Available online at www.sciencedirect.com

SCIENCE DIRECT®

Bioresource Technology 97 (2006) 522–528

BIORESOURCE TECHNOLOGY

# Characterization of a phosphorus–potassium solution obtained during a protein concentrate process from sunflower flour. Application on rye-grass

C. Ordoñez [a], M. Tejada [b], C. Benítez [a], J.L. González [a,*]

[a] *Departamento de Química Agrícola y Edafología, Facultad de Ciencias, Universidad de Córdoba, Campus de Rabanales, Edificio C-3, Ctra. Nacional IV, km. 339.6, 14014 Córdoba, Spain*

[b] *Departamento de Cristalografía, Mineralogía y Química Agrícola, EUITA, Universidad de Sevilla. Ctra. Utrera km 1. 41013, Sevilla, Spain*

Received 6 August 2003; received in revised form 28 February 2005; accepted 28 February 2005
Available online 21 April 2005

**Abstract**

The process that permits the ability to obtain a protein extract from defatted sunflower flour also produces a solution very rich in phosphorus (P) and potassium (K), which also contains small concentrations of humic substances. The aim of this study has been to determine the possible agricultural use of this extract. Therefore the phosphorus–potassium solution (experimental solution) was analyzed to determinate its pH and its content of nitrogen, proteins, organic carbon, humic substances potassium and phosphorous. The experimental solution was applied on rye-grass (*Lolium multiflorum* Lam.) and afterwards the results were analyzed we calculated the germination percentage and the fresh and dry weights that were obtained after each cut throughout the duration of the experiment. In addition the different pigment types (chlorophyll *a*, chlorophyll *b* and carotenoids) were quantified. The conclusions of the study examine how this time-stable experimental solution improves the long-term effects and also the level of pigments, especially carotenoids, of the plants that have been treated.


*Keywords:* Phosphorus–potassium solution; Pigments; Rye-grass production; Humic substances

## 1. Introduction

The recycling of residues could mitigate environmental hazards resulting from intensive agriculture. Consequently, in recent years, the addition of industrial byproducts such as beet vinasse, the byproduct of the two-step olive oil mill process, protein extract from defatted sunflower flour, and other byproducts to agricultural soils is a common practice, thus an improvement is observed in the physical, chemical and biological properties of the soil and the increase in quality and quantity of the crop (Madejon et al., 2001; Ordoñez et al., 2001; Tejada and Gonzalez, 2001, 2003; Tejada et al., 2001a,b).

In the process of obtaining a protein concentrate from defatted sunflower flour (Ordoñez et al., 2001), a floating liquid can also obtained. This liquid (experimental solution) contains high phosphorus and potassium contents and a smaller amount of humic substances and nitrogen, making it potentially useful as a fertilizer. There are many studies that have shown the availability of these elements in plants and their numerous functions. Those functions related to potassium are less specific, although equally important.

Phosphorus is an essential part of the process of photosynthesis. Plants use the energy of sunlight, and P must be present in the active parts of the plant for this energy transfer to be made and for photosynthesis to

* Corresponding author.
*E-mail address:* qe1gofej@uco.es (J.L. González).

0960-8524/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biortech.2005.02.047

occur. Phosphorus is also an important macro-nutrient in stimulating early root growth and promoting early plant vigor (Longstreth and Nobel, 1980; Verberic et al., 2002). Potassium plays an essential role in the metabolic processes of plants and is required in several enzymatic reactions, particularly in those involving the adenosine phosphates (ATP and ADP), which are the energy carriers in the metabolic processes of plants and animals. Potassium is also essential in the metabolism of carbohydrates, a process by which energy is obtained from sugar. There is also evidence that potassium plays a role in photosynthesis and protein synthesis (Navarro, 2000; Verberic et al., 2002).

