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Introduction

Organic agriculture is holistic production management systems, which promotes and enhances agro ecosystem health, including biodiversity, biological cycles and soil biological activity.

The availability of plant nutrients is dependent on soil ”chemical properties”. To provide economically sustainable yields, chemical nutrients must be present in sufficient quantities in soil and they must be available for root uptake. Feed the soil approach is based on organic nutrient additions to increase soil microbial activity. This strategy seeks to build a nutrient bank account and maintain a healthy balance in it.

This approach does not account for soils in which nutrient concentration may be very high. In such soil conditions this philosophy can result in nutrient additions that increase the potential for environmental pollution or plant toxicity. Organic matter content, rock or other limiting horizons, infiltration, drainage, % of mineralization should be considered through very sophisticated fertility program. This task is big challenge and requires deep multi-scientific knowledge and capability to make links between all the topics.

Composting is very useful methods and high recommended in organic farming. Compost is well known as a stable organic matter not so rich in nutrients, and effective in correlation with its origin. Numerous studies were conducted on composted process, parameters that determine its quality, and its utility.

Recently a certain attention was given to the use of compost extracts in organic farming mainly as natural fungicide, and contradictory results were obtained through different brewing system. Still under big discussion between scientists is method that should be applied during extraction procedure. Both anaerobic and aerobic methods give good results in some aspects and needs more consideration.

On the other hand, lack of scientific data for compost extract utilization through fertigation system, as additional value to organic fertilizer and amendments, opened new researching field.

Particularly knowledge that for the short-season, crops nutrient availability management with organic nutrient-low and slow releasable products is very difficult, made very clear state that sometimes-additional intervention is required. Compost extract could be ideal solution.

The main conceptual idea of this work was to study the influence of the compost water extract on plant and soil properties.

This work is ideal continuation of the research program started last year on the Mediterranean Agronomic Institute-Bari and the reason to develop this study existed in the need of conforming or correcting previous conclusions.

Chapter 1.
Review of literature

1.1. Principles and definitions of organic farming systems

Organic farming is a production system, which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent feasible organic farming systems rely on crop residues, animal manures, legumes, green manures, off-farm organic wastes, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests. **(USDA).**
Organic agriculture is holistic production management systems, which promotes and enhances agroecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. **(Codex Alimentarius).**

Organic agriculture includes all agricultural systems that promote the environmentally, socially and economically sound production of food and fibres. These systems take local soil fertility as a key to successful production. By respecting the natural capacity of plants, animals and the landscape, it aims to optimise quality in all aspects of agriculture and the environment. Organic agriculture dramatically reduces external inputs by refraining from the use of chemo-synthetic fertilizers, pesticides and pharmaceuticals. Instead it allows the powerful laws of nature to increase both agricultural yields and disease resistance. **(IFOAM).**

The cyclical principle is a principle for how to interact with nature. It saysthat organic food cycles should emulate and benefit from nature's systems and cycles, fit into them, and help sustain them. This is the oldest and most established organic principle. Kindred concepts are the ecological principle and the idea of naturalness.
The precautionary principle is a principle for how to make decisions on changes in technology and practice. It says that action should be taken to prevent harm, even if there is no conclusive scientific evidence that this harm will occur. The principle also calls for the active promotion of cleaner, safer technologies and comprehensive research to detect and reduce risks.
The nearness principle is a principle for how to learn and communicate. It says that possibilities for personal experience and close contact between consumers, producers, researchers and other organic actors should be created and maintained. All relevant actors should be encouraged to take part in the development of organic agriculture. This participation should be facilitated by promoting transparency and cooperation in the production and communication processes in the organic food cycles.**(IFOAM)**

1.2. Soil fertility management in organic farming system

"I have sinned against the wisdom of the creator and, justly, I have been punished. I wanted to improve his work because, in my blindness, I believed that a link in the astonishing chain of laws that govern and constantly renew life on the surface of the Earth had been forgotten. It seemed to me that weak and insignificant man had to redress this oversigt". **(Justus von Liebig, inventor of chemical agriculture, when looking back on his life and work. From: Agrikulturchemie, 8. Auflage, 1865).**

