al., 2004; Nogueira et al., 2006). Understanding physiological and molecular genetics may lead to the understanding of stress response and aid in development of new varieties with stress tolerance.

Breeding for drought tolerance has been an important strategy adopted by researchers to alleviate the water stress problems and to ensure the production in environments prone to drought (Pereira et al., 2012; Santos et al., 2013; Songsri et al., 2008). However, the inheritance of characters associated with drought adaptation is likely to be genetically complex, due to the number and arrangement of genes governing quantitative traits (Leal-Bertioli et al., 2012). Researchers have attempted to improve performance by selecting plants with good yield under drought conditions in order to enable stability of production.

The selection of plants with ability to extract water from the soil is an additional procedure to aid to genetic improvement to drought tolerance. Deep rooting, root length density and root distribution are adaptive traits often adopted as selection criteria for drought resistance (Benjamin and Nielsen, 2006; Matsui and Singh, 2003; Taiz and Zeiger, 2006 Yusuf Ali et al., 2005). According to Rucker et al. (1995), large root system may improve the plant's ability to continue growth during a drought period.

Peanut (*Arachis hypogaea* L.) is an important oleaginous food, widely cultivated in tropical and semiarid regions, where drought is one of the most limiting factors for production. In environments where water availability is deficent, upright cultivars represent an important alternative to farmers due to short cycle and low water requirement during the growth (Painawadee et al., 2009; Vorasoot et al., 2003). However, even grown under irrigation, peanut may experience drought because of limited water supply or because irrigation water is applied in amounts or at frequencies that are less than optimal for plant growth, especially during pod and seed filling (Awal and Ikeda, 2002; Pereira et al., 2012; Songsri et al., 2008).

According to Azevedo Neto et al. (2009), who evaluated several physiological and biochemical traits in interspecific genotypes of *Arachis* submitted to moderate water stress, the osmotic adjustment and the activity of antioxidant enzymes are more effective in tolerant plants, as a response to avoiding major damage to cell metabolism. Jain et al. (2001) identified several up-and down-regulated transcripts associated with water stress in water-stressed peanut plants, all of them exhibiting qualitative and quantitative differences in the gene expression.

In agronomical aspect, the criteria for selection of peanut-drought resistance are often based on biomass production and pod yield under water stress conditions (Duarte et al., 2013; Santos et al., 2010). Drought-stressed plants lose moisture from pods that can lead to reduction in physiological activity of the seeds and consequentially affecting both yield and nutritional quality (Songsri et al., 2008).

In a correlation study carried out by Songsri et al. (2008) involving traits associated to drought tolerance and pod production, authors found high magnitude correlations among drought tolerance index (DTI), pod yield, root length density (RLD) and harvest index (HI), indicating that RLD in deeper soil contributed to pod yield and HI under drought conditions. This association is quite relevant to peanut because pods have underground growth and the adequate moisture in root zone is critical for peg and pod development. Water deficit in the pegging and root zones can decrease pod and seed productions in approximately 30% (Kambiranda et al., 2011).

The Brazilian Company of Agricultural Research (EMBRAPA) coordinates a robust program of peanut improvement focused on northeast semiarid environment. This region is characterized by soils of low fertility, erratic rainfall and moderate *veranicos* that occur in rainy season. Periodically, several intra and interspecific lines are generated by crossings for further use in selection procedures in order to identifying high yield and drought tolerant materials. The selection criteria are based on biochemical, physiological and agronomic traits. In 2012, a bulk of 20 intraspecific lines was evaluated in field condition in order to selecting earliness and high yield materials for further recommendation to food markets situated in Northeast region. Two top lines were selected showing pod yield 23% higher than the average of population. In this work, we report about these materials, evaluated during two years in order to determine the effects of moderate drought on yield based on physiological and agronomical traits.

2. Material and methods

2.1. Water stress assay in greenhouse

Seeds of four peanut genotypes (2 bred lines and parents) were grown in greenhouse and submitted to moderate water stress. Experiment was carried out at the Agricultural Department of Federal Rural University of Pernambuco, Brazil, located in Recife, PE (08° 03′ 14” S, 34° 52′ 52” W, 4 m). A summarized description of each genotype is presented: BR 1 (*A. hypogaea* subsp. *fastigiata*, ♀), is an earliness and drought tolerant-upright cultivar developed by EMBRAPA to semiarid environment (Graciano et al., 2011; Santos et al., 1999, 2013); LViPE-06 (*A. hypogaea* subsp. *hypogaea*, ♂) is a high yield- runner genotype and sensible to drought (Santos et al., 2013), LBM-06 and LBR-06 are, respectively, an upright-short cycle and a runner-mid cycle top lines, both generated by crossing between BR1 × LViPE-06.

The experimental procedure was carried out according to Azevedo Neto et al. (2009). Four seeds of each genotypes were sown in pots (10 L) containing sandy-loam texture soil previously limed and fertilized (NPK, 20:60:30, ammonium sulfate, single superphosphate and potassium chloride). Fourteen days after emergence, seedling were thinned to two per pot. The watering (100% field capacity) was daily until seedlings aged 20 days, when water treatments were established: control (100% field capacity) and water stress (total withdrawal of water during 21 days). Field capacity was determined by gravimetric method after 72 h of draining. The pots of both treatments were weighed daily and, in the control treatment, the water lost by transpiration was replaced. In order to prevent the losses by evaporation, soil surface of each pot was covered with polyethylene discs. A completely randomized design with bi-factorial scheme was adopted (4 × 2), with 10 replications. Leaf temperature, air relative humidity and photosynthetic active radiation (at noon) data were recorded at 1, 2 and 3 weeks of water stress establishment (Table 1).

2.2. Physiological traits

Diffusive resistance (Rs), transpiration (T) and leaf water potential (Ψ_w) were periodically evaluated on abaxial and adaxial

Table 1
Data collected in greenhouse by steady-state porometer LI-1600, during water stress establishment.

	1 w			2 w			3 w		
Genotype	LT	RH	PAR	LT	RH	PAR	LT	RH	PAR
BR1	32.7	49.9	507.6	31.9	52.1	558.1	33.9	50.8	754.4
LViPE-06	31.3	51.9	558.7	33.9	55.7	747.3	32.0	60.6	368.9
LBM Branco	33.7	51.9	434.8	33.9	53.4	625.7	34.3	50.5	670.7
LBR-Branco	32.7	54.7	647.6	33.4	47.9	591.9	33.6	49.3	507.0

w—week of water stress, LT— leaf temperature (°C), RH—relative humidity of air (%), PAR— photosynthetically active radiation (μmol.m^{-2} s^{-1}).