CAM photosynthetic transition as a tool to develop drought- and salinity-tolerant cultivars

At ICAR-DGR, while working on alleviation of drought- and salinity- stress by endophytic bacteria with groundnut cultivar TG37A, we have identified a number of facultative CAM transited stable natural variants from population of TG37A in 2013, capable of switching to CAM mode of photosynthesis, on imposition of severe drought- stress.

Subsequently, all the variants were characterised for expression of all the modules of functional facultative CAM viz. carboxylation, decarboxylation, mesophyll succulence, and invert stomatal behaviour underpinning drought- and salinity- tolerance. The genes for enzymes and transporters, recruited to transit to CAM mode of photosynthesis from C3, on imposition of certain degree of moisture-deficit- and salinity- stress, were monitored, in real time and in diel cycle, and described. The network of pathways recruited for transition to CAM mode of photosynthesis from C3, have also been described.

Field evaluation of these CAM over-expressing variants (DGRMB5, DGRMB13, DGRMB17, DGRMB19, DGRMB24, DGRMB31, DGRMB32, etc.) exhibited extreme tolerance to drought and gave 1000-1400 kg/ha of pod yield as compared to TG37A (400-450 kg/ha) with soil water equivalent to 120 mm (no irrigation after emergence in summer groundnut). Further evaluation of these variants indicated that application of 4 irrigations (equivalent to 240 mm of rainfall) can yield (up to 3000 kg/ha) as much as that can be obtained with application of 8-10 flood irrigations (regular practice for summer groundnut; equivalent to 480-600 mm of rainfall) after emergence in medium black calcareous soil of Junagadh. Thus, with the expression of CAM, water dependence of groundnut can be reduced by 50-60%.

Fig 1. *Evaluation of CAM transited variants of TG37A: Left: with normal (10 irrigations after emergence); right: with 2 irrigations after emergence at DGR's experimental plot*

The performance of the selected CAM variants (DGRMB24 and DGRMB32) were further evaluated in drought-prone area in Ananthapur district of Andhra Pradesh (KVK-Reddipalli and KVK-Kalyandurga), at farmers field, without any protective irrigations during kharif season of 2019, with a drought period of 50-65 days after sowing across locations. TG37A and Kadiri 6 were kept as checks. DGRMB24 outperformed Kadiri 6 and TG37A significantly and gave 11.8% higher pod (1813 kg/ha in DGRMB32) than Kadiri 6.

Six CAM transited variants (DGRMB5, DGRMB5B, DGRMB24, DGRMB32, DGRMB19 and DGRMB42) were also evaluated at CCSRI, Mandvi, Bhuj keeping TG 37A and GG 7 as checks at soil EC (4.55 dSm-1 at harvest) during kharif 2019. DGRMB19 (3687 kg/ha) and DGRMB5 (3663 kg/ha), gave 15.7% and 14.9% per cent higher pod yield than the local check GG 7 (3187 kg/ha).

Further evaluation of the variants are underway at both salinity- affected and drought- prone locations of India.

This is the first report of natural occurrence of CAM transition in any agricultural field crop in Fabaceae underpinning both drought- and salinity- tolerance, addressing the fundamental issues of reduced photosynthesis and biomass gain during both the stresses.

Further research is on to understand the phenomenon further in the context of circadian control of the transition and possibility of finding existence of the same phenomenon in many other crops exploiting the evolutionary lineage.

Inputs from: *K. K. Pal, R. Dey, K. Chakraborty, R. Bhadania, D. Sherathia, M.K. Mahatma, A.L. Rathnakumar, Ajay B.C., Narayanan G., B. Nawade, S. Patel, H. Bhalani, HB Lalwani, P. Dash, V. Singh, H. Purohit, L.K. Thawait, S. Raval, S. Ahmad, S. Acharya, and Radhakrishnan, T.*