

## Dual benefits: *MOT1;1/1;2* coordinates both crop growth and productivity

Md. Mahadi Hasan<sup>1\*</sup>, Mohammad Shah Jahan<sup>2,3\*</sup>

<sup>1</sup>State Key Laboratory of Herbage Improvement and Grassland Agro-Ecosystems, College of Ecology, Lanzhou University, Lanzhou, 730000, China

<sup>2</sup>Guangdong Key Laboratory for New Technology Research of Vegetables/Vegetable Research Institute, Guangdong Academy of Agricultural Sciences, Guangzhou, 510640, China

<sup>3</sup>Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, 1207, Bangladesh

### \*Corresponding authors

Md. Mahadi Hasan

Email: [hasanmahadikau@gmail.com](mailto:hasanmahadikau@gmail.com)

And Mohammad Shah Jahan

Email: [shahjahansau@gmail.com](mailto:shahjahansau@gmail.com)

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### ABSTRACT

Molybdenum (Mo) fertilization is crucial for grain fitness and yields. However, transition metal-dependent hormone delivery system is largely unknown in soybean legume. Recently, *Zhang et al* discovered the Mo-transporter genes *MOT1;1* and *MOT1;2* through a genome-wide association study (GWAS). The transporter genes orchestrate plant growth and plant productivity in soybean by facilitating Mo-dependent auxin synthesis.

### INTRODUCTION

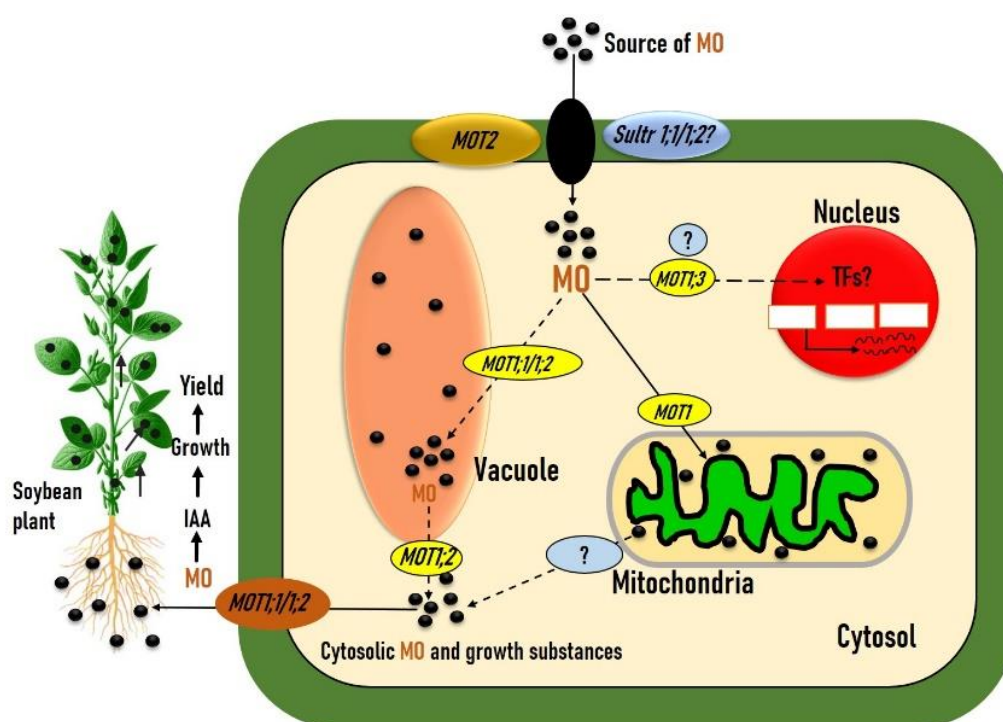
Plant growth and yield are key traits coordinate total agricultural production to global food security. The major grain crop is grown around 1% that is lower than the growth rate of world population [1]. Therefore, food security of the global population seems to be under threat. In this scenario, increasing food crops growth and productivity through ecofriendly approaches should be major focused for sustainable agriculture. Mineral boosting in grain along with crop improvement is an effective strategy, where molybdenum (Mo) serves as the active center of nitrogenase enzyme and possesses immense potential for auxin synthesis that led to improve plant growth and productivity [2]. The Mo-concentration is driven by *MOT1;1* and *MOT1;2* transporters that enhance auxins, growth, and yield traits in plants [2, 3]. Various studies have explored the function of molybdate transporter specially *MOT1;2* participate in interorgans Mo translocation and remobilization in different rice cultivars [3, 4]. Zhang et al identified and characterized key Mo-transporters *MOT1;1* and *MOT1;2* in soybean that driven Mo-uptake and translocation, while *MOT1;3* is not fully active in Mo-transport activity [2]. The *MOT1;1* and *MOT1;2* transporters driving enhancement of Mo-concentration lead to improving yield traits by regulating auxin (Indole 3-acetic acid) synthesis under acidic to moderate acidic soils.



