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Amino Acid Functions in Soil & Plant Growth

"General Overview of Amino Acids and Plant Growth[i]

Every plant, like any organism needs certain components for growth over and above soil, sun, rain and air. The basic component of living cells is protein, with its building block material being; amino acids. Proteins are formed by sequence of amino acids.

Plants synthesize amino acids from the primary elements, the carbon and oxygen obtained from air, hydrogen from water in the soil, forming carbon hydrate complexes by means of photosynthesis and combining it with the nitrogen which the plants obtain from the soil, leading to synthesis of amino acids, by collateral metabolic pathways. Only L – amino acids are part of these proteins and have metabolic activity.

The requirement of amino acids in essential quantities is well known as a means to increase yield and overall quality of crops.

The application of amino acids for foliar use is based on its requirement by plants in general and at critical stages of growth in particular. Plants absorb amino acids through stomas and requirement is proportionate to environment temperature.

Amino acids are fundamental ingredients in the process of protein synthesis. About 20 important amino acids are involved in the process of each function. Studies have proved that amino acids can directly or indirectly influence the physiological activities of the plant.

Amino acids are also supplied to plant by incorporating them into the soil. It helps in improving the microflora of the soil thereby facilitating the assimilation of nutrients.

Foliar nutrition in the form of liquids containing amino acids and foliar spraying provide readymade building blocks for protein synthesis.

Protein Synthesis

Proteins have a structural function, metabolic function (enzymes), a transport function and a stock of amino acid functions.

Only L - amino acids are assimilated by plants. D - amino acids are not recognised by the enzymatic locus and therefore cannot participate in protein synthesis. Amino acids in BioAg products are all derived from microbial and/or feedstock sources, so are of the L isomer.

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Hence amino acids obtained by organic synthesis are not well assimilated. No synthesised amino acids are added to any BioAg product.

Stress Resistance

Stress factors such as high temperature, low humidity, frost, pest attack, hailstorm and floods have a negative effect on plant metabolism with a corresponding reduction in crop quality and quantity.

The application of amino acids before, during and after the stress conditions supplies the plants with amino acids which are directly related to stress physiology and thus has a preventing and recovering effect.

Effect of Photosynthesis

Plants synthesize carbohydrates by photosynthesis, Low photosynthesis rate implies a slow growth leading to death of the plant; chlorophyll is the responsible molecule for the absorption of the light energy.

Glycine and glutamic acid are fundamental metabolites in the process of formation of vegetable tissue and chlorophyll synthesis.

These amino acids help to increase chlorophyll concentration in the plant leading to higher degree of photosynthesis. This makes crops lush and green.

Action on the Stomas

Stomas are the cellular structures that control the hydric balance of the plant, the macro and micronutrient absorption and the absorption of gases.

The opening of the stomas is controlled by both external factors (light, humidity, temperature and salt concentration) and internal factors (amino acids concentration, abcisic acid etc.)

The stomas are closed when light and humidity are low & temperature and salt concentration are high, when stomas are closed photosynthesis and transpiration are reduced (low absorption of macro & micronutrients) and respiration is increased (Carbohydrate destruction)

In this case the metabolic balance of the plant is negative. Catabolism is higher than anabolism. This implies slow metabolism and stops the plant growth.

L - glutamic acid acts as a cytoplasm osmotic agent of the "guard cells". Thus favouring the opening of the stomas.

Chelating Effect

Amino acids have a chelating effect on micronutrients. When applied together with micronutrients, the absorption and transportation of micronutrients inside the plant is easier.

This effect is due to the chelating action and to the effect of cell membrane permeability.

L - glycine & L - glutamic acid are known to be very effective chelating agents.

Amino Acids & Phyto-hormones

Amino acids are precursors or activators of phyto-hormones and growth substances. L - methionine is precursor of ethylene and of growth factors such as espermine and espermidine, which are synthesized from 5 - adenosyl methionine.

L - tryptophan is precursor for auxin synthesis. L - tryptophan is used in plants in L - form only. L - tryptophan is available only if hydrolysis of protein is carried out by enzyme action.

If hydrolysis is carried out by acid or alkali, as done in many European countries, L - tryptophan is destroyed.