Organic farmers strive to improve soil fertility to provide a soil system that is ideal for planth growth. They recognize that soil fertility is dependent upon the interactions of soil physical, chemical and biological properties, and in practical sense implement management practice to" build healthy soil". **(Baldwin,2001).**

Root growth and proliferation are dependent upon soil "physical properties". Improvements in soil physical properties such as aggregate stability (tilth), porosity, infiltration, drainage, water holding capacity, bulk density, and resistance to crusting and compaction minimize constraints to root growth. A root system that occupies more soil volume has access to more soil moisture and nutrients. **(Sharma , 2001).**

The availability of plant nutrients is dependent on soil" chemical properties". To provide economically sustainable yields, chemical nutrients must be present in sufficient quantities in soil and they must be available for root uptake. Furthermore, organic agriculture is more likely to be based on mixed farming systems where there are greater opportunities for improving the efficiency of nutrient use through transfers between different components of the system.
Organic farming seeks to build up the reserves of nutrients in the soil while at the same time, reducing inputs. This apparent conflict can only be resolved by increasing the efficiency of nutrient use and moving away from a definition of fertility based on the production of maximum yields. **(Sheperd et al., 2000).**

Feed the soil approach is based on organic nutrient additions to increase soil microbial activity. This strategy seeks to build a nutrient bank account and maintain a healthy balance in it. This approach does not account for soils in which nutrient concentration may be very high. In such soil conditions this philosophy can result in nutrient additions that increase the potential for environmental pollution or plant toxity. Organic matter content, rock or other limiting horizons, infiltration, drainage, % of mineralization should be considered through fertility program. **(Baldwin,2001).**The soil micro flora is composed of a number of different groups of organisms: bacteria, fungi, algae, protozoa, acrasiomycetes, and myxomycetes.
The soil micro flora is composed of a number of different groups of organisms: bacteria, fungi, algae, protozoa, acrasiomycetes, and, myxomycete. Soil

microorganisms the living component of the soil occupy usually microorganisms, the living component of the soil, usually occupy less than 1% of the soil volume, while their number is very high. A teaspoon of productive soil generally contains between 100 million and 1 billion bacteria. (**Figure1**)

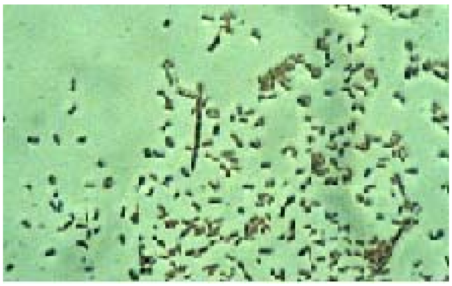

Figure1. A ton of microscopic bacteria may be active in each acre of soil.
Credit: Michael T. Holmes, Oregon Sta. University, Corvallis

Figure2. Bacteria dot the surface of strands of fungal hyphae.
Credit : R. Campbell. In R.Campbell,1985.Plant Microbiology. Edward Arnold; London.P.149. Reprinted with permission of Cambridge University Press.

Unlike the other soil microorganisms, most bacteria prefer nutrient rich soil of neutral or slightly alkaline pH and a close C/N ratio. Nitrogen-fixing bacteria form symbiotic associations with the roots of legumes like clover and lupine, and trees such as alder and locust. Visible nodules are created where bacteria infect a growing root hair **(Figure 2**).

