CHAPTER VII

GENERAL DISCUSSION AND CONCLUSION

Drought is one of the major constraints to peanut production, especially the mid-season drought which occurs during the pod and seed formation stages and the terminal drought which occurs during the pod filling stage. Mid-season drought has been shown to significantly reduce pod yield of peanut (Nageswara Rao et al., 1989), while terminal drought can cause not only the reduction in yield but also the increase in the incidences of aflatoxin contamination (Holbrook and Stalker, 2003; Arunyanark et al., 2009; Girdthai et al., 2010). Drought stress can also occur during the early flowering stage, but early-season drought stress is not detrimental to peanut yield and it sometimes gives a yield increase (Nageswara Rao et al., 1985; Nautiyal et al., 1999). To cope with the problem of yield reduction from mid-season and terminal drought and take advantage of yield increase from early-season drought, peanut cultivars that are tolerant to mid-season and terminal drought and those that give a positive response to early-season drought are needed. Information on traits conferring resistance to mid-season and terminal drought or positive response to early-season drought will facilitate breeding work for the desirable genotypes.

This research partly addressed the early-season drought and partly addressed the mid-season and terminal drought. The objectives were i) to identify drought resistant peanut genotypes from a collection of peanut germplasm and establish the relationships among drought resistance traits, ii) to investigate the responses of root dry weight and root length density (RLD) of peanut genotypes to pre-flowering drought stress and their relationships with pod yield, iii) to classify root distribution patterns and their contributions to peanut yield under mid-season drought, and iv) to compare the capability of GLUE with GENCALC and manual calibration in estimating cultivar coefficients of peanut lines for use with the CSM-CROPGRO-Peanut model. Objective 1 addressed both the mid-season and terminal drought as drought stresses were imposed throughout the entire crop duration during the screening test. Objective 2 addressed the pre-flowering drought, and Objective 3 addressed mid-season drought, while Objective 4 could be used to address all three types of drought stress. Although several plant traits have been shown to be related to the differential responses on pod yield of peanut genotypes to different moisture levels, in this research the emphasis was put on root traits as shown by the traits of focus in Objectives 2 and 3 and the intention of Objective 4 to eventually use the CSM-CROPGRO-Peanut model in predicting root responses to drought stress, while Objective 1 was primarily intended to identify peanut lines with different responses to drought stress for use in Objective 3. The emphasis on root traits came from the consideration that these traits are difficult to obtain, thus, are generally lacking in the studies on genotypic responses to drought stress. Information on root characteristics of peanut genotypes and their relationships with yield and other traits conferring differential responses to drought stresses at different growth stages should help explain the mechanisms for drought tolerance to mid-season and terminal drought and for positive response to early-season drought that breeding work could be based upon. To be able to efficiently use the crop simulation model in prediction root responses to drought stresses, a simple method for deriving the required crop cultivar coefficients is needed.

In this research, four studies were conducted, each corresponded with each objective. Two sets of peanut lines were used. The first set consisted of 60 germplasm lines from various sources. These lines were used in Study 1 (Objective 1), out of which 29 were selected for use in Study 3 (Objective 3) together with 11 additional lines to have a broader range of responses to mid-season drought stress. The second set consisted of six lines with different responses to early-season drought selected from the previous study of Puangbut et al. (2009). These included three drought resistant lines from ICRISAT (ICGV 98305, ICGV 98324 and ICGV 98330), one drought resistant line from USDA (Tifton-8) and two released cultivars commonly grown in Thailand (KK 60-3 and Tainan 9). These lines were used in Study 3 (Objective 3), the data of which were also used in Study 4 (Objective 4) as the observed data in model calibration.

Study 1 was essentially a screening test for long-term drought resistance of 60 germplasm peanut lines from various sources. The lines were tested in four water gradients, i.e., field capacity (100%); FC, 75% of FC, 60% of FC and 40% of FC, and measurements were made on traits that have been found to be related to drought resistance, i.e., TDM, pod yield, HI, WUE, SLA and SCMR. The results (Chapter 3) showed that drought stress reduced TDM, pod dry weight, HI, WUE and SLA, but increased SCMR and canopy temperature. SCMR appeared to be the most appropriate surrogate trait for WUE, confirming the finding of previous studies (Sheshshayee et al., 2006). Among the 60 genotypes tested, Tifton-8, PI 430238, PI 430238, KK60-3, PI 268659 and KKU 60 were identified as drought resistant genotypes. Tifton-8, PI 430238 and PI 442925 had high WUE in all drought levels, while KK 60-3 and PI 268659 had high WUE in severe drought conditions only, and KKU 60 had high pod yield and SCMR and low canopy temperature. Data on responses to different levels of drought stress of the 60 test peanut lines for the above measured traits were also obtained, and were used in selecting 29 lines with different degrees of drought resistance for use in Study 3.

