Variation of SPAD Chlorophyll Meter Readings (SCMR) in the Mini-Core Germplasm Collection of Chickpea

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Drought is one of the major causes of yield losses in chickpea (*Cicer arietinum*). A large portion of such losses can be avoided through crop improvement. Simple analytical models are often used to dissect out and to understand the effects of model parameters on the final yield. Passioura (1977) proposed one such model where yield is considered a function of transpiration, transpiration efficiency (TE) defined as crop biomass production per unit water transpired, and harvest index. Among these three components, genetic enhancement of TE has been taken up as a major research effort in crop improvement programs throughout the world (Bindu Madhava et al. 2003). Although TE is considered a highly useful trait, it was also categorized as a difficult one to screen. Therefore, it becomes necessary to identify surrogate traits that are closely associated with TE for rapid screening of a large number of genotypes. A direct close relationship of TE with SPAD Chlorophyll Meter Readings (SCMR) was reported in groundnut (Nageswara Rao et al. 2001; Bindu Madhava et al. 2003) and SCMR is a direct linear relationship through extracted leaf chlorophyll (Yadava 1986) and also related leaf nitrogen concentration (Kantety et al. 1996; Bullock and Anderson 1998). The advantages such as easy and rapid measurement, nondestructive method and light weight made SPAD meters the best choice for use in the trait-based groundnut breeding program to improve the drought tolerance of groundnut at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (Serraj et al. 2004).The same strategy can be applied to chickpea, provided baseline information is available on genetic diversity of SCMR in chickpea. The chickpea mini-core collection has been chosen to collect such information as the number is manageable for initial exploratory efforts and it represents the diversity of the whole germplasm collection (Upadhyaya and Ortiz 2001), Thus, the main objective of this study was to document the extent of variation available for the SCMR readings in the mini-core germplasm of chickpea, and also to identify accessions with contrasting SCMR.

The entire mini-core germplasm collection of *C. arietinum* (211 accessions) along with five genotypes (Annigeri, ICC 4958, Chafa, ICCV 2, and ICC 898) as references were evaluated by measuring the SCMR in a precision Vertisol field (fine montmorillonitic isohyperthermic typic pallustert) in ICRISAT during the 2005/06 postrainy season. The seeds were sown on 15 November 2005. Before sowing, 18 kg N ha^{-1} and 20 kg P ha^{-1} as di-ammonium phosphate were applied. The experiment was conducted in a Split Plot design with two different irrigation treatments (rainfed and optimally irrigated) in three replications. In optimally irrigated treatment, furrow irrigation was applied at 27, 50 and 66 days after sowing (DAS) besides the post-sowing irrigation. The SCMR measurement was taken at 62 and 90 DAS by using SPAD-502 meter (Minolta Konica Co. Ltd., Japan).

SCMR at different leaf positions from the topmost expanded to 6th that compose the plant canopy surface was measured among randomly selected 9 accessions in the irrigation treatments prior to the first measurement at 62 DAS. A significant difference was obtained for SCMR among the leaf positions (Fig. 1). The top and second leaf had significantly lower SCMR than the other leaves; on the other hand there was no significant difference in SCMR among the leaves below the third leaf. This suggests that the third leaf can be considered as representative of the plant canopy for SCMR measurement. Therefore, the third leaf was used for further SCMR measurements.

At 62 DAS, differences in SCMR readings among the entries were significant at <0.001 level in both rainfed and optimally irrigated conditions (Fig. 2a and b). The overall mean of rainfed condition (57.6) was significantly higher than the overall mean in irrigated condition (47.4). This irrigation environment influence might be due to

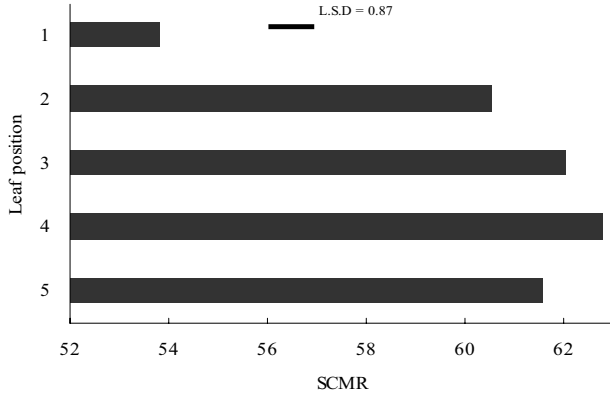

Figure 1. SCMR of different leaf positions in of chickpea accessions (Note: The values are means of 5 replications.)