Since the fungi prefer a rather low soil pH and a wide C/N ratio, they dominate in raw humus, and moder and mull soils. (**Figure 3**) Ectomycorrhizae are important for nutrient absorption by tree and grape roots. The fungus does not actually invade root cells but forms a sheath that penetrates between plant cells.(**Figure4**). Special enzymes are produced by the organisms and act intra or extra cellularly. They are immobilized on soil colloids, resistant to biotic and abiotic destruction and thus reactive for the long time.(**Schinner ,1996**)

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Figure3. Fungus beginning to decompose leaf Veins in grass clippings.
Credit :No48 from Soil Microbiology and Biochemistry Slide Set. 1976. J.P.Martin,*et al.*,SSSA,Madison Wi

Figure4. Fungus forms sheat that penetrate between plant cells.In this photo sheat is white ,but may be black, orange,yellow.
Credit :USDA, Forest Service, PNW Research Station, Corvallis, Oregon

Earthworm activity has physical and biochemical consequences for agriculture. Earthworms burrow, improving macro porosity (**Brussard, 1990**) and infiltration properties (**Douglas et al., 1990**).

While burrowing they ingest large amounts of soil plant residue, of which 99% is egested as casts, deposited at the surface in burrows or in other macro pores(**Lavelle, 1974**).

Casts usually contain more organic carbon, total nitrogen and exchangeable cations than the surrounding topsoil. (**Mulongoy,1989**).Casts also have higher microbial populations and enzymes activity than the ingested soil. Firm conclusion on the effects of casts on plant nutrition is not yet possible. (Hauser **et al, 1997**).

Plants are the most important primary producers on earth. From the carbon dioxide using solar energy they produce organic biomass. During life cycle they continuously take up nutrients and trace elements from the soil. Their death is followed by decay of the organic matter. During metabolic turnover, the elements pass through a number of oxidation and reduction stages catalyzed by enzymes. The soil micro flora responds to soil management as well as to environmental pollutants. Biological processes induced by pollutants cause decrease in soil nutrient pool. Further, it should be noted that plant nutrition fully depends on soil micro flora; thus, changes in the soil biota have direct or indirect effect on the health and vitality of plants. (**Schinner, 1996**).

1.2.1. Irrigation

Proper irrigation design and scheduling minimizes NO3 leaching. Irrigation should be applied when needed by the crop and in amounts just sufficient for storage and use within crop rooting zone. (**Smith, Cassel, 1991**).

In coastal areas saline water is an ever-present threat due to inadequate absorption of fresh ground water, which in under natural conditions is delicately balanced on top of denser seawater. (**UNESCO 2002**).

Irrigation to remove the salts from the root zone will also leach nitrates. When water use is excessive underground water table rises and brings with it dissolved salts from the lower regions of the soil. This initially lowers crop yield. (**Sharma, 2001**).

In Mediterranean countries the majority of reclaimed areas are under irrigation using drip or sprinkler irrigation systems. Moreover in further plans for the countries, for a better saving both water and fertilizers, it has been decided to introduce pressurized systems in the light textured soils of the old lands, which are irrigated traditionally by using gravity methods.

Therefore the future perspectives the future perspectives for fertigation shouldn't be limited and should be developed rapidly. **(Nassar,2000).**

In the modern irrigation agriculture N top dressing is applied as a soluble fertilizer in the irrigation water, particularly in drip irrigation and he added that supplementary N side dressing is needed in organic cropping systems when the release of available N soils and composted manures applied annually in is inadequate to meet crop requirement. Such conditions prevail in soils, which have recently been converted to organic farming, or high demand crops. **(Hadas,1992)**.

1.2.2. Tillage practices

With-no tillage, the soil macro structure is distributed very little and most macro pores remain intact from the soil surface to their full depth. Those macro pores provide flow paths, which enable water to bypass much of the soil matrix. (**Thomas et al.,1989**).

In conventional tillage practices where soils are disturbed by ploughing and the crop residues are incorporated, there is much less spatial and temporal differentiation of food webs structure and function. Greater portion of biomass is bacterial in origin and concentrated in the plough layer where is susceptible to the flushes of mineralization imposed by tillage events and wet/dry cycles.

In NT systems, fungal-based food webs often developed on surface-applied crop residues. In this environment mycelial fungi play a key role in the immobilization of mineral N.(**Beare,1997**).

The vertical stratification of bellow-ground food web, shift from a fungal-based food web near the soil surface, to a more bacterial deeper in profile.