Study 2 evaluated the root responses to pre-flowering drought of six selected peanut lines known to have different responses to this type of drought on pod yield and above ground biomass (Chapter 4). Three types of yield response were observed: yield increase, yield reduction and yield non-responsive. Under pre-flowering drought stress, the group with increased pod yield had greater root dry weight and root length density in deeper soil layer than under non-stress condition. These results agreed with the study of Songsri et al. (2008a) which showed that root traits were related to the responses of yield under long-term drought conditions. Thus, root traits appeared to be well associated to yield under both early-season drought and long-term drought conditions. The peanut genotypes that gave yield increase under pre-flowering drought and those that showed resistance to long-term drought were the ones that had greater root development in deeper soil layers under drought conditions.

The association of yield and root traits under mid-season drought was the main research question of Study 3 (Chapter 5). A total of 40 lines with different degrees of drought resistance were evaluated under mid-season drought conditions in this study, 29 of which were selected from Study 1 and 11 were chosen from other studies. The results showed that under mid-season drought condition these lines had different root patterns. Based on RLD percentage for each of the three soil-depth layers (upper, middle and lower layers), six root patterns were recognized, i.e., HHL, HLH, HLL, LHH, LHL and LLH. The RLD percentages in the lower level were highly and positively correlated with yield traits, indicating that this trait is an important determinant of pod yield under mid-season drought conditions, probably because of its ability to better extract water under drought conditions. The results of this study, thus, expanded the scope of importance of root traits in determining peanut yield under drought conditions to cover all types of drought stress, including early-season drought (Study 2), mid-season drought (this study) and long-term drought (Songsri et al., 2008a). These findings suggested that selecting for deep root system would be beneficial for all types of drought stress, e.g., the lines with deep root system will not be only tolerance to mid-season and long-term drought stress but also will give a yield increase under early-season drought stress condition. Thus, selection for deep root system would be an important strategy for breeding peanut for drought resistance.

Measurements on root traits, however, are difficult, making direct selection for the desirable root traits of peanut impractical. The CSM-CROPGRO-Peanut model has a potential to facilitate root trait selection, as the model can simulate root characteristics under various management conditions, including different moisture regimes. However, this feature of the model needs to be validated before it can be used in such a breeding application. The CSM-CROPGRO-Peanut model requires cultivar coefficients of individual peanut lines as an input for model simulation. Determination of the cultivar coefficients of peanut lines by the normal procedure is difficult and also requires special skill of users. A more simple but accurate procedure for model calibration of the cultivar coefficients is needed as a prerequisite for breeding application of the model. The availability of GLUE, a software program that can automatically calibrate the cultivar coefficients from end-of-season data without user intervention, can fulfill this need, but its accuracy needs to be established.

The fourth study dealt with the above issue. In this study, GLUE was compared with GENCALC and manual calibration in estimating the cultivar coefficients of six peanut genotypes in Study 2 using their end-of-season data under well irrigated conditions from Study 2 for model calibration. The derived cultivar coefficients were validated against an independent data set from previous studies (Songsri et al., 2008a; Puangbut et al., 2009). The results (Chapter 6) indicated that GLUE was as effective as GENCALC and manual calibration in deriving the cultivar coefficients of peanut lines for use with the CSM-CROPGRO-Peanut model. As the estimation of the cultivar coefficients by GLUE is simple and can be done by anyone who can run the CSM-CROPGRO-Peanut model, the need for a simple but accurate procedure for model calibration is fulfill. However, further work is needed in the validation of the capability of the CSM-CROPGRO-Peanut model in accurately predicting root traits, particularly RLD, of peanut genotypes under different moisture regimes.

Overall, the four objectives of this study have been achieved. The major finding is that root traits have significant contribution to the differential responses to drought stress of peanut genotypes. High RLD at the lower soil layer is the trait that contributes to the tolerance to mid-season and long-term drought and the positive response to pre-flowering drought of peanut genotypes. Thus, selection for this root trait would have beneficial effects for all types of drought stress. This finding has significant implication for breeding of peanut for drought resistance. However, more research is still needed to assess the consistency across environments and the magnitude of genotype x environment for this root trait to determine appropriate breeding strategy for its improvement. It also remains to be seen whether root traits will play an important role to the differential responses of peanut genotypes to terminal drought. As direct measurement of root traits is difficult, it was thought that crop model could be used in evaluating root responses to drought stresses of peanut genotypes. This goal was partially fulfilled as the scope of the study was limited to the identification of a simple but accurate procedure for determining the cultivar coefficients of a large number of peanut lines. The study has shown that GLUE could be used in deriving the cultivar coefficients of peanut genotypes from end-of-season data automatically without user intervention. The simplicity in the application of GLUE will open up the opportunity for using the CSM-CROPGRO-Peanut model in breeding applications, particularly in evaluating root responses to drought stress of peanut genotypes. However, the latter breeding application of the model needs to be validated before its actual practice.