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Implementation of Olive Mill by Products in Agriculture

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INTRODUCTION

The two major constraints affecting crop production in arid rainfed areas are the chronic water limitations [1] and low availability of fertile soils [2-4]. The mineral nutrition requirements of plants are traditionally discussed as two separate topics: organic and inorganic nutrition [3]. Inorganic nutrition is the acquisition of mineral elements from the soil by plants and the main concern in plant nutrition is the availability of these essential mineral elements to crop plants and the resulting productivity. Farmers add chemical fertilizers to improve soil fertility and to increase the yield of their crop [5]. However, extensive applications of fertilizers can be disadvantageous to the environments [6, 7]. These chemicals may undergo decomposition and may be leached from the soil into ground water and lakes [8]. An alternative to chemical fertilizer is organic fertilizer, added to the soil either directly before planting or during crop growth. Organic fertilizers such as animal manure (compost), sod and green manure, compost and sewage sludge may be added to cultivated soil [9]. This practice may improve the physical and biological properties of the soil and provide a source of mineral nutrients [10].

Many Mediterranean countries are characterized by the presence of many olive plantations, with over 10 million trees [11]. In 1998, Jordan had 197,500 acres planted with olive trees. The average olive production in Jordan is 105,000 tons per year [11], most being processed for oil [12]. This agro-industry produces three main products: olive oil, a solid residue called Jift and a wastewater called Zebar. Jift and Zebar are rich in organic materials and minerals [13]. In Jordan, the amount of Jift produced is estimated to be over 100,000 tons per year and the amount of Zebar is about 500,000 m^3 a year [14]. Olive mill by- products (OMP) can be utilized in agricultural practices as soil amendments or even as organic fertilizer, but little information exists on the utilization of this organic waste as soil amendments [15]. OMP are available year round, at low cost. Their application can therefore decrease the production cost of many crops if they can be used instead of chemical fertilizer [16].

Factors Affecting Productivity of Field Crops: Productivity of a crop is a measurable output of that crop. The weight of new organic matter created via photosynthesis over a given period, is expressed as a rate of productivity [17]. The surrounding environment, plant condition, agro-biological managements and socio- economical factors and their interaction influence crop productivity or yield. Mathematically, crop yield can be expressed according to the equation Y= f (E, P, M, S) [18], where Y is the yield, E is the environment, f is an equation cofactor, P is the plant, M is the management and S is the social-economic. Maximum yield of a crop in a given environment is possible only when all these factors are at optimum levels. If any of these factors becomes a limiting then the crop yield will be adversely affected.

Olive Mill by-Products: Pollution, posed by Olive Mill by-Products disposal is a typical problem of particular interest in the Mediterranean area [19], where the production of olive oil has been established since long time ago. Olive oil processing is an important business in the Mediterranean area, where around 1.4-1.8 million tons of olive oil is annually produced [20]. It is establish 1 to 1.2 tons of wastewater from processing one ton of olive, taking in accounts both of the vegetable and processing wastewater. Therefore, olive mills during a short harvesting period, which is recognized as an olive

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mill wastewater during November - December every year, generate a great stream of liquid waste. The waste is mainly composed of particulate organic matter which composted of sugars, pectins, phenols, soluble organic compound and mineral salts diluted in a large quantity of wastewater [21-24]. In addition to the olive mill wastewater, a solid by-product; pomace locally known as Jift is also accumulated.

Olive Mill by-Products often directly or indirectly get disposed into the surrounded environments including the cultivated soil. Generally, olive mill wastewater is collected inside closed or open lagoons and some times directly discharged into streams and rivers or sewage system [25]. The harmful potentials of olive mill by-peoducts upon the environments are mainly due to their high content of organic matter and allelopathic compound [15, 19, 26]. However, it was postulated that those olive mill by-products if applied to soil, could become as potential soil fertilizer [27].

Proper management and utilization of olive mill by-products is becoming more urgent with time due to the expansion in this industry and increasing awareness about environments protection [16]. In Spain, Italy and Greece, three Mediterranean countries most involved in solving the olive mill by-products problem, many studies have been made regarding the possible ways of cleaning and recycling olive mill by-products [27].

Several advantages were reported for proper uses of olive mill by-products that include economical way to dispose of the olive mill by-products, relinquishing and water from the olive mill wastewater, using them as source of plant nutrients and a supply of organic matter to improve soil fertility. On the other hand, the disadvantages may be represented by, the polluting load and accumulation of high mineral elements and organic phytotoxic compound.

