GmPT7

Increasing yield and nutrient use in soybean and other legumes

Field tested in soybean over two years

Evaluation and Licensing Opportunities

For further information on this technology and evaluation / licensing opportunities please contact:

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Tech ID: 16.617

Patent Literature

Publications: WO/2018/146481, US 2019/0367937 A1, CN 110573623A

***GmPT7* encodes a phosphate transporter. Researchers at Fujian Agriculture and Forestry University have found that over-expressing PT7 increases yield of soybeans in the field – with increased numbers, mass and metabolic activity of the root nodules. Although *GmPT7* has been previously described, prior literature cites it as a low-affinity Pi transporter, and although its role is generally considered to be an involvement in managing internal Pi homeostasis its precise function, and utility, has not been understood until now.**

Prof Hong Liao, Director of the Root Biology Center at Fujian Agriculture and Forestry University, Fuzhou, China, has now established that GmPT7 is in fact a wide affinity phosphate transporter and is localised in the symbiosome membrane of root nodules. Moreover, it is essentially required for efficient nitrogen fixation and thus has a significant impact on crop yield.

Symbiotic nitrogen fixation requires complex material exchanges between the host plant and rhizobia, and the role of phosphate (Pi) in this relationship is often overlooked or underestimated. The FAFU team used transgenic overexpression and downregulation of *GmPT7* in soybeans to show that altering *PT7* expression significantly changes Pi uptake from the rhizosphere and Pi translocation from host cells to bacteroids, and subsequently affects nodulation as well as nitrogen fixation.

Overexpression of *GmPT7* increased soybean yield by up to 36% during two years of field trials conducted by the FAFU group. Seed number was also increased (by up to 28%) (Fig 1). This is associated with significant increases in nodule number, nodule mass and nitrogenase activity (Fig 2). In contrast, transgenic downregulation of *GmPT7*, together with suppression of another phosphate transporter PT5, almost completely abolished nodulation and dramatically reduced plant biomass and nitrogen content. The inventors have previously shown that GmPT5 does not function in direct Pi uptake in the root nodules (Qin et al *Plant Physiol.* 159, 1634-1643 (2012)) and this leaves GmPT7 as the only candidate high-affinity Pi transporter acting in direct Pi uptake by root nodules. Radiolabelled Pi uptake studies in the up- and down-regulated transgenic plants confirms this (Fig 3).

The inventors also found that GmPT7 is, in addition, located in the symbiosome membrane and here acts as a low-affinity Pi transporter involved in Pi translocation into the bacteroids. This is the first report of a functional Pi transporter critically acting in the symbionts of legume nodules.

Thus GmPT7 is unique among legume phosphate transporters in having a critical and flexible role both in the acquisition of phosphate from the external environment and in maintaining the health of the bacteroids for active nodule function. Its importance in both these functions is reflected in the effect on crop yield achieved by its **transgenic over-expression**.

The inventors have also demonstrated that natural **genetic variation of GmPT7 expression** among soybean cultivars, and also in progenies of a RI population, is positively associated with soybean yield and yield components in the field. Data available upon request.

The GmPT7 technology from Fujian Agriculture and Forestry University, covering transgenic and other genetic modification approaches and selection for GmPT7 expression in soybean germplasm, is available for licensing from PBL.

References:

Chen L et al (2019). A nodule-localized phosphate transporter GmPT7 plays an important role in enhancing symbiotic N_2 fixation and yield in soybean. *New Phytol*; 221(4): 2013-2025.

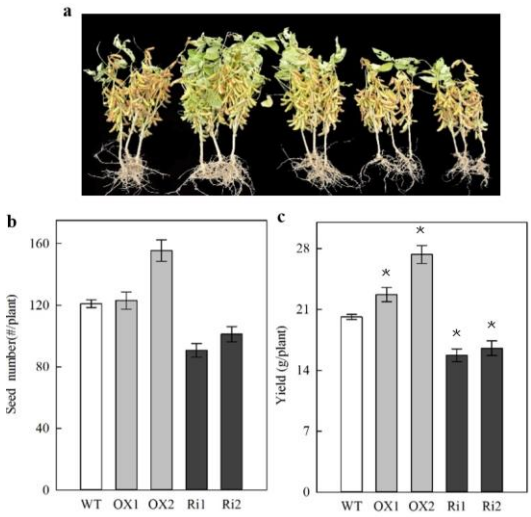


Fig 1. Effects of overexpression or knockdown of *GmPT7* on soybean yield in the field (2016)

a: growth performance, b: seed number, c: yield.

WT: wild-type HN66, OX: over-expressing lines, R: knockdown lines.