Humic substances play important roles in plant growth, as follows: (i) germination (Vaughan and Malcolm, 1985; Zhukova and Anikhovskaya, 1988; Zhukova et al., 1990), (ii) root proliferation and growth (Vaughan and Malcolm, 1985; Chen and Aviad, 1990; Piccolo et al., 1993), (iii) incorporation of macro- and micro-elements (Mishra and Srivastava, 1988; Rzaev et al., 1989; Chen and Aviad, 1990; Piccolo et al., 1993) and (iiii) biochemical effects, such as respiration and photosynthesis (Zimmerman, 1981; Vaughan and Malcolm, 1985; Nardi et al., 1991), protein and nucleic acid synthesis (Vaughan and Malcolm, 1985), enzyme activities (phosphatase, invertase, choline esterase, among others). (Malcolm and Vaughan, 1979; De Almeida et al., 1980; Concheri et al., 1992), and organogenesis (Muscolo et al., 1993; Nardi et al., 1994).

The development of liquid fertilizers in recent years has promoted an increase in the number of research projects in fertilizing solutions for their application on diverse crops, especially fertilizers that applied through foliar application and by spray irrigation (Haq and Mallarino, 1998, 2000; Bednarz et al., 1999; Umar et al., 1999; Mallarino et al., 2001). The main aim of this work is to study the application of a phosphorus–potassium solution with low contents of humic substances and N (experimental solution) obtained from a protein concentrate from defatted sunflower flour (Ordoñez et al., 2001). Comparison of results with those found in standard fertilizer solutions will help to determine possible application on crops.

## 2. Methods

### 2.1. Floating liquid properties (experimental solution)

The phosphorus–potassium solution that was used was a byproduct, that came from processing of a protein concentrate. This process consisted initially in grinding and defatting sunflower flour. Three samples in triplicate were subjected to a protein extraction process with a KOH 0.5 N solution at 40 °C during one hour. Proteins were subsequently precipitated with a pH 4.5 and 0.5 N phosphoric acid solution; they were finally decanted, filtered and centrifuged. Finally, the precipitate was washed and dried, obtaining a powder-like protein concentrate (Ordoñez et al., 2001). The scheme of the process to obtain the experimental solution is shown in Fig. 1 (Ordoñez et al., 2001).

To characterize this extract, it was necessary to determine the amount of proteins that it contained with the Kjeldahl method (Duchafour, 1975), organic carbon (Sims and Haby, 1971), humic substances (Métodos

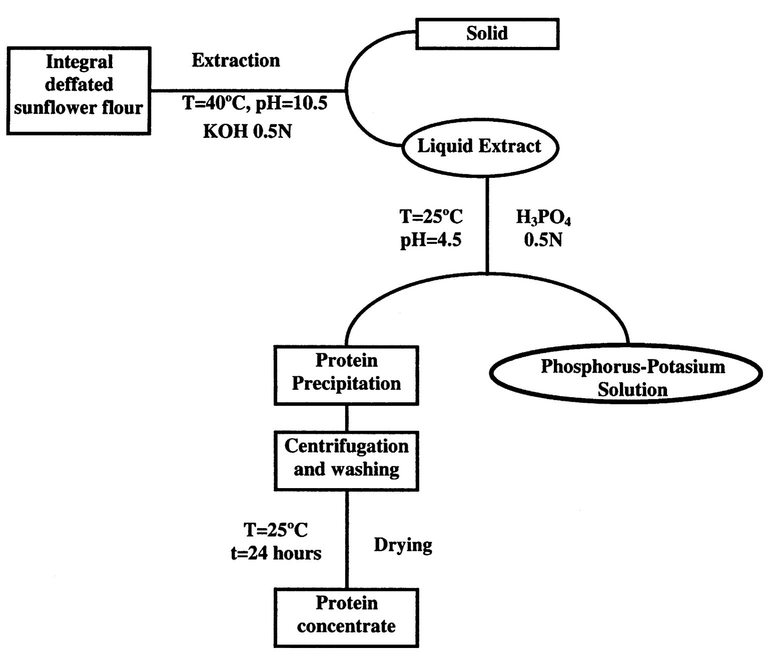


Fig. 1. Global scheme of the process to obtain the protein concentrate and the phosphorus–potassium solution (from Ordoñez et al., 2001).