White Paper

Amino Acid Functions in Soil and Plant Growth

Amino acids are molecules critical in plant growth, flowering, fruiting and resilience to stress and disease.

General Overview of Amino Acids and Plant Growth

Every plant, like any organism needs certain components for growth over and above soil, sun, rain and air. The basic component of living plant cells is protein, which are built from a sequence of amino acids.

Plants synthesise amino acids from the primary elements, carbon and oxygen are obtained from air, nitrogen from the soil and hydrogen from water in the soil. By means of photosynthesis, carbon hydrate complexes are formed, leading to the synthesis of amino acids, by collateral metabolic pathways (chemical reactions).

Amino acids can play many different roles in plants including; acting as stress-reducing agents, being a source of nitrogen, as a hormone precursor, involved in biosynthesis of non-protein compounds like vitamins, coenzymes, pigments, etc.[i]

Amino acids also play a signalling role for different physiological processes in plants. Recent studies have identified Glutamate receptors in plants, which are also capable of binding to other amino acids. These receptors, when activated by amino acids, can trigger a series of physiological processes such as the regulation of nitrogen uptake,[ii] root development and antioxidant metabolism.[iii] Stimulation of root growth can enhance aspects such as nitrogen fixation and nutrient accessibility.

Recent research has revealed the importance of amino acids and their functions in plant physiology (Table 1). While a more detailed description of the function and role of amino acids can be found in appendix 2.

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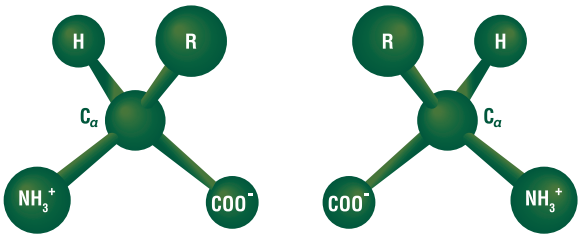
Importantly every amino acid (except glycine) can occur in two isomeric forms; L and D isomers.

This is analogous to left-handed and right-handed configurations. Only L-amino acids are manufactured by plant cells and incorporated into plant proteins.

Figure 1 – L and D Isomers of Amino Acids



L-isomer D-isomer

Supplying Amino Acids

In addition to the synthesis of amino acids within plants; amino acids can be absorbed through plant roots and leaves via diffusion through the membrane pores.[iv]

Studies on the foliar application of amino acid mixtures on plants have shown a beneficial effect, such as increased productivity, higher accumulation of dry matter mass, increased levels of chlorophyll, carbohydrates and polysaccharides.[v] Research has also shown that applying amino acids increases the number of flowers, fruit set and fruit yield.[vi]

The overall improvement in plant growth parameters and yield due to the application of amino acids is a result of plants being provided a readily usable source of growth building blocks (amino acids), for production of proteins in living tissues.

In addition, applying a mixture of amino acids proved to be effective in improving plant growth under abiotic stress[vii] such as heatwaves, droughts and frost.

The application of amino acids as either a soil or foliar treatment has become common practice in recent years.

Importantly though, it is only L-amino acids that can be utilised in the building of proteins and in plant metabolic processes.

Sources of Amino Acids

While amino acids can be extracted from plants and products like fish meal or seaweed extracts, they can also be synthesised in a chemical process, however this produces both L and D isomers.

Alternatively, amino acids can be synthesised utilising plant or microbial processes. In these circumstances L-amino acids are produced, the required isomers utilised by plants.

BioAg Biostimulants Contain L-amino Acids

BioAg offers a range of fermented microbial biostimulants, each provides a range of amino acids (see Appendix 2), and as they are produced through microbial fermentation, they are present as L-isomers.

Table 1 – Fundamental Functions of Amino Acids in Plants[viii]

Function	Amino Acid
Anti-stress Agent	Proline
Chelating Agent	Glutamic acid, Glycine, Histidine, Lysine
Cold Weather Resistance	Alanine, Arginine
Generative Development of Plants and Improvement of the Plant Pollen Fertility	Proline
Growth Stimulator	Glutamic Acid
Precursor of Auxin	Serine, Tryptophan, Valine
Precursor of Chlorophyll	Glycine
Precursor of Polyamines: Necessary to Start the Cell Division	Arginine
Precursor to the Formation of Lignin and Woody Tissues	Phenylalanine
Regulation of the Water Balance	Proline, Serine
Reserve of Organic Nitrogen Necessary for the Synthesis of other Amino Acids and Proteins	Glutamic Acid
Stimulation of the Chlorophyll Synthesis	Alanine, Lysine, Serine
Stimulation of the Ethylene Synthesis	Methionine
Stimulation of the Germination	Aspartic Acid, Glutamic Acid, Lysine, Methionine, Phenylalanine, Threonine
Stimulation of the Hormone Metabolism	Alanine
Stimulation of the Resistance Mechanism to Viruses	Alanine

More about BioAg's Fermented Liquid Biostimulants

BioAg's *Soil & Seed*®, *Balance & Grow*® and *Fruit & Balance*® are formulated to stimulate and feed the plant and the soil microbiome.

