Response of plants to natural protein hydrolysates as a nitrogen fertilizer and chelating agent in organic agricultural systems

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Background

Nitrogen (N) is the essential plant element that most frequently limits irrigated crop production in organic production systems in Egypt. There are numerous organic fertiliser materials available and the effective and economical use of these materials is important to organic producers. Commercial organic fertilisers are only available in small quantities, at high prices and of a undocumented and poor quality. Therefore locally produced organic N-rich fertilisers are a cost-effective means of supplementing the soil or the plant during growth. Such development could significantly enhance the production of organic vegetables in Egypt. However, the scope is broader as this development will be of relevance to organic crop production world-wide.

It is now well documented that crop plants do not only utilise ammonium and nitrate. Several plants can also take up and absorb amino acids; these amino acids are sometimes better N sources than ammonia or nitrate (e.g. Ashmead et al., 1986).

The use of liquids following soaking of plant material is an established practice in organic farming. KIOF (Kenyan Institute of Organic Farming) recommend this as a standard procedure to their farmers, using pruning of trees, among others. In Egypt, organic producers have been experiencing with similar approaches by soaking Persian clover material in water for several days before using it as a strong acting fertiliser that is applied either as a foliar spray or to the soil. However, there have never been any investigations of the acting compounds in such solutions. However, foliar nutrition in the form of hydrolysed amino acids through foliar spray provides readymade building blocks for protein synthesis (Priya Chemicals 2002).

Uptake mechanisms are not well described but presumably, in most of the cases, the amino acid is absorbed by the cells as such, and is simply fed into the metabolic machinery of the cell. It has been reported that aspartate and glutamate are taken up in intact form and utilised as a nitrogen source by both peas and clover. ^{14}C-labelled tyrosine has found to be taken up as a unit by maize and sunflower roots. Likewise, when radioactive glutamate is given to bean seedlings, the intact glutamate molecule enters the cell and forms a pool of free glutamate inside the cells. Evidently, the cells absorb the glutamate faster than it is metabolised, as the glutamate eventually is found in glutamine, glutathione, and protein. The subsequent utilisation of these pools of free glutamate in various synthetic and derogative processes leaves little doubt that at least some plants can incorporate amino acids directly into their metabolic pathways.

The ability of individual amino acids to be good nitrogen sources in organic crop production is dependent upon two factors: (a) that solutions can easily be made locally, and (b) a fast rate of absorption.

Furthermore, it is desirable that any N source when applied to the soil is not lost under excessive irrigation. The fact that zwitterions have both a positive and negative charge is extremely important. This means any nitrogen that is made up from amino acids can attach to the clay colloids in the soil and thus will not be lost to the surrounding environment. Wendell Owens (2002) summarised the benefits of using amino acids in the fertility program to: "*Fertilisers made up of zwitterions will not pollute the environment as readily as the basic nitrogen element. A smaller amount of nitrogen per acre can accomplish the same yield using zwitterions-type fertiliser. It is much better for the organic matter portion of the soil. Nitrogen sources such as anhydrous ammonia will actually liquefy organic matter; therefore organic matter is decreased over time. Great increase in microbial activity using zwitterions-based fertility can be observed easily.*"

Amino acids as chelating agents

Plant uptakes of metal nutrients are a function of the absolute levels, relative levels to each other, soil pH, oxidative state, and solution. The amino acids found in soil organic matter help protect metal cations from harmful reactions with plants and help to regulate plant uptake (Brady, 1974).

When a single legend binds to a cation, that cation is considered "complexed". If a metal cation is joined with an organic compound at two or more exchange sites to form a ring structure, then that structure is considered a metal chelate (Meister, 1999). Two amino acids will bind to a metal to form a chelate (Ashmead et al., 1986). Chelating makes otherwise unavailable compounds plant available under normal pH conditions (AAPFCO, 1998). Chelated nutrients are more plant available than complexes nutrients, and complexes nutrients are more plant available than free ions. Amino acids have the ability to chelate metal (Miller, 1998; Baker and Ammerman, 1995). The metal cations most often chelated are calcium, copper, iron, magnesium, manganese, potassium, and zinc. These are usually sulphates or occasionally as oxides (Ashmead, 1986).

Various complex protein sources may be decomposed into amino acids that are then turned into available nitrogen source. Certain commercial formulations of soil amendments and foliar feeds claim 'amino acids' on the label when they are in fact using denatured protein sources such as blood meal, fish meal, whey, soy isolate or other plant or animal by-products.

Research objectives

The major research objective of this study is to investigate amino acid content and composition in soakings of different plant materials. Fertilizer and plant growth effects of such soakings will be investigated as well as their ability to chelate micronutrients in the soil.

The following specific research questions will be addressed:

1. Effect of time and temperature for soaking plant material for release of nitrogen.
2. Determine the nature and importance of different nitrogen containing compounds in solutions from different model plant materials.
3. Evaluate the effects of foliar fertilisation products at various rates and timing of application on the growth, development and the yield of crop plants.
4. Explore the possibilities of using amino acids from plant-soaked solutions as chelates for metal ions with special focus on micronutrients.
5. Economically evaluate the potential of using amino acids as a nitrogen source and chelating agents.

Materials and Methods

In order to achieve the above mentioned objectives, 3 natural rich sources of protein will be used as model material and prepared for the hydrolysis process. The materials used will be 1) fresh shoot material from Persian clover that is widely grown in Egypt, 2) soybean material, and 3) yeast (Saccahromycies cervisea)

The hydrolysis of the protein will be done in different methods

1. Enzyme hydrolysis by the use of different enzyms. This will depends on the enzymatic compounds that are identified in plant soaking solutions.
2. Acid or alkali hydrolysis will be used as a control to the enzymatic hydrolysis, taking into consideration that the final products is expected to be very different.

The experiments will take place partly in Egypt and partly at KVL.

Expected outcome

1. The identified amino acids will be tested as sources of the required plant nutrients on selected crops.
2. The degree of hydrolysis will be determined and related to temperature and time of soaking.
3. The type of amino acids will be determined using GLC techniques,
4. The effect of using the amino acids hydrolysis as foliar application on some selected plants and seedlings
5. Different growth parameters and crop yield will be determined.
6. Soil fertility status will be also examined. Soil biology, fauna and flora will be determined due to application of the produced natural N and other nutrient sources.
7. Development of general recommendations on the use of plant material soakings in organic farming.

Time frame

Activity	***Year 1***	***Year 2***	***Year 3***
Supplementary PhD courses KVL	Xxx	xxx	
Effect of time and temperature for soaking plant material for release of N.	xxxxxxxxxxxx	xxxxx	
Determine nature and importance of different N containing compounds in solutions from dif model plant materials.		xxxxxxxxxxx	
Evaluate effects of foliar fertilisation products at various rates and timing of application on the growth, development and the yield of crop plants.		xxxxxxxxxxxxxx	Xxxx
Explore the possibilities of using amino acids from plant-soaked solutions as chelates for metal ions with special focus on micronutrients.		xxxxxxx	Xxxxxxxx
Economically evaluate the potential of using amino acids as a nitrogen source and chelating agents.			xxxxxxxxx
Finalizing the PhD thesis			xxxxx

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