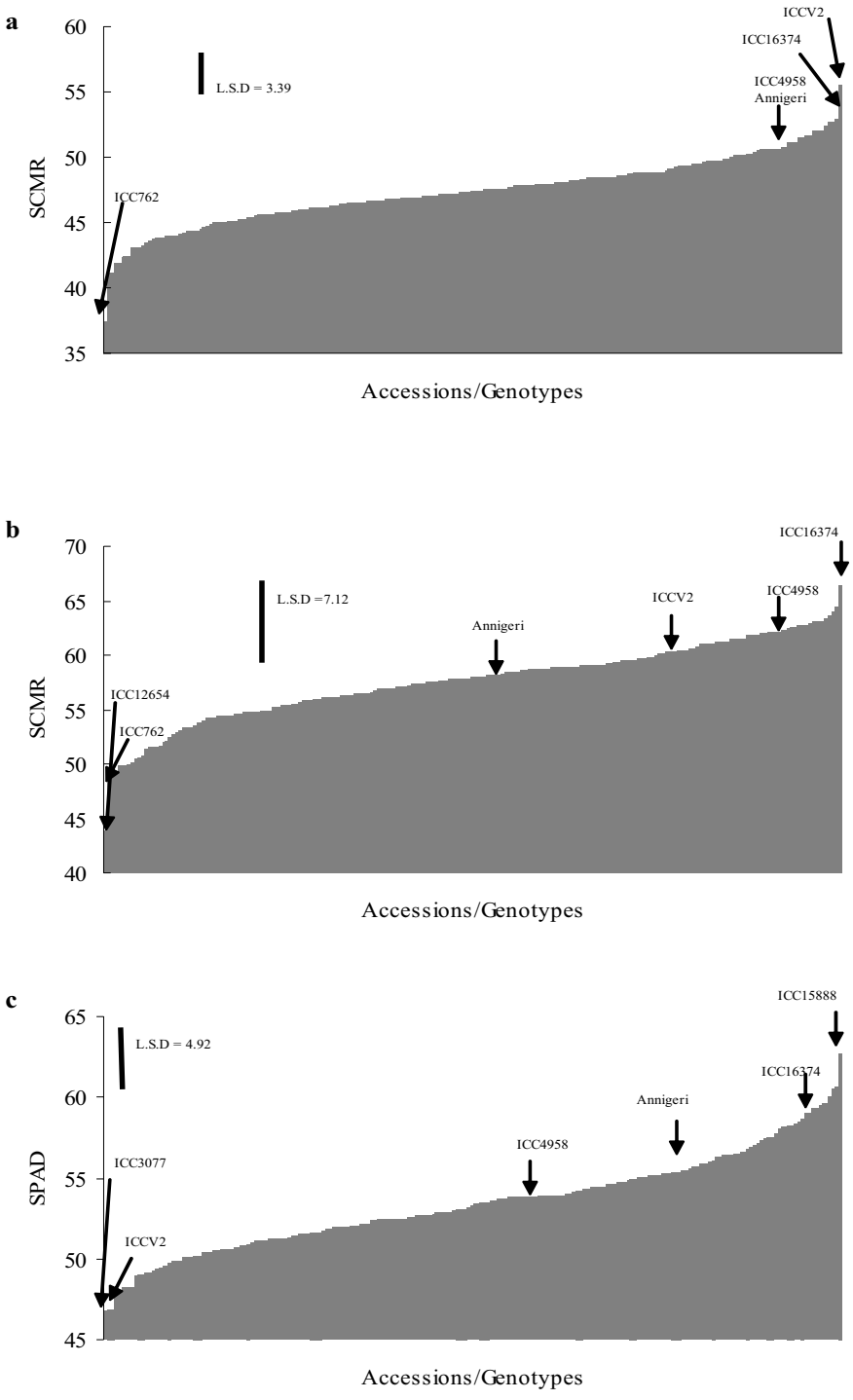

Figure 2. SCMR of the mini-core chickpea germplasm accessions (n=211), 5 cultivated genotypes: (a) in rainfed condition at 62 DAS; (b) irrigated condition at 62 DAS; (c) irrigated condition at 90 DAS (Note: The values are means of three replications.)