Complexed carbohydrates are a key component of these products; they are a highly effective food source for microorganisms. Carbohydrates stimulate microorganism activity and grow their populations, increasing their positive effects on the soil, plant emergence, plant health, plant growth, and yield potential. The proteins (in the form of amino acids) feed both the plant and the micro-biology.

At planting, *Soil & Seed* conditions the soil and prepares it for maximising moisture and nutrient retention, as well as fertiliser use efficiency.

Tailored towards increasing vegetative growth, the foliar *Balance & Grow* provides a very wide range of food sources that act very fast after application is complemented by other inputs such as calcium nitrate or gibberellic acid.

Fruit & Balance provides highly available and fast acting food sources tailored for flowering and fruit set.

Appendices

Appendix 1 – Role of Amino Acids and their Mode of Action.

Plant Growth Stimulation

Addition of L-tryptophan to soil has a beneficial effect on the growth and development of some plants because of its catabolism (destructive metabolism) into auxins by rhizosphere microflora. Pot trials conducted on cotton revealed that specific growth parameters were significantly promoted, such as plant height (27.3%), dry weights of shoot (45.7%) and root (35.8%), biomass (43.3%), and number of branches (37.5%), flowers (63.3%) and bolls per plant (22.4%) in response to L-tryptophan treatments. Similarly, the nitrogen (N), phosphorus (P), and potassium (K) concentrations in plant tissues and their uptake were also significantly affected by the exogenous application of L-tryptophan.[ix]

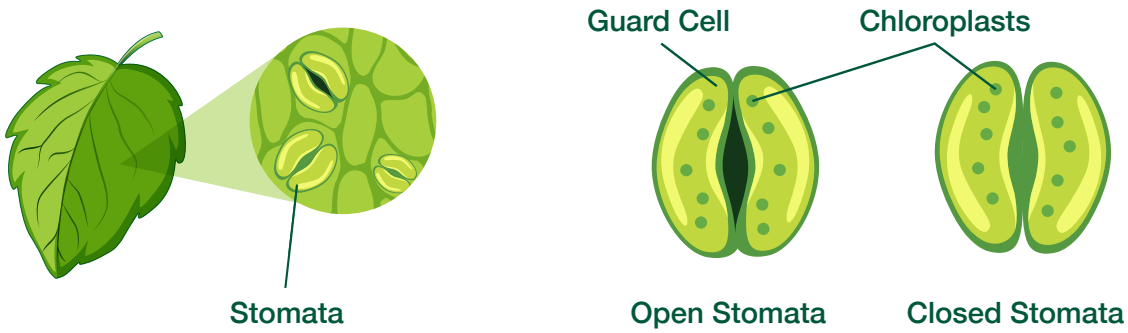
Effect on Photosynthesis

Plants perform photosynthesis to produce carbohydrates. Low rate of photosynthesis slow growth due to reduced production of carbohydrates. The concentration of chlorophyll impacts the absorption of light energy and subsequently photosynthesis. L-glycine and L-glutamic acid are essential metabolites in the formation of plant tissue and chlorophyll. These amino acids help to increase chlorophyll concentration in the plant leading to a higher degree of photosynthesis.

Action on Osmotic Pressure and Stomata

Amino acids are osmotically active substances that contribute in osmotic pressure adjustments during water scarcity stress. They aid in keeping the cell wall rigid and keep cells from shrinking due to dehydration. Externally sourced amino acids can help in regulating membrane permeability and ion uptake which is how amino acids mitigate drought or salt stresses.[x]

Stomata (the surface cells of leaves and needles) regulate the water balance of the plant, macro and micronutrient absorption off the leaf and the absorption of gases. The opening of stomata is controlled by both external factors (temperature, humidity, light, and salt concentration) and internal factors (amino acid concentration, L-abscisic acid etc.). Stomata are closed when light and humidity are low or if temperature or salt concentration are high. When stomata are closed photosynthesis and transpiration (movement of water through the plant and evaporation through leaves, plants and flowers) are reduced. This reduces the absorption of macro- and micro-nutrients and increases respiration (the breakdown of sugars (carbohydrates)), depleting vital plant reserves. In these circumstances the metabolic balance of the plant is negative, catabolism is higher than anabolism, which slows metabolism and stops plant growth.



