cause of anaemia. Three different approaches for iron biofortification are the agronomic approach, breeding and genetic engineering. Lack of genetic diversity makes breeding programs ineffective, while consumer resistance hampers the widespread application of genetic engineering approach. An agronomic approach, especially Fe fertilization is thus a promising solution for improving iron concentration and bioavailability to address on-going human Fe-deficiency. However, the high cost/easy oxidation of the soluble plant available Fe(II) fertilizer and readily conversion of Fe(III) fertilizer into insoluble Ferric oxide make iron biofortification a global challenge.

Thus, there is a need to provide solutions that can overcome, or at least ameliorate, one or more of the disadvantages described above.

Summary

In one aspect of the present disclosure, there is provided a method for promoting plant growth, comprising subjecting at least one part of a plant to a carbon dot, wherein:

the carbon dot is doped with one or more doping material selected from the group consisting of plant macronutrients and plant micronutrients;

the doping material is conjugated within and on the surface of the carbon dot;

the carbon dot comprises a carbonized carbon source; and

the carbon source is selected from the group consisting of ethylenediaminetetraacetic acid (EDTA), metal-EDTA, Fe-EDTA, Fe-Na-EDTA, Zn-EDTA, Cu-EDTA, Mg-EDTA, and combinations thereof.

In another aspect of the present disclosure, there is provided a use of a carbon dot for plant growth, wherein the carbon dot is doped with one or more doping material selected from the group consisting of silica, plant macronutrients, plant micronutrients, and drug molecules; and wherein:

the doping material is conjugated within and on the surface of the carbon dot;

the carbon dot comprises a carbonized carbon source; and

the carbon source is selected from the group consisting of ethylenediaminetetraacetic acid (EDTA), metal-EDTA, Fe-EDTA, Fe-Na-EDTA, Zn-EDTA, Cu-EDTA, Mg-EDTA, and combinations thereof.

In an example of the present disclosure, there is provided a method for promoting plant growth, comprising subjecting at least one part of a plant to a carbon dot, wherein the carbon dot is doped with one or more doping material selected from the group consisting of silica, plant macronutrients, plant micronutrients, and drug molecules; and wherein the doping material is conjugated within and on the surface of the carbon dot.

In another example of the present disclosure, there is provided a use of a carbon dot for plant growth, wherein the carbon dot is doped with one or more doping material selected from the group consisting of silica, plant macronutrients, plant micronutrients, and drug molecules; and wherein the doping material is conjugated within and on the surface of the carbon dot.

Advantageously, the carbon dots of the present disclosure may be purified easily with high yield, making it advantageously scalable in production.

Further advantageously, the carbon dots of the present disclosure may possess high loading capacity of doping material, making it advantageously useful in material delivery to support plant growth.

Also advantageously, the carbon dots of the present disclosure may be capable of prolonged delivery of doping material over a long period of time. This advantageously results

CLAIMS

1. A method for promoting plant growth, comprising subjecting at least one part of a plant to a carbon dot, wherein:

the carbon dot is doped with one or more doping material selected from the group consisting of plant macronutrients and plant micronutrients;

the doping material is conjugated within and on the surface of the carbon dot;

the carbon dot comprises a carbonized carbon source; and

the carbon source is selected from the group consisting of ethylenediaminetetraacetic acid (EDTA), metal-EDTA, Fe-EDTA, Fe-Na-EDTA, Zn-EDTA, Cu-EDTA, Mg-EDTA, and combinations thereof.

2. Use of a carbon dot for plant growth, wherein the carbon dot is doped with one or more doping material selected from the group consisting of silica, plant macronutrients, plant micronutrients, and drug molecules; and wherein:

the doping material is conjugated within and on the surface of the carbon dot;

the carbon dot comprises a carbonized carbon source; and

the carbon source is selected from the group consisting of ethylenediaminetetraacetic acid (EDTA), metal-EDTA, Fe-EDTA, Fe-Na-EDTA, Zn-EDTA, Cu-EDTA, Mg-EDTA, and combinations thereof.

3. The method of claim 1 or the use of claim 2, wherein the carbon dot is formed by an *in situ* process selected from the group consisting of hydrothermal processes, assisted hydrothermal processes, and thermal processes of carbonization of the carbon source in the presence of the doping material, wherein during the *in situ* process, the carbon source and the doping material form carbon dots that contain doping material conjugated within and on the surface of the carbon dots.

4. The method of claim 1 or 3 or the use of claim 2 or 3, wherein the carbon dot is not doped with doping material after the formation of the carbon dot.

5. The method of any one of claims 1, 3 or 4 or the use of any one of claims 2 to 4, wherein the hydrothermal process is performed at a temperature of 150 °C to 300 °C.

6. The method of any one of claims 1 or 3 to 5 or the use of any one of claims 2 to 5, wherein the process is performed for a duration of at least 1 hour.

7. The method of any one of claims 1 or 3 to 6 or the use of any one or claims 2 to 6, wherein the plant micronutrients are selected from the group consisting of metal ions, boron, chlorine, and combinations thereof.

8. The method or the use of claim 7, wherein the metal ions are selected from the group consisting of iron ions, zinc ions, calcium ions, magnesium ions, copper ions, manganese ions, potassium ions, molybdenum ions, and combinations thereof.

9. The method or the use of claim 7 or 8, wherein the metal ions are selected from the group consisting of Fe^{2+}, Fe^{3+}, Zn^{2+}, Ca^{2+}, Mg^{2+}, Cu^{2+}, Mn^{2+}, K^{+}, Mo^{2+}, and combinations thereof.

10. The method of any one of claims 1 or 3 to 9 or the use of any one of claims 2 to 9, wherein the conjugation is via chelation, complexation or adsorption.

11. The method of any one of claims 1 or 3 to 10 or the use of any one of claims 2 to 10, wherein the carbon dot contains 0.2 mmol/g to 30 mmol/g of plant macronutrients and/or plant micronutrients.

12. The method of any one of claims 1 or 3 to 11 or the use of any one of claims 2 to 11, wherein the average diameter of the carbon dots is 3 nm to 200 nm.

13. The method of any one of claims 1 or 3 to 12 or the use of any one of claims 2 to 12, wherein the carbon dot is an iron-doped carbon dot, copper-doped carbon dot, or a zinc-iron co-doped carbon dot.

14. The method of any one of claims 1 or 3 to 13 or the use of any one of claims 2 to 13, wherein the carbon dots are effective at inhibiting the growth of bacteria.

15. The method or the use of claim 14, wherein the bacteria are selected from the group of the genus *Xanthomonas*, *Pseudomonas,* and *Ralstonia*.

16. The method or the use of claim 14 or 15, wherein the bacteria are selected from the group consisting of *Xanthomonas campestris pv. campestris 8004*, *Pseudomonas syringae pv. tomato DC3000*, and *Ralstonia solanacearum GMI1000*.

17. The method of any one of claims 1 or 3 to 16 or the use of any one of claims 2 to 16, wherein:

the carbon dot is a carbon dot doped with iron, copper and/or zinc;

the carbon dot is formed by an *in situ* hydrothermal process of carbonization of the carbon source in the presence of metal ions selected from the group consisting of iron, copper and zinc ions, wherein during the process, the carbon source and metal ions form carbon dots that contain iron, copper and/or zinc ions conjugated within and on the surface of the carbon dots.

18. The method or the use of claim 17, wherein the carbon dots are iron-doped, copper-doped or zinc-iron co-doped carbon dots.