relatively less restricted leaf expansion and with relatively less chlorophyll formation in irrigated condition. Also the differences on crop growth rate and the nitrogen fixation ability between the irrigated and rainfed treatments possibly influence the chlorophyll concentration. It is also likely that the irrigation treatments influence the specific leaf area. There was no genotype by irrigation ($G \times I$) interaction observed. Also, there was a significant correlation in SCMR between in the rainfed and irrigated conditions ($r = 0.534$, $p<0.01$). In rainfed condition, ICCV 2 showed the highest SCMR reading (55.5), and both ICC 4958 and Annigeri showed 51.6, with a rank of 11th. Regardless of the irrigation schemes, ICC 16374 had a superior SCMR with 66.4 (1st rank) in irrigated conditions and its rank was 4th in rainfed environment. ICC 4958 also had a better SCMR irrespective of the irrigation schemes (11th rank in rainfed, 3rd in irrigated).

At 90 DAS, the SCMR measurement was taken in optimally irrigated treatment only as most of the entries in rainfed condition had senesced and matured. There was a significant difference on SCMR among the entries (Fig. 2c). ICC 15888 had the highest SCMR value of 62.7. The accession ICC 16374 also showed a higher SCMR value (59.0); ranking 10th. On the other hand, ICCV 2 which had the highest SCMR in rainfed condition at 62 DAS was 2nd lowest with 46.8. Being extra-early in maturity, ICCV 2 matured on 97 days after sowing under irrigated condition. And as a consequence, the process of senescence and remobilization had already started in this and other early genotypes, leading to poor SCMR values. Although there was a significant linear correlation between at 62 and 90 DAS observations within the optimally irrigated treatment ($r = 0.276$, $p<0.01$), there also existed a significant $G \times I$ interaction ($p<0.001$) reflecting the effects of duration on SCMR observation. This would suggest that meaningful observations can be obtained at early stages of crop growth.

The germplasm accession ICC 16374 showed superior and more consistent SCMR readings than the others. The new genotypes identified, though the results need to be confirmed, could be utilized as valuable breeding sources to improve the drought resistance of chickpea. Also, ICC 4958, a well known drought resistant genotype with a deep and prolific root system (Junichi Kashiwagi et al. 2005) had better, SCMR possibly due to its strong root systems.

This screening of the mini-core germplasm is being repeated during 2006/07 to confirm the results obtained. Any queries related to this study may be directed to Dr J Kashiwagi, Associate Scientist, Crop Physiology, ICRISAT.

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References

Bindu Madhava H, Sheshshayee MS, Shankar AG, Prasad TG and **Udayakumar M.** 2003. Use of SPAD chlorophyll meter to assess transpiration efficiency of peanut. Pages 3–9 *in* Breeding of drought resistant peanut: Proceedings of a Collaborative Review Meeting, 25–27 Feb 2002, Hyderabad, India (Cruickshank AW, Rachaputi NC, Wright GC and Nigam SN, eds.). ACIAR Proceedings No. 112. Canberra, Australia.

Bullock DG and **Anderson DS.** 1998. Evaluation of the Minolta SPAD-502 chlorophyll meter for nitrogen management in corn. Journal of Plant Nutrition 21:741–755.

Junichi Kashiwagi, Krishnamurthy L, Upadhyaya HD, Hari Krishna, Chandra S, Vadez V and **Serraj R.** 2006. Genetic variability of drought-avoidance root traits in the mini-core germplasm collection of chickpea (*Cicer arietinum* L.). Euphytica 146:213–222.

Kantety RV, Van Santen E, Woods FM and **Wood CW.** 1996. Chlorophyll meter predicts nitrogen status of tall fescue. Journal of Plant Nutrition 19:881–899.

Nageswara Rao RC, Talwar HS and **Wright GC.** 2001. Rapid assessment of specific leaf area and leaf N in peanut (*Arachis hypogaea* L.) using chlorophyll meter. Journal of Agronomy and Crop Science 189:175–182.

Passioura JB. 1977. Grain yield, harvest index and water use of wheat. Journal of Australian Institute of Agricultural Science 43:117–120.

Serraj R, Krishnamurthy L, Jyostna Devi M, Reddy MJV and **Nigam SN.** 2004. Variation in transpiration efficiency and related traits in groundnut mapping population. International *Arachis* Newsletter 24:42–45.

Upadhyaya HD and **Ortiz R.** 2001. A mini core subset for capturing diversity and promoting utilization of chickpea genetic resources in crop improvement. Theoretical and Applied Genetics 102:1292–1298.

Yadava UL. 1986. A rapid and nondestructive method to determine chlorophyll in intact leaves. Horticulture Science 21:1449–1450.