Supporting information

for

Enhancing the Mobilization of Native Phosphorous in the Mung Bean Rhizosphere Using ZnO Nanoparticles Synthesized by Soil Fungi

Ramesh Raliya,[†] Jagadish Chandra Tarafdar,[‡] and Pratim Biswas*[,†]

[†]Washington University in St. Louis, St. Louis, Missouri 63130, United States
[‡]Central Arid Zone Research Institute, Jodhpur 342003, India

*Corresponding Author

Phone: +1 314-936-5548. Fax: +1 314-935-5464.
Email: pbiswas@wustl.edu

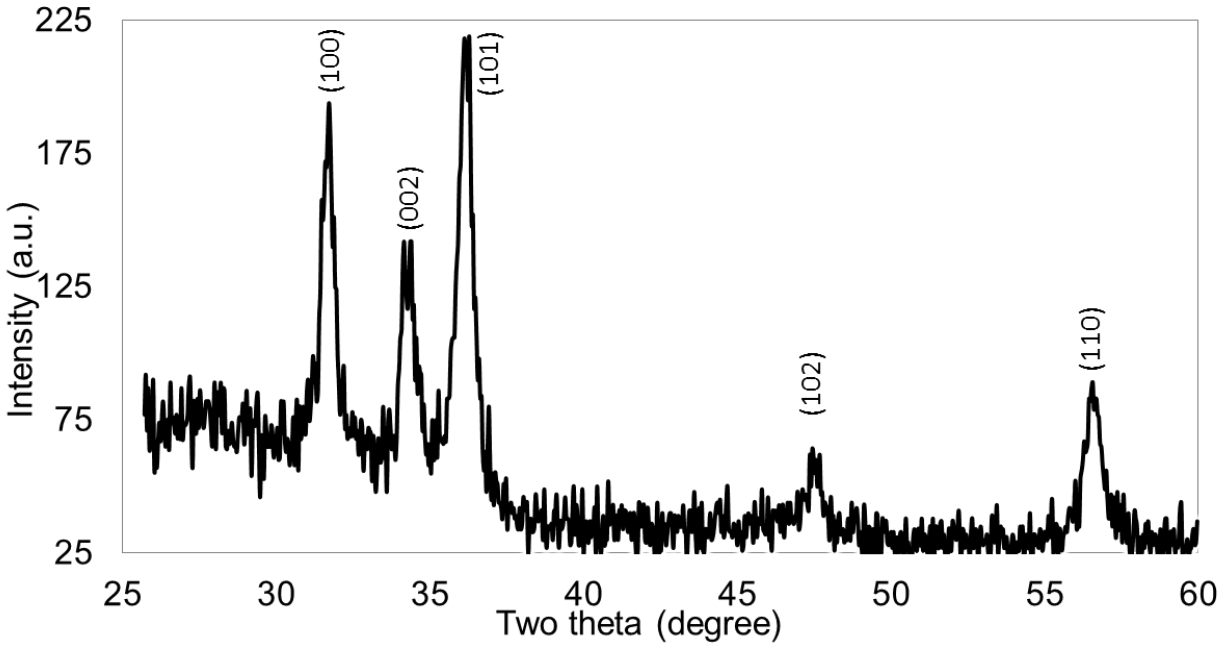

Fig. S1. X-Ray diffraction analyses of synthesized ZnO nanoparticles, showing five distinct peaks for zincite crystal (100, 002,101,102,110) of zinc crystal nature.

