TWINN

Mechanism of Action of TwinN in Crop Plants

BACKGROUND

TwinN is a freeze dried microbial product for use in improving crop productivity. The microbes are *Diazotrophs* whose modes of action in improving plant productivity have been comprehensively described in the literature over many years. TwinN has been successfully used in broad acre crops including wheat, corn, barley, oats, sorghum, rice, cotton, soybean, lupins, mung beans, pastures and many others. It has also been used in many horticultural and tree crops including cauliflower, tomato, lettuces, celery, spinach, potatoes, grapes, apples, macadamia and citrus. The microbes are applied to the foliage or the root system. After application they multiply to exist within the plant foliage, stem and roots as endophytes and also colonise the rhizosphere (the soil zone in close proximity to the roots and root hairs). TwinN can be applied in combination with reduced rates of chemical nitrogen in conventional production systems, or applied without co-application of nitrogen fertiliser in organic systems.

PRIMARY EFFECT

TwinN microbes act to fix atmospheric nitrogen into nitrogenous compounds that are immediately available to the plants. The nitrogen is fixed within the tissues by the endophytes and is also released by the TwinN microbes living in the rhizosphere where it is efficiently captured by the plant roots. The ability of TwinN microbes to fix nitrogen for both leguminous and non-leguminous crops enables a reduction in the application of chemical nitrogen sources such as urea.

Diazothrophs, including TwinN microbes, have evolved to produce an enzyme called nitrogenase which is used to fix nitrogen for the plant's use via the conversion of dinitrogen (N_2) from the atmosphere to ammonia (NH_3) which is available for use by the plant. The reaction consists of:

$$N_2 + 8\,H^+ + 8e^- \rightarrow 2NH_3 + H_2$$

The result is the fixation of nitrogen from the atmosphere into the crop plants in a manner very similar to fixation of nitrogen by *Rhizobium* in legumes.

SECONDARY EFFECTS

1. *Diazotrophs* such as those provided by TwinN have been shown to produce a range of Plant Growth Factors (PGFs), some of which mimic plant hormones such as auxins. These induce increased plant growth, particularly root growth. The resultant larger root system acts to capture nutrients more effectively. Application of urea and other chemical nitrogen fertilisers is well known to result in significant leaching of the fertilisers, as they are poorly bound by soil particles. This results in environmental problems as the nitrogenous compounds enter waterways and aquifers. It also results in decreased economic efficiency as expensive fertilisers are washed out of the root zone. More efficient

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SECONDARY EFFECTS *cont'd*

capture of applied nitrogen and other nutrients by the larger root systems induced by the TwinN microbes is part of the mechanism by which TwinN increases plant growth and productivity. The improved capture of nitrogen that would otherwise be lost to leaching and other loss mechanisms is part of the reason TwinN allows maintenance of high yields with reduced inputs of chemical nitrogen fertilisers.

2. *Diazotrophs*, such as the TwinN microbes existing in the rhizosphere, have been shown to release a range of substances that solubilise nutrients such as phosphorous and some micronutrients that, in many soils, are bound so tightly that they are unavailable to crops. Application of TwinN acts to make an increased proportion of these available to the plant roots for uptake. This is via the production of organic acids such as gluconic acid, oxalic acid, citric acid, lactic acid, tartaric acid, and aspartic acid. These drive the following reactions to release bound phosphorous from substrates such as dicalcium phosphate and hydroxyapatite into a soluble form for use by the crop plant:

$$\text{(Dicalcium Phosphate)}\quad CaHPO_4 + H^+ \rightarrow H_2PO_4 + Ca^{2+}$$
$$\text{(Hydroxyapatite)}\quad Ca_5(PO_4)_3(OH) + 4H^+ \rightarrow 3HPO_4^{2-} + 5Ca^{2+} + H_2O$$

These reactions are two of a number of reactions by which bound nutrients are made available for uptake by the action of microbial exudates.

CONCLUSION

TwinN is used in a broad range of crops primarily due to the capacity to retain or improve crop yields with reduced rates of nitrogen fertiliser application. This occurs via a combination of the mechanisms described above, as well as more general improvements to soil structure and health that result from reduced chemical nitrogen inputs and a more balanced microbial population. The contribution of each of these factors is likely to vary in different cropping situations. TwinN represents a new technology that enables mainstream crop producers to conveniently use 'biological approaches' that have previously been incompatible with their cropping systems.