

CHAPTER 2

LITERATURE REVIEW

Clark *et al.* [38] studied the growth of Maize (*Zea mays* L.) on an acid soil, amended with two high calcium sulfate (CaSO_4) flue gas desulfurization by-products (FCD-BPS) and calcium carbonate (CaCO_3) at varied calcium/magnesium (Ca/Mg) equivalency ratios to determine treatment effects on growth traits. Results showed maize grown on this acid soil amended with FGD-BPS received benefits when caution was used to alleviate mineral deficiencies/toxicities inherent in the soil.

Mukhtar *et al.* [39] used bottom ash (BA) and composted dairy manure (CM) as by products of coal combustion and livestock production, respectively. This study focuses on potential water quality impacts associated with using blended BA and CM as a soil amendment. The four blends (BA:CM, v/v) namely, B1 (100%:0%), B2 (70%:30%), B3 (50%:50%) and B4 (0%:100%), were subjected to flow-through water table management and two blends, B2 (70%:30%) and B3 (50%:50%), were subjected to constant water table management using deionized water. The results showed that higher CM content resulted in higher total solids (TS), volatile solids (VS), total Kjeldahl nitrogen (TKN), P and K concentrations in the leaching and the standing water. Concentrations of these constituents were higher in the leaching than in the standing water. Based upon these results, it was concluded that additional column studies of BA and CM blends with reduced CM content (5%, 10% and 20%) should be performed to further assess the feasibility of BA and CM blends as an environmentally safe soil amendment material.

Dudka *et al.* [40] evaluated the blends of class A biosolids (composted sewage sludge) and bottom ash from power plants as commercial potting mixes in growing various ornamentals (geraniums, petunias, marigolds, and poinsettias). The experimental data concluded that blends class A biosolids and bottom ash from power plants produces material that meet the EPA's definition for an exceptional quality product and have properties suitable to grow ornamental plants. The tested blends had sufficient concentrations of major nutrients (NPK), low soluble salts content (EC) and a pH in the range of 6.0 to 7.0, and the level of regulated elements (As, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Se, Zn) were below current environmental limits. These blends were successful in supporting growth of petunias, geraniums, and marigolds in a research greenhouse as well as poinsettias under normal production conditions in a commercial greenhouse. Comparing to control plants, geraniums, petunias, and marigolds grown in biosolid-ash mixtures had darker leaves and showed no symptoms of nutrient deficiency. Besides looking healthier, marigolds grown in the tested blends produced much bigger biomass than the control. The poinsettia plants looked healthy, visually attractive, and were not significantly different from the plants grown in commercial mixes. Therefore, biosolid-ash blends are at least as effective as commercial mixes in supporting plant growth. Cost estimates revealed that the bottom ash-biosolid blends are cheaper than the commercial potting mixes and they can offer extra savings to greenhouse (nursery) operators by decreasing fertilizer requirements.

Jensen *et al.* [41] investigated the physical characteristics of four media (rockwool, perlite, coconut coir and peat moss) and the yield response of tomatoes produced in a greenhouse. The results showed that there were no significant

differences in yield and fruit size among the five different growing media. There is a real difference between the physical properties, of rockwool and perlite. The coconut coir and the peat-lite have a similar water holding capacity to the rockwool but twice the air porosity. In southwestern part of the United States and northern Mexico, the rockwool and the peat-lite are far more expensive than the perlite and the coconut coir. The perlite is undoubtedly suitable for greenhouse vegetable production. The coconut coir also appears suitable for greenhouse vegetable production.

Baran *et al.* [42] investigated the composted grape marc (CGM) as a plant growth medium of *Hypostases* (*Hypostases phyllostagya*). Seven media were prepared using CGM mixed with native peat and perlite, in different ratios. The following mixtures were used: 100% CGM, 75% CGM+ 25% peat, 50% CGM+50% perlite, 25% CGM+75% peat, 50% CGM+ 25% peat+ 25% perlite, 25% CGM+50% peat + 25% perlite and 100% peat. The experiment was arranged in a randomized plot design with four replicates under greenhouse conditions. After a growing period of three months, some horticultural parameters were measured. Besides, some physical and chemical properties of the growing medium were determined. The mixtures of 50% CGM+ 50% peat, 25% CGM+ 75% peat and 100% peat were found to be most suitable based on the horticultural parameters. This was confirmed through the physical characteristics. Up to 50% composted grape marc can be used in mixtures with peat on account of its low cost and high nutrient content. The N, P and K contents of shoot and root parts increased depending on the CGM content. Especially, total P and K contents of root parts grown in 100% CGM medium were found higher than in those growing in other mixtures.

Poole *et al.* [43] reported that the optimal ranges for potting plants with regard to N, P, K and Ca were $1.5\pm 4.5\%$, $0.15\pm 0.3\%$, $1.5\pm 5.0\%$ and $0.6\pm 1.5\%$, respectively. Comparing their findings for P, K and Ca contents of the plants grown in different mixtures, it was observed that they were generally higher than optimal values, except for nitrogen. It is possible that those differences cannot result from nutrient deficiency since the fertilization was carried out regularly through a nutrient solution.