Field trials were conducted in southern China from March to June 2016. Plants were inoculated with rhizobia and planted in four reps each of 15 plants for each line tested.

NB similar results were obtained in the field in 2015.

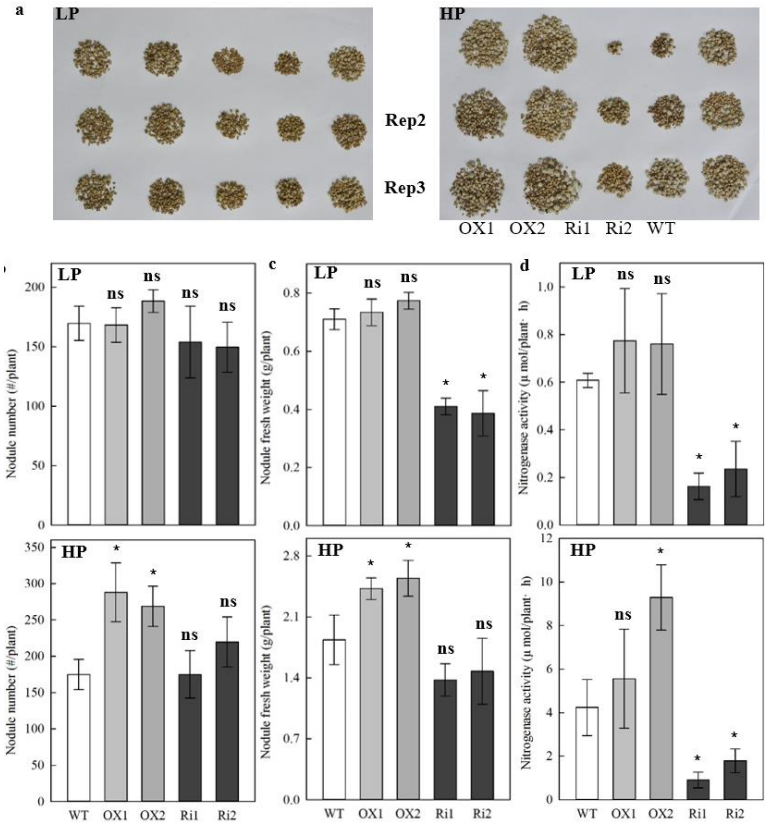


Fig 2. Effects of overexpression or knockdown of *GmPT7* on soybean nodulation

a: Nodule growth performance, b: nodule number, c: nodule fresh weight, d: nitrogenase activity of different lines.

WT: wild-type HN66, OX: over-expressing lines, Ri: knockdown lines.

LP: low P (5μM), HP: sufficient P (250μM) – both with 500μM supply.

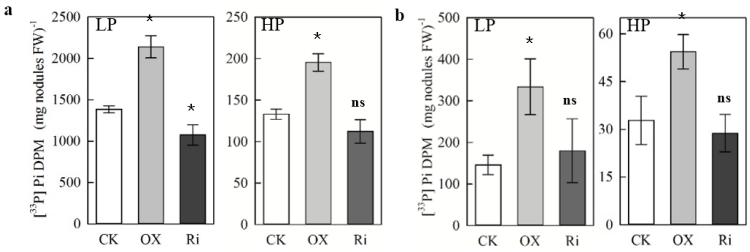
7d–old plants inoculated with rhizobia then grown in growth chamber for 30 days prior to analysis

Fig 3. *In vitro* assays for radioactive ^{33}P- Pi uptake and translocation in transgenic nodules

a: ^{33}P- Pi in the whole nodule. b: ^{33}P-Pi in symbiosomes.

CK: empty vector nodules, OX: *GmPT7*-overexpressing nodules, Ri: *GmPT7* knockdown nodules.

LP: low P (5μM), HP: sufficient P (250μM)



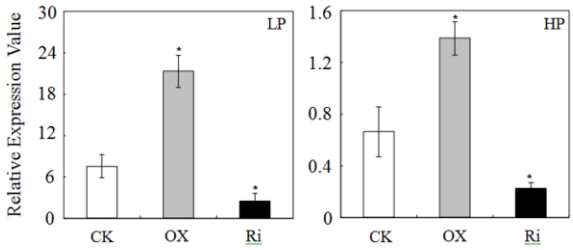


Fig 4. Relative expression of *GmPT7* in nodules

qPCR relative to soybean housekeeping gene *TefS1*

Lines: empty vector (CK), over-expression (OX) and 203 *GmPT7* knockdown (Ri).

LP: low P (5μM), HP: sufficient P (250μM)