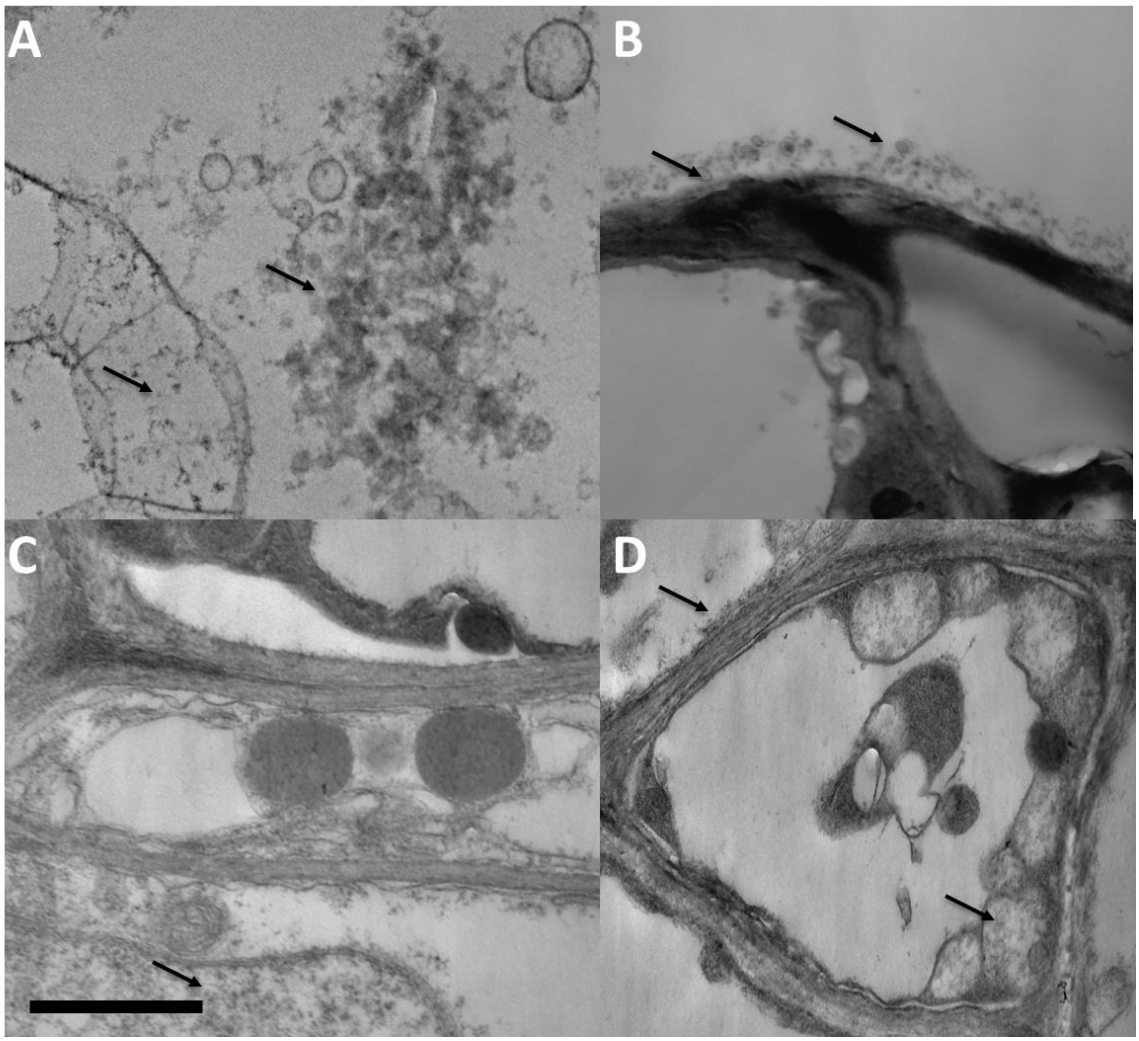

Fig. S2. Fate and transport of ZnO nanoparticles in mung bean plants. TEM micrograph of the stem (A), root (B), leaf (C) and seeds (D). Scale bar equals to 1 µ.

Isolation of Fungi. The soil fungus, *Aspergillus fumigatus* TFR-8 (NCBI GenBank Accession No. JQ675291) was isolated rhizospheric soil of mung bean. Isolation of fungi was carried out by plating the inoculum on Martin Rose Bengal Agar medium (Hi-Media, India, pH 7.2) after serial dilutions of the soil sample. Inoculated plates were incubated at 28ºC for 72 h in BOD incubator. Individual fungal colonies were picked and further purified by sub-culturing on Potato Dextrose Agar media.

Molecular Characterization of Fungal Isolate. Molecular level identification of fungus strain was carried out by partial DNA sequencing of 18S and 28S rRNA and complete sequence of Internal Transcribed Sequence 1 (ITS-1), Internal Transcribed Sequence 2 (ITS-2) and 5.8S r RNA gene (Complex of -18S-ITS1-5.8S-ITS2-28S-) was done using universal primer ITS1 (5'-TCCGTAGGTGAACCTGCG-3') and ITS 4 (5'-TCCTCCGCTTATTGATATGC-3'). The r RNA sequence was submitted to GenBank of National Centre for Biotechnological Information (NCBI).

Table S1. Effect of ZnO NPs on phenological parameters of mung bean

Treatment	Shoot length (cm)	Root length (cm)	Root area (cm^2)	Root diameter (cm)	Root nodules (No.)
Control	47.0	22.4	16.5	0.4	11.7
Bulk ZnO	58.7	24.6	21.9	0.4	17.7
Nano ZnO	62.4	29.1	25.3	0.4	18.6
LSD (p = 0.05)	0.23	0.09	0.07	NS	1.39

Table S2. Effect of ZnO NPs on total chlorophyll and total soluble leaf protein content of mung bean

Treatment	Total chlorophyll (μg g^{-1})	Total soluble leaf protein (mg kg^{-1})
Control	8.4	52.3
Bulk ZnO	9.1	58.5
Nano ZnO	11.3	65.4
LSD (p = 0.05)	0.18	0.5

Table S3 Effect of ZnO NPs on microbial population of mung bean rhizosphere

Treatment	Bacteria (cfu×10^{-6})	Fungi (cfu×10^{-4})	Actinomycetes (cfu×10^{-5})
Control	38.7	21.0	13.7
Bulk ZnO	40.0	23.0	13.7
Nano ZnO	45.7	27.0	16.0
LSD (p = 0.05)	0.08	0.04	0.05

Table S4. Effect of ZnO NPs on enzymatic activity in the mung bean rhizosphere

Treatment	Acid phosphatase ($EU \times 10^{-4}$)	Alkaline phosphatase ($EU \times 10^{-4}$)	Phytase ($EU \times 10^{-2}$)	Dehydrogenase ($pkat\ g^{-1}$)
Control	5.2	4.3	2.5	5.7
Bulk ZnO	7.5	6.9	4.0	8.2
Nano ZnO	10.3	8.3	5.2	10.5
LSD (p = 0.05)	0.09	0.04	0.04	0.14

Table S5. Effect of ZnO NPs on grain yield and dry biomass of mung bean

Treatment	Grain yield (kg ha^{-1})	Dry biomass (kg ha^{-1})
Control	944	1716
Bulk ZnO	965	2035
Nano ZnO	1005	2354
LSD (p = 0.05)	13.8	162.4

Table S6. Effect of ZNO nanoparticles on available P in the rhizosphere and total plant P of mung bean

Treatment	Olsen P (mg kg^{-1})	Plant P (mg kg^{-1})
Control	33.7	978.2
Ordinary Zn	26.5	998.2
Nano Zn	24.6	1084.4
LSD (p = 0.05)	0.3	1.37