Gue'rina *et al.* [44] assessed the growth of ornamental shrubs in peat alternative substrates. One ornamental species, *Viburnum tinus L.*, was cultivated in a number of different substrates in two climates: a French oceanic (Oce) and a Spanish Mediterranean (Med). In Oce, three mixtures (1/1, v/v) of Finnish peat/yard compost, yard compost/raw coir and Finnish peat/raw coir were used while the expanded perlite/composted manure (1/1), forest compost/composted bark (1/1) and forest compost/cattle manure compost (2/3) were tested in Med. A mixture (1/1) of Finnish peat/pine bark compost was used in both climates as a control. Plants were cultivated at a density of six plants /m² in 4 L containers with drip irrigation. Plant height, dry mass, and leaf area were measured at intervals during cultivation. In Oce, substrates with yard compost or raw coir produced plants of similar size to those in the control substrate. In Med, forest compost/cattle manure compost mixture produced plants with the same height as those in the control mixture and the two other mixtures produced shorter plants. Using those parameters, significant effects of different substrates were revealed. Those effects are related to the substrate characteristics, mainly physical. As peat is used in a large range of situations, the experiment showed

that substrate performance varies with its use, so alternative substrates can show better performance.

Papafotiou *et al.* [45] studied and investigated the possibility of using olive-mill wastes compost (OWC) in the production of ornamentals replacing part of the peat in the growing medium. A medium of 1 peat :1 perlite (by volume) was used as control. A total of 50 and 75% replacement of peat caused a decrease of the total porosity and the easily available water. Increasing replacement of peat by OWC induced a gradual decrease of the plant height, bract number and node number where the first bract was initiated. All the above parameters of growth were significantly reduced even when 25% of peat was replaced, except the bract number that was significantly reduced only in case of 50% or more peat replacement. Root dry weight was reduced only when 75% of the peat was replaced. The restriction of vegetative growth occurred only during the first month of culture in media with 25 and 50% peat replacement, while in 75% replacement there was growth restriction all over the culture period. Media with 50 and 75% peat replacement caused delayed pigmentation of the bracts and flowering, while plants in the medium with 25% peat replacement showed color and flowered simultaneously with the control.

Apaolaza *et al.* [46] used different waste materials - pine bark, coconut fiber and sewage sludge as substrates in the production of ornamental plants. The plant species tested were *Pinus pinea*, *Cupressus arizonica* and *C. sempervirens* and the substrate mixtures were: (1) pine bark, (2) pine bark with 15% of sewage sludge compost, (3) pine bark with 30% of sewage sludge compost, (4) coconut fiber, (5)

coconut fiber with 15% of sewage sludge compost and (6) coconut fiber with 30% of sewage sludge compost. Substrates were physically and chemically well characterized, and 75-cm plants were grown on them for one year. Plant and substrate status were periodically tested along the experiment. As biosolid recycling is the main objective of the present work, the mixtures with 30% of composted sewage sludge will be the most convenient substrate to use. For *C. sempervirens* and *C. arizonica*, a mixture between pine bark or coconut fiber and 30% of biosolid compost in volume gave the best results, but the lower cost of the pine bark than the coconut fiber substrate indicated the preferred use of the PB+ 30% CSS. For *P. pinea* the research of new combinations between waste products is recommended to attain better results.

Benito *et al.* [47] used pruning wastes compost (PWC) as a growing media component for ornamental plants. The main physical, chemical and biological characteristics of PWC were analysed in order to evaluate its suitability for use in soil-less cultivation. Six growth substrates were prepared by mixing PWC with peat (P), ground leaves (GL), sand (S) and spent mushroom compost (SMC) in different proportions. Two different pot experiments were carried out to test its characteristics of production using perennial ryegrass (*Lolium perenne* L.) and cypress (*Cupressus sempervirens* L.) as indicators and the different media as treatments. The growth experiments showed that PWC required mixing with a nutrient-richer material to produce higher results. Therefore, substrates containing SMC (PWC + P + SMC and PWC + SMC) seem to be the most adequate growing media. They concluded that the PWC could be used as a growing media component.

Dueitt *et al.* [48] found that fresh and composted rice hull media, containing also peat and vermiculite, produced impatiens plants with heights similar to those of the control (5 peat:5 vermiculite).

Marianthi [49] studied the feasibility of replacing peat or perlite with rice hulls and ground kenaf core to grow a Mediterranean species (*Pinus halepensis* M.). Treatments involved the following growing media: 70 peat : 30 perlite as a control, 70 peat : 30 rice hulls, 50 peat : 50 rice hulls, kenaf (100%) and 60 kenaf : 20 peat : 20 rice hulls. The seedlings' quality and the physical and chemical properties of the substrates were evaluated. The results showed that the growth medium 70 peat : 30 rice hulls can successfully be used for the production of *P. halepensis*, since the seedlings' nursery and field performance were similar to, or even better than those obtained with the control medium. The seedlings produced in the growth media containing kenaf did not attain a suitable planting size and showed poorer field performance than control seedlings.

