CLAIMS

1. A system for monitoring a crop and nutrient supply in a cultivation zone, comprising:

a nutrient monitoring unit, comprising:

a sample flow cell, the sample flow cell including a channel configured to receive a sample of a liquid nutrient from the cultivation zone, the channel defining a flow path extending across a sampling zone;

a first optical sensor in combination with a laser, the first optical sensor being disposed to acquire emission data from the laser interaction with the sample flowing in the sampling zone; and

a spectral analyzer, the spectral analyzer being configured to generate an elemental spectral data based on the emission data;

at least one imaging spectroscope unit, the at least one imaging spectroscope unit being configured to monitor a non-root part and a root part of the crop to determine a crop health condition of the crop,

wherein the at least one imaging spectroscope unit is displaceable between the crop to another crop.

2. The system as recited in claim 1, further comprising:

a processor, the processor in operation being in signal communication with a non-transitory memory storing processor-executable instructions which when executed by the processor cause the processor to:

determine the respective quantitative measure of each of a plurality of constituent elements in the sample based on the elemental spectral data; and

predict a deviation of a sample composition of the sample from a target nutrient composition using a first machine learning model, the deviation being expressed in terms of a respective quantitative level of deficiency and/or a quantitative level of toxicity of any one or more of the plurality of constituent elements in the sample,

wherein the system is configured to monitor changes in the respective quantitative measure of each of the plurality of constituent elements at predetermined time intervals.

3. The system as recited in claim 2, further comprising a nutrient delivery unit, the nutrient delivery unit being in signal communication with the processor and controllable by the processor to dispense one or more nutrient supplement responsive to the deviation predicted.

4. The system as recited in claim 3, responsive to the deviation being a quantitative level of deficiency of any one or more of the plurality of constituent elements in the sample, one or more nutrient supplement is dispensed to the liquid nutrient provided to the crop in the cultivation zone, the one or more nutrient supplement having a supplement composition selected to replenish the one or more of the plurality of constituent elements predicted to have a quantitative level of deficiency.

5. The system as recited in claim 3, responsive to the deviation being a quantitative level of toxicity of any one or more of the plurality of constituent elements in the sample, the nutrient supplement is selected to have a supplement composition selected to form a neutralizing precipitate with the one or more of the plurality of constituent elements predicted to have a quantitative level of toxicity; or the nutrient delivery unit is configured to add a calculated volume of water to dilute the liquid nutrient.

6. The system as recited in any one of claims 2 to 5, wherein the plurality of constituent elements in the sample comprise any two or more of the following: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S), magnesium (Mg), carbon (C), oxygen (O), hydrogen (H), iron (Fe), boron (B), chlorine (Cl), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), sodium (Na), and nickel (Ni).

7. The system as recited in any one of claims 1 to 6, wherein the processor is caused to predict the crop health condition using a second machine learning model based on an input acquired from the at least one imaging spectroscope, the crop health condition comprising any one or more of the following: a growth stage of the crop, a stress condition of the crop, a disorder type of the crop.

8. The system as recited in claim 7, the at least one imaging spectroscope unit comprising:

a first imaging spectroscope, the first imaging spectroscope being disposed at the cultivation zone and oriented to acquire leaf images of the non-root part of the crop; and

a second imaging spectroscope, the second imaging spectroscope being disposed at the cultivation zone apart from the first imaging spectroscope, the second imaging spectroscope being oriented to acquire root images of the root part of the crop, the processor being caused to acquire the leaf images and the root images as the input to the second machine learning model.

9. The system as recited in claim 8, wherein the processor is configured to determine one or more vegetation indices and one or more spectral signatures of the crop based on a plurality of data cubes acquired by the at least one imaging spectroscope unit, the plurality of data cubes comprising a plurality of leaf data cubes of the non-root part of the crop and a plurality of root data cubes of the root part of the crop, wherein the processor is configured to determine a root growth, a root disease, and a root extrudate based on the root data cubes.

10. The system as recited in any one of claims 7 to 9, wherein the second machine learning model is trained using one or more reference libraries, each of the one or more reference libraries comprising training data pertaining to a respective specific crop type, wherein at least one of the one or more reference libraries comprise: one or more disorder types associated with the specific crop type; and one or more growth stages associated with the specific crop type, wherein the processor is caused to create the one or more reference libraries, each one of the one or more

reference libraries comprising the elemental spectral data relating to a specific nutrient type.

11. The system as recited in any one of claims 7 to 10, further comprising:

one or more environmental sensors configured to obtain measurements of one or more environmental conditions, the one or more environmental sensors including a pH meter configured to measure a pH of the liquid nutrient in the source; and

providing the measurements of the one or more environmental conditions to the processor as input to the second machine learning model.

12. The system as recited in claim 10, the processor being further configured to:

determine a change, the change being in a spectral data for the crop from the one or more reference spectral libraries or in a spectral data over a period of time; and

based on the change, determine a growth stage of the crop and/or determine if the crop is characterized by a deficiency/disorder.

13. The system as recited in claim 1, wherein the sample flow cell comprises a rotatable stage, the rotatable stage being controllably rotatable to centrifugally spread out the sample, wherein the system further comprising a user interface, the user interface in operation being in signal communication with the processor to provide an alert/feedback responsive to any one or both of the deviation of the sample composition and the crop health condition, wherein the nutrient monitoring unit is configured to discard or recycle the sample downstream of the sampling zone.

14. The system as recited in claim 1, comprising a plurality of the crop in the cultivation zone, wherein the at least one imaging spectroscope unit is coupled to a robot, the robot being controllable by the processor to acquire a plurality of leaf data cubes and a plurality of root data cubes of respective ones of the plurality of the crop.

15. The system as recited in any one of claims 1 to 14, comprising:

a crop support, the crop support being configured to support the crop, the non-root part of the plurality of the crop being at least partially disposed to be exposable to a light source; and

a grow tray, the grow tray being disposed under the crop support, the grow tray being configured to collect a first volume of the liquid nutrient, the liquid nutrient being provided to the root part of the crop.