L - arginine induces synthesis of flower and fruit related hormones.

It is now well established that there are two sources of phyto-hormones naturally available for the plants: endogenous production by the plant tissues, and exogenous production by associated microorganisms, including numerous soil bacteria and fungi[ii]

Pollination and Fruit Formation

Pollination is the transport of pollen to the pistil, so fecundation and formation of the fruit is possible.

L - Proline helps in fertility of Pollen. L - Lysine, L - Methionine, L - Glutamic Acid are essential amino acids for pollination.

These amino acids increase the pollen germination and the length of the pollinic tube.

Equilibrium of Soil Flora

The equilibrium of the microbial flora of the agriculture soil is a basic question for a good mineralisation of the organic matter and also for a good soil structure and fertility around the roots.

L - methionine is precursor growth factors that stabilize the cell walls of the microbial flora.

General

L - Glutamic Acid & L - Aspartic Acid, by transamination give rise to the rest of the amino acids.

L - Proline & Hydroxy Proline act mainly on the hydric balance of the plant strengthening the cellular walls in such a way that they increase resistance to unfavourable climatic conditions.

L - Alanine, L - Valine & L - Leucine improve quality of fruits.

L - Histidine helps in proper ripening of fruits."

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Quantative Analysis[iii]				
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 hydolysed to Aspartic Acid during sample preparation. Glutamine hydrolysed to Glutamic Acid during sample preparation			

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Free Amino Acid	Most Common Function in Plant Growth
Histidine	Histidine plays a critical role in plant growth and development, both as one of the standard amino acids in proteins, in the active sites of numerous enzymes and as a metal-binding ligand
Serine	Serine has a fundamental role in metabolism and signalling in living organisms. In plants, the existence of different pathways of serine biosynthesis has complicated our understanding of this amino acid homeostasis.
Arginine	L-arginine is an important and unique amino acid in plants. It serves not only as an important nitrogen reserve and for N recycling, but also as a precursor of the biosynthesis of polyamines, nitric oxide and so on Arginine content is kept at higher level in roots during overwinter period. Arginine metabolism plays an important role in adaptation of plant to environmental disturbances.
Glycine	Glycine and serine are also the main sources of one-carbon units in higher plant cells and, therefore, are at the basis of the whole C metabolism. Glycine also plays a part in regulating plant stress
Aspartic Acid	In plants and microorganisms, aspartate is the precursor to several amino acids, including four that are essential for humans: methionine, threonine, isoleucine, and lysine.
Glutamic Acid	One of the essential amino acids, known to be a plant growth regulator. Deficiency in GA can lead to decreased yield
Threonine	The receptor serine threonine kinases (RSTK), interact with other proteins to effect a wide array of processes ranging from disease resistance to developmental regulation
Alanine	Plant growth regulator, thought to be beneficial in plant recovery following water-logging
Proline	Proline accumulation is a common metabolic response of higher plants to water deficits, and salinity stress. Proline protects membranes and proteins against the adverse effects of high concentrations of inorganic ions and temperature extremes. Exogenously supplied proline is osmo-protective for bacteria, facilitating growth in highly saline environments. Insect herbivores, including members of Orthoptera and Lepidoptera, benefit from increased nitrogen in their food, particularly if it is in the form