Komarmy *et al.* [50] studied a quantitative method for the analysis of high nitrate solids by the adaptation of the phenol-disulfonic acid method. Use of either spectrophotometers or filter photometers permits wide application of the method. The nitrate concentration in a sample may be determined with an accuracy of ± 1 percent when the Klett-Summerson photoelectric colorimeter is used to measure the optical density of the yellow complex. Due to its rapidity, routine control analysis of high nitrate content solids by this method is feasible.

Leach *et al.* [51] used a detector for the flow injection (FI) determination of phosphorus by means of the vanadomolybdophosphoric (VMP) acid spectrophotometric method. A comparison with previous studies in which lamp-based instrumentation was utilized proves that radio luminescence (RL) is a viable alternative source. RL enables the design of compact, inexpensive light sources for spectroscopic studies. Through the selection of a radioisotope and scintillation medium, the spectral and temporal characteristics of the source can be chosen independently. In this study, a broadband radio luminescent source provided detection limits similar to those of conventional lamp-based detectors while increasing the dynamic range of the method. Possible interferences caused by the use of a broadband light source have been explored as a function of the spectral region employed.

Matthew *et al.* [52] studied the potassium-calcium adsorption kinetics on a Llano vermiculite and an Arizona montmorillonite by using a stirred-flow technique. Various experiments were conducted to distinguish between (i) instantaneous equilibrium and time-dependent reactions, and (ii) solution-concentration-dependent kinetic models. It was found that K-Ca exchange on montmorillonite was too rapid to be measured with the stirred-flow technique. Adsorption kinetic parameters should be included in transport models to more accurately predict the fate of ions in soils dominated by vermiculitic and micaceous soil minerals.

Evangelou *et al.* [53] investigated the binary and ternary cation-exchange reactions involving NH_4^+ , K^+ , and Ca^{2+} on vermiculite and hydroxy-Al interlayered vermiculite (HIV). In the case of vermiculite, NH_4 -Ca exchange was nearly

indistinguishable from the non-preference isotherm while HIV exhibited preference for NH_4^+ . The presence of K^+ had significant suppressing impact on the apparent NH_4^+ selectivity in NH_4 -Ca exchange in HIV most likely because of retardation of Ca^{2+} diffusion in the interlayer. For vermiculite, the presence of K^+ in the NH_4 -Ca system induced apparent high affinity sites for NH_4^+ most likely because of interlayer collapse. The overall study demonstrated that cation-exchange selectivity coefficients in vermiculite and HIV are dependent on number and type of cations present.

Dua *et al.* [54] studied and investigated of some factors controlling the adsorption of potassium (K^+) onto two soils, named Ariake soil and Akaboku soil. The KCl solution and multi-salt solution containing KCl, NaCl and CaCl_2 were selected as the synthetic leachates. The results shown that with the increase of the solid/solution ratio, the adsorbed amount of K^+ decreased for both soils. This dependence of adsorption behavior on the solid/solution ratio was found more significant for the Ariake soil. Both soils arrived an equilibrium condition in short time less than the contact time prescribed by the ASTM and USEPA standard batch-type tests. It was observed that both soils adsorbed larger amount of K^+ in the case of KCl solution condition than in the case of multi-salt condition.

Shima *et al.* [55] investigated the adsorption characteristics of heavy metal ions using various particle sizes of MSWI bottom ash. Since bottom ash has a broad particle size distribution, it was sieved to size classes of +20, -20, -48, -80, -100 mesh. Cation exchange capacity (CEC) was analyzed by the ammonium acetate method to evaluate the potential as an adsorbent. The results showed that the CEC values and

surface areas increase as the range of particle size becomes finer. The adsorption rate of heavy metal increases with decreasing bottom ash particle size and with increasing liquid/solid ratio. The rate and extent of adsorption are proportional to the specific surface area and particle size of adsorbent.

Kim *et al.* [56] examined the adsorption rates and characteristics of heavy metal ions (Cd^{2+} , Cr^{3+} , and Zn^{2+}) with solutions mixed with red soil, white soil, a mixture of red & white soil and zeolite under various pHs and initial concentrations. As expected, adsorption rates of heavy metal ions generally increased with increasing pH; however, Cr^{3+} showed a particular behavior. A mixture of red & white soil among the soil minerals tried in this study showed the highest Cr^{3+} adsorption rate at the low pH conditions (lower than pH 5). From the result, it is concluded that the adsorption characteristics of heavy metal ions depend not only on the physical properties of the adsorbent itself such as the cation exchange capacity (CEC) but also on the concentration and existence of exchangeable cations, pH, ligands, etc.