Pioneer attempts were carried out in Italy and Spain to transform olive mill by-products into organic fertilizer by composting those products under aerobic and anaerobic conditions [21, 22]. This process reduce the volume of wastes, removes it's phytotoxicity and improves it's organic values [20]. The composted olive mill by-products obtained was used as soil amendments. It showed no phytotoxic effects. On the contrary it had beneficial effects on soil fertility, particularly enhancing N_2-fixers, ammonia producing bacteria, nitrifying bacteria, cellulostic and ligninolitic bacteria [15, 20, 24, 28]. An increase in water retention properties and ion-exchange capacity of soil together with the general improvement in the soil properties were also recorded [27]. Olive mill by-products was also, mixed with lime prior to application in the field. Thus, the sludge obtained was found, to be suitable to be used as fertilizer for field crops [27].

Process of Olive Oil Extraction: Olive oil extraction process usually yields into three products, i) olive oil (20-32%), ii) solid by-products, (30%) and iii) aqueous phase (40-50%) [29]. The extraction of olive oil is a seasonal operation of agro-industrial activity in the Mediterranean region. This industry results in the production of high-density wastewater and solid waste [11, 12, 15, 30].

Olive oil extraction is mainly carried out by the traditional discontinuous press process or by the more recent continuous solid-liquid centrifuge system. During the later extraction process olive fruits are grinded and pressed to separate the residual solid (husk or pulp the Jift) [31] which contain residual oil of about 4.5 %. This oil could be recovered later on by means of organic solvent (Hexane) under high temperature and pressure. Finally, the oil is separated from the vegetation waters by centrifugation [29].

The washing water and the vegetation water together comprise the Olive Mill Wastewater. The volume of olive mill wastewater produced by the traditional press process was reported to be 4-4.5 m^3/ton of olives. Almost all minerals were present in olive mill wastewater [28].

Composition of Olive Mill Waste Water: The Olive Mill Wastewater which results from olive fruits press is usually dark red to black, depending on its state of degradation and the olives region which came from [15]. Olive mill wastewater density varies from very watery lace to slightly viscous according to olive crop.

Chemical analysis of olive mill wastewater revealed that it contains various organic components such as sugars, tannins, polyphenolos, polyalchohols, pectins and lipid [22, 32]. The composition of fresh olive mill wastewater varies according to source, season and extraction process. In spite of the great variability of their composition, olive mill wastewater always have high organic matter content (80-150 kg m^{-3} as dry weight) and considerable amount of mineral nutrients with the following range total nitrogen as N: 0,6-1.0 kg m^{-3}; potassium as K_2O: 4.5-6.0 kg m^{-3}; of total phosphorus as P_2O_5: 1.0-1.5 kg m^{-3}, [15, 31]. In addition to organic matter and mineral nutrients, olive mill wastewater is characterized by the presence of several phytotoxic compounds. More than 50 phenols have been identified, together with alchohols, aldehydes and other small organic molecules [15, 22, 24, 32].

Composition of Olive Mill Solid Waste: The olive mills solid wastes, which is produced by the traditional mills and press process contains an average of 15% and 2% of volatile solids and inorganic matter, receptively [24]. Cellulose, pectin are among other components of the olive mills solid wastes corresponding to total suspended solid (TSS) in olive mill wastewater [15].

The possibility of safe usage of composted olive mill solid as horticultural substrate is strongly determined by the presence of residual fatty acids, organic acids and phenols. Some of these compounds are originally present at very high concentrations in the olive mill by-products [22]. Many of these compounds have been reported as phytotoxic to plants when present in the culture substrate or in a fertilizer composting material [26].

Organic acids were reported to be inhibitory to plant growth may they prevent seed germination [26]. Fatty acids probably affect the physical properties of a substrate that may cause strong phytotoxicity with concentrations near 600 ppm [21].

Effect of Olive Mill by-Products on Plant: Olive mill industry waste contain high amount of organic matter together with minerals, such as nitrogen, potassium, phosphorus, as well as some micronutrients which are important in plant nutrition [3, 15, 21, 22, 32-34]. Land supplement with wastes, containing humified fraction or organic materials, which can easily be humified, has been considered as positive soil treatments in agriculture [27]. The suitability of olive wastes as soil amendment was suggested by Paredes *et al.* [23]. They concluded that olive mill by-products undergo processes lead to production of humic acids. These substances have similar role in soil as other naturally humic fraction usually present in soils [27].

Several experiments confirmed the degradation of organic load in soil degraded in a relatively short time with a consequent enrichment of soil in nitrogen, phosphorus and potassium [4, 15, 21, 22, 32]. Crop yield improvement has been recorded by many authors, after supplying different amounts of olive mill by-products to cultures [4, 27, 30, 33, 35]. The results lead to the conclusion that many cultures may becomes beneficial from olive mill by-products when such a waste is distributed in adequate amounts at a right time. The beneficial effects are particularly evident in olive trees, vineyard and cereal [15, 22, 27].