	of easily digested amino acids. There is experimental evidence that grasshoppers detect and preferentially feed on grasses treated with the amino acids proline and valine, which commonly increase in plants under drought stress. This ability may lead to insect concentrations on drought-stressed and nitrogen-enriched plants and thus exacerbate acridid population outbreaks through enhanced growth and survival.
Lysine	L-lysine, L-methionine, and L-glutamic acid are essential amino acids for pollination. These amino acids increase pollen germination and the length of the pollen tube. Lysine is also a precursor for glutamate, an important signalling amino acid that regulates plant growth and responses to the environment.
Tyrosine	Plant growth regulator and plays a role in plant signalling. Has been shown to increase yield in beetroots – "Tyrosine and proline proved to be successful agents in improving growth and yield characters of beet plants."
Methionine	L-lysine, L-methionine, and L-glutamic acid are essential amino acids for pollination. These amino acids increase pollen germination and the length of the pollen tube. Methionine is the immediate precursor of S-adenosylmethionine (AdoMet). AdoMet metabolism seems somehow implicated in plant growth via an as yet fully understood link with plant-growth hormones such as cytokinins and auxin and in plant pathogen interactions
Valine	Valine, leucine and isoleucine represent 3 of the 10 essential amino acids needed for human nutrition. These amino acids are critical for protein synthesis and normal plant growth, while also providing precursors for a number of secondary metabolites such as; cyanogenic glycosides, glucosinolates, and acyl-sugars. Insect herbivores, including members of Orthoptera and Lepidoptera, benefit from increased nitrogen in their food, particularly if it is in the form of easily digested amino acids. There is experimental evidence that grasshoppers detect and preferentially feed on grasses treated with the amino acids proline and valine, which commonly increase in plants under drought stress. This ability may lead to insect concentrations on drought-stressed and nitrogen-enriched plants and thus exacerbate acridid population outbreaks through enhanced growth and survival.

Isoleucine	Valine, leucine and isoleucine represent 3 of the 10 essential amino acids needed for human nutrition. These amino acids are critical for protein synthesis and normal plant growth, while also providing precursors for a number of secondary metabolites such as; cyanogenic glycosides, glucosinolates, and acyl-sugars. Our understanding of plant defensive mechanisms against herbivore and pathogen attack has significantly increased over the past decade. The complex cascade of defensive events is initiated and controlled by a network of interacting plant hormones. Especially, the conjugate of jasmonate and isoleucine is a major regulator which controls gene expression and production of secondary metabolites after biotic challenges.
Leucine	Valine, leucine and isoleucine represent 3 of the 10 essential amino acids needed for human nutrition. These amino acids are critical for protein synthesis and normal plant growth, while also providing precursors for a number of secondary metabolites such as; cyanogenic glycosides, glucosinolates, and acyl-sugars. Every cell is surrounded by a greasy cell membrane. Signals from other cells and from the environment must be sensed at the cell surface, transduced across this membrane and translated into a specific response inside the cell. All organisms have evolved membrane receptor proteins to get these complex tasks done, but plant membrane receptors look drastically different from the well studied players in animals and bacteria. The plant steroid receptor BRI1, which can sense a small steroid hormone promoting plant growth, belongs to the family of leucine-rich repeat (LRR) receptor kinases, which are responsible for most membrane signaling events in plants.
Phenylalanine	In a study on the growth and metabolic activities of maize and broad beans, plants have been shown to have a degree of sensitivity to salinity. The aim was to determine the role of amino acids proline or phenylalanine in increasing the salt tolerance of these plants. Dry mass, water content, leaf area and photosynthetic pigment of maize and broad bean plants decreased with increasing salinity.

	These changes were accompanied with a drop in the contents of soluble sugars, soluble proteins and amino acids. When maize and broad bean plants were sprayed with proline or phenylalanine saccharides as well as proteins progressively increased at all sanitization levels.
Tryptophan	Addition of L-tryptophan (L-TRP) to soil can have an ecological impact on the growth and development of some plants through its catabolism into auxins by rhizosphere microflora. A pot experiment was conducted to assess the influence of L-TRP on growth and chemical composition of cotton *(Gossypium hirsutum* L.). Seven L-TRP levels (10^{-7} to 10^{-1} g/kg soil) were applied as a soil drench in addition to a control. Data obtained 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-TRP 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-TRP[iv]
Hydroxyproline	Hydroxyproline rich glycoproteins (HRGPs) are implicated in many aspects of plant growth and development but there is limited knowledge about their localization and function during somatic embryogenesis of higher plants. Hydroxyproline rich glycoproteins play an important developmental role, especially in the process of regeneration and germination of embryos during plant regeneration via somatic embryogenesis.

[i] http://www.priyachem.com/effect.htm#
[ii] http://www.bashanfoundation.org/baca/bacamicrobila.pdf
[iii] Australian Proteome Analysis Facility (APAF)
[iv] http://www.tandfonline.com/doi/abs/10.1080/01904169509364904#.VBotzvmSw78

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