L-glutamic acid acts as a cytoplasm osmotic agent of the ‘guard cells’ (specialised plant cells in leaves that are used to control gas exchange), helping to keep stoma open.

Chelation

Amino acids also act as chelators of metal ions. Chelated nutrients have increased cell membrane permeability; aiding mobility and absorption in plants. Microelements chelated with amino acids form small, electrically neutral molecules, which accelerate

Precursors of Phytohormones (Auxin, Cytokinin, Gibberellin, Ethylene)

Amino acids are precursors or activators of phytohormones, chemical messengers that coordinate cellular activities. As an example, L-methionine is precursor of ethylene and of growth influencing compounds such as polyamines (spermine and spermidine) that improve produce shelf life.

Effect on Pollination and Fruit Formation

Pollination is the transport of pollen to the pistil, to support fecundation and fruit development. L-proline improves the fertility of pollen; L-lysine, L-methionine and L-glutamic acid also are crucial amino acids for pollination. These amino acids increase pollen germination and the length of the pollinic tube.

Amino Acid Role in Root Development and Soil Microbiota

Nitrogen is present in all amino acids and plays an important role in plant growth. Excessive applications of nitrogen fertiliser tend to negatively impact nitrogen uptake and result in a reduction in root growth. Plant vegetative growth (shoots) may still be observed, however the growth of lateral roots will be inhibited due to excess nitrates inhibiting the production of auxins. Auxins are plant hormones responsible for growth and have an essential role in root development. Reduced root mass has a knock-on effect of significantly reducing a crops resistance to drought and access to nutrients.

Application of amino acid can improve the elongation of roots and improve nutrient absorption. Studies have provided convincing evidence of increases in secondary roots and morphological changes after application of amino acids.[xiii] L-glutamate can act as an external signalling molecule to trigger changes in the root development increasing the plant's ability to compete with neighbouring plants and soil microorganisms. When subjected to environmental stress, amino acids can help improve the foraging mechanism of roots. Plants adapt to stress by increased growth of lateral roots to help scavenge heterogeneously distributed nutrients in the soil.[xiv]

Amino acids play a role in increasing the activity of beneficial soil microorganisms which in turn improves the mineralisation of organic matter, thereby increasing soil fertility and supply of nutrients to plants. The balance of soil microbiota plays a key role in improving the physical and chemical properties of the soil. L-methionine is a precursor of a growth factor that stabilises the cell walls, builds the resilience, of microbial flora.

Appendix 2

Table 2 – Analysis Results for Amino Acids in BioAg Fermented Biostimulants

Quantative Analysis[xv]				
Amino Acid	Unit	BioAg Products		
		Soil & Seed®	*Balance & Grow®*	*Fruit & Balance®*
Histidine	µg/ml	77	81	98
Serine	µg/ml	404	161	137
Arginine	µg/ml	280	152	70
Glycine	µg/ml	613	439	343
Aspartic Acid	µg/ml	2,398	546	504
Glutamic Acid	µg/ml	1,655	695	631
Threonine	µg/ml	381	133	86
Alanine	µg/ml	864	382	316
Proline	µg/ml	437	346	347
Lysine	µg/ml	367	334	145
Tyrosine	µg/ml	129	39	32
Methionine	µg/ml	35	20	2
Valine	µg/ml	463	284	248
Isoleucine	µg/ml	325	240	218
Leucine	µg/ml	471	342	350
Phenylalanine	µg/ml	283	195	168
Tryptophan	µg/ml	8	300	Not Analysed
Hydroxyproline	µg/ml	Not Analysed	Not Analysed	161
Note	Asparagine Hydrolysed to Aspartic Acid during Sample Preparation.			
	Glutamine Hydrolysed to Glutamic Acid during Sample Preparation.			

Amino acids in BioAg products are all derived from microbial activity (due to the use of a fermentation process use of natural feedstocks), so they are all the L-isomer. No synthesised amino acids are added to any BioAg product.

White Paper

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xv Australian Proteome Analysis Facility (APAF)

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