

Figure S1. The main metal ion concentration of NS (0.1 g/L) measured by ICP-MS after digesting NS with nitric acid.

Table S1. Weight ratio of main metal component in NS.

Metal Element	Zn	Fe	Cd	As	Mn
Weight ratio (%)	90	1.6	2.7	5.2	0.5

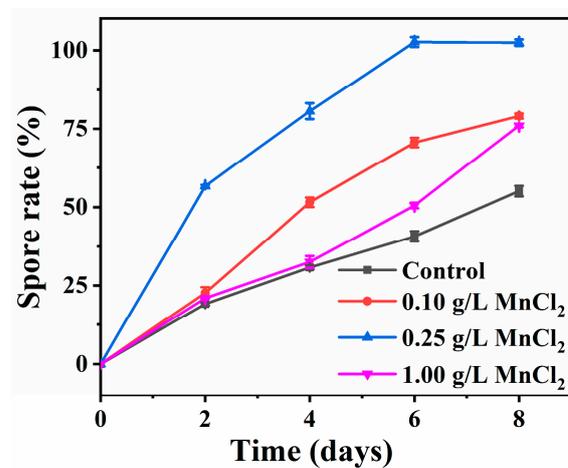


Figure S2. Sporulation efficiency of *B. subtilis* with different concentrations of Mn²⁺ after incubation at 37 °C for 8 days.

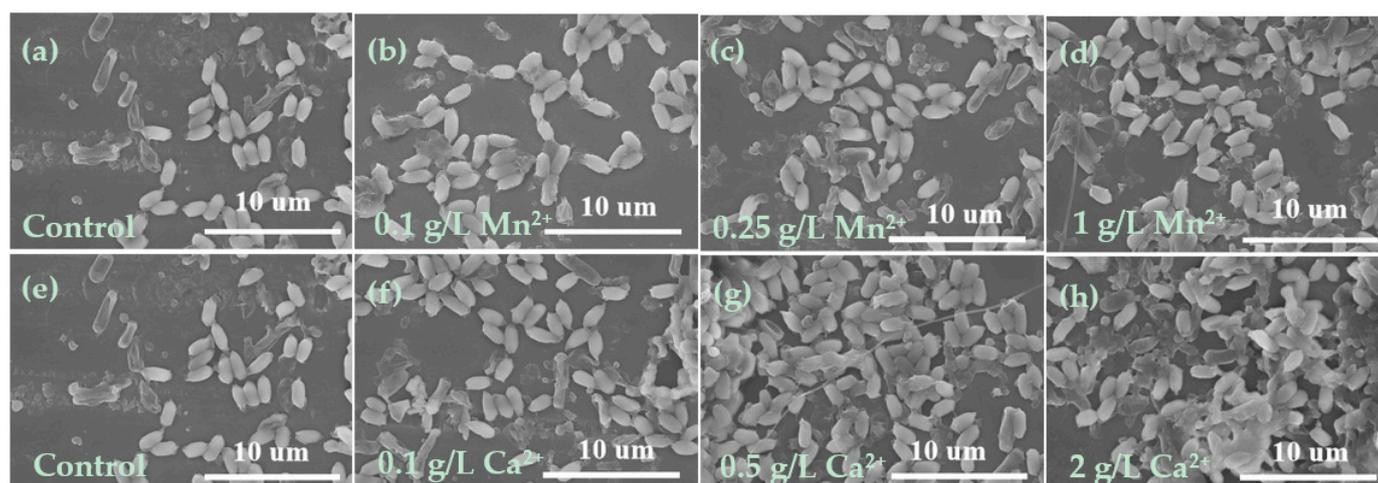


Figure S3. (a–d) SEM images of *B. subtilis* cultured in NB medium supplemented with different concentrations of Ca²⁺ for 8 days; (e–h) SEM images of *B. subtilis* cultured in NB medium supplemented with different concentrations of Mn²⁺ for 8 days. In both cases, the cell density of produced spores was increased with the increase of metal ions (Magnification: 5000×).