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## INVOLVEMENT OF *MOT1;1/1;2* IN MOLYBDATE UPTAKE AND MOBILIZATION

The *MOT1;1* and *MOT1;2* are crucial Mo transporters involved in Mo uptake and transportation in plants. It has already been reported the function of *MOT1;1* coordinates interorgans Mo distribution in several rice genotypes [3, 4]. A rice mutant harboring a complete deletion of *MOT1;2* showed lower grain Mo concentration compared to WT. In contrast, the concentration of Mo in grains was restored through induction of WT *MOT1;2* [4]. These findings were consistent with the recent breakthrough in soybean plant by Zhang et al., where in *mot1;1/1;2* double mutant *MOT1;1* and *MOT1;2* functionally redundant and root derived the decline of Mo concentration in shoots and seeds. Based on these above insights a key model figure was drawn (Figure 1). However, the *MOT1;1* and *MOT1;2* overexpression lines increased the Mo accumulation in leaves and seeds that also validated the Mo-transport ability which found in double mutant soybean lines (Figure 1). This observation is very consistent with recent finding where the expression of *MOT1;2* was upregulated in flag leaf and the second leaf during the grain filling stage, and *MOT1;2*-GFP protein localized to the vacuolar membrane when it found to be expressed in tonoplast [3]. Furthermore, the overexpression of *MOT1;2* enhanced mobilization of Mo from seedling roots to shoots. The result suggests that *MOT1;2* or *MOT1;2* may active as vacuolar Mo exporter mediating the efflux of Mo from vacuole into cytoplasm, subsequently translocated into shoots, grains and aerial parts (Figure 1).



**Figure 1.** Working model of *MOT1;1/1;2*-involving regulation into cells leading growth and yield traits in plants. The Mo is transported into mitochondria via *MOT1;1*, subsequently *MOT1;2* export Mo from vacuole into cytosol. The cytosolic Mo further transported out of the cells for long distance transport to shoots, leaves and grains. The black dots in the figures indicates form of molybdenum. Abbreviation, Mo, molybdenum, *MOT2*, molybdate transporter family 2 proteins, *Sultr*, sulfur transporter, IAA, indole-3-acetic acid; TF, transcription factor. The dotted lines indicate the possible mechanism of Mo regulation.

## CROSSTALK AMONG *MOT1;1/1;2*, CROP YIELD, AND GROWTH REGULATION

The *MOT1;1/1;2* controls yield related traits by regulating Mo-dependent indole-3-acetic acid (IAA) synthesis [2]. The *MOT1;1/1;2* is a causal candidate that changes both transcription and protein activity, contributed to regulating Mo-concentration uptake and long-distance transport, which led to enhance yield in plants. Interestingly, *MOT1;1* and *MOT1;2* also coordinated growth enhancement by regulating increased indole-3-acetic acid (IAA) synthesis rather than associated with nitrogen assimilation or symbiotic nitrogen fixation (SNF) [2]. Soil pH is another factor that influence crop yield, amendment-based enhancement of soil pH level assists to crop yield up to 13-36 % [5]. In contrast, Zhang et al. noticed *MOT1;1/1;2* was active in improving yield traits in soybean while the plants were cultivated at acidic to moderate acidic soils [2]. The *MOT1;1* and *MOT1;2* genes enhanced plant growth by regulating indole-3-acetaldehyde (IAAld) aldehyde oxidase (AO)-mediating IAA synthesis. Additionally, Mo-concentration may vary in different plant organs due to activation of *MOT1;1* and *MOT1;2* [2]. These above findings suggest Mo-uptake, transportation, plant growth and yield regulated by *MOT1;1/1;2* where natural variant also a factor.

## CONCLUDING REMARKS AND FURTHER DIRECTION

It is generally known that plant growth and yield is regulated by several plant growth regulators, bio-stimulants, multiple environmental factors. How such types of growth and yield traits regulated by mineral transporters genes is an interesting area in grain crops that needs attention. However, molecular mechanisms underlying mineral transporters involving growth, yield, nutrient enrichment in grains remains largely unknown. The findings by Zhang et al. disclosed a new direction of trace element-transporters derived regulation of plant growth and yield traits in plants [2]. This study further connects the understanding of functional mechanisms towards foliar application of Mo fertilizer and Mo-nanofertilizer based boosting nutrient and yield enhancement in grain crop species. Finally, it would be useful and fascinating to the grain crop breeders and farmers for grain crop improvement through breeding programs.

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## AUTHOR CONTRIBUTIONS

The two authors contributed equally to this work.

## CONFLICT OF INTERESTS

The authors declare no conflict of interests.

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