Although, many experiments were supported the hypothesis that olive mill by-products may have beneficial effect on soil fertility, the polluting charge of the waste and it's inhibition effects on seed germination [26], sometimes lead to avoiding the agricultural usage of those wastes. The mineral content, the acidity and the presence of phytotoxic compounds, mainly phenols, in olive mill by-products can induce negative effects on culture. Such effects are linked to the quantity of waste supply, soil characteristics and to culture.

Microbial degradation of organic matter such as polyphenols and fat tend to reduce phytotoxical effects of the olive mill by-products [15, 36]. This is more evident in herbaceous crops. However, no harmful effects have been reported on tress and some seed legume crop such as pea (*Pisum sativum* L.) and bean (*Phaseolus vulgare* L.) [26]. Although a final conclusion cannot be drawn, the negative effects of supplying depend on the modification of chemical and physical properties of soil over a short period of time.

Effect of Olive Mill by-Products on Soil Properties: Many analytical data are available regarding the effect of olive mill by-products on soil properties. An increased stability of soil aggregates was reported by Flouri *et al.* [37], whereas, Paredes *et al.* [23] found a higher compactness and hardness which could lead to impairment in soil aeration, thus reducing soil ability to degrade waste. On the other hand, the fact that organic waste pressure in soil is strongly and rapidly reduced seems to lead to general improvement in structural properties of soil, which permits an enhancement of microbial activities. Negative effects on soil properties have been raised by Paredes *et al.* [23].

In the long term of OMP application might resulted in formation of saline soil. Soil pH decreased immediately after waste supply, afterward tends to return to the initial value [23]. No alteration in the pH value has been found below 30-40 cm depth [26].

Effect of Olive Mill by-Products on Soil Pathogen: Very little information is available about the possible suppressive effect of olive mill by-products on parasites in soil. Flouri *et al.* [37] reported an inhibitory effect on some root pathogen, particularly *Oomycetes,* which were strongly suppressed when olive mill by-products were added to land. Flouri *et al.* [37] reported, also, that the population of microflora and N_2 fixing bacteria were increased with increasing the amount of olive mill by-products applied to land. At the same time these materials, olive mill by-products, has a suppression effect on soil pathogens [23].

Plant Micronutrients Deficiencies Induced by Land Utilization of Waste Materials: In some cases, land utilization of wastes has lead to plants deficiencies of micronutrients [38]. The deficiencies were generally caused by excessive application of the wastes, or by change in pH, P or redox caused by waste application [34]. I) Induced Mn deficiency: Espinoza *et al.* [38] suggested that Mn deficiency occur when organic waste applied on soil. The reason for this Mn deficiency refer either, there is high Zn concentration, that inhibiting of Mn uptake, or organic waste may raise the soil pH enough to reduce plant Mn uptake [35, 38]. II) Induced Fe and Zn deficiency: in soil Cu or Ni inhibition of Fe translocation from root to shoot of plant [35]. Zn deficiency appears due to high available P content and high soil pH [38].

Phytotoxicity of Microelements in Organic Waste: Accumulation of microelements in soil may result due to repeated application of waste materials [39]. Phytotoxicity is depending on soil pH, crop species and higher accumulation of micronutrients [39]. There are several factors present in- organic wastes that reduce or prevent toxicity of metals. First, wastes rise in pH from mineralization of organic-N to ammonia. Second, organic wastes increase the soil organic matter content, also, increase cation exchange capacity (CEC) metal adsorption capacity. In addition, wastes add large of P which prevents phytotoxicty by reaction in soil or plant. Finally, microelements interaction may be phytotoxicty [39-41].

Reaction of Waste-borne Microelements with Soil: Reaction can be characterized by Langmuir or Freundlich isotherm [35]. Metals adsorption increase with increase soil pH, microelement may be adsorbed on clay, organic matter and Mn or Fe oxide [35].

Several factors affecting Zn diffusion include Zn concentration, soil texture, clay and organic matter and soil moisture content [42]. Added OW will be decrease Fe concentration in soil as a result of increase Zn concentration [43].

Enhanced Mineral and Water Uptake: Attempts to improve plant nutrition by inoculation with soil microorganisms fall mainly in two categories: improving nutrient availability and enhancing plant uptake. Less than 5% of the total content of soil phosphate is available to plants. Early efforts to improve phosphorus availability to plants by soil microorganisms resulted in isolation and characterization of several phosphate- solubilizing bacteria. It become clear that these bacteria may increase the availability of P to plant by either solubilization of organic phosphate via the action of phosphatase (mineralization) or by solubilization of unavailable inorganic phosphates with organic acid [44, 45].

Little attention has been given to potential agriculture effect of rhizobacteria on phosphorous uptake by plants. Although, the capacity of some root-colonizing bacteria to alter root cell permeability leads to an increase in plant ion uptake [44, 45], no direct selection for such bacteria characteristics has been published so far [46].

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