In NT, the shift from a bacterial-dominated biomass in the cool season to a more fungal-dominated biomass in the warm season corresponds with a significant decrease in C losses relative to CT where bacterial based food web persist throughout the year.

The shift toward more fungal-based soil food web in NT also appears to contribute to a lower mineralization and greater retention of N as compared with bacterial-based food web in CT (conventional-tillage). (**Beare, 1997**).

Long-term run off records showed that infiltration and potential ground water recharge could increase by more than 100mm/yr in watersheds farmed with no-tillage practices as compared to similar fields with conventional tillage. (**Owens, 2000**).

1.2.3. Crop rotation

Crop rotation has been a part of farming ever since its beginnings. The principal reasons for the development of rotations were to help prevent the build-up of pests and diseases and to allow a period in which the soil could recover some of its fertility. In Britain, a three-course rotation of two cereals, one fallow held sway for over 1500 years.

It was not until the eighteenth century that the development of new crops, notably clover and roots, began a move away from fallows and towards more varied rotations. In the past century, increasing intensification and specialization has led to the abandonment of strict rotations, with agrochemicals used to fulfill the roles of controlling fertility, pests and disease previously managed through rotations.

Without the use of agrochemicals and inorganic fertilizers, organic farming relies heavily on rotations for managing pests, diseases and soil fertility. Many organic arable rotations are based on old rotation courses used in the past. (**Lampkin, 1992**).

Besides classical rotation(one crop per field), intrcropping, mixed cropping, and under sowing are options to optimize crop interactions.(**Sharma,2001**).

Field residues from broccoli-harvest may typically provide nearly 7-ton dry matter per hectare, and residues from other vegetables such as tomato, lettuce, onions, and garlic may respectively add on average 2,500, 1,200, 700, and 500 kg of dry matter per hectare.(**Mitchell et al.,2000**).

1.2.4. Cover crops and catch crops

These two terms are often interchangeable but perhaps catch crops are best considered as green manure crops sown between main crops as a source of organic matter and nutrients; cover crops are sown specifically in the autumn to decrease nitrate leaching. On stockless farms, N and organic matter can be added to the soil by growing leguminous green manures, which may be cut and mulched or incorporated directly into the soil. Fresh green residues will decompose rapidly (**Rasmussen *et al.,* 1998**) and have been shown to be about seven times more decomposable than SOM (**Shen *et al.,* 1989**).

The quantity of N in the manure crop does not represent the net input to the soil as some of the crop N will have been derived from the soil.(**Table 1**).
Forage legumes generally obtain a much greater proportion of their N by fixation than do grain legumes, such as peas and beans, which often depend on soil for 50% of their N. (**Paul & Clark, 1996**).

Table 1. Offtake of N in tops and roots of various legumes **(Heinzman, 1981,cited by von Fragstein, 1995)**

Crop	N in tops (kg/ha)	N in roots (kg/ha)	Total N (kg/ha)	% of total N in roots
Grain legumes				
Lupin white	498	93	547	17
Fava bean	320	57	377	15
Field pea	291	40	331	12
Spring wetch	238	36	274	13
Fodder legumes				
Red clover	381	118	499	24
White clover	322	131	453	29
Lucerne	469	157	626	25
Sainfoin	184	140	324	43

Studies indicate that the release of N following incorporation of the cover crop is not always predictable. In trials in Sweden where cereals were undersown with ryegrass as a catch crop, simulations indicated that N mineralisation increased following incorporation of plant material in spring but the N may have been released too late to be fully available to the following crop (**Aronsson & Torstensson, 1998**).

In winters where precipitation and potential leaching are low, cover crops may have an overall detrimental effect on the following crop, by locking up N, which would otherwise be available (**Thorup *et al.,* 1998**).

1.2.5. Manure

The most widely used soil amendment is farmyard manure (FYM), a mixture of animal waste high in N and bedding material, usually straw. Straw is high in K and on farms where manure is bought in, the straw component can be an important source of K (and, to a lesser extent, P) for the farm nutrient budget (**Lampkin, 1992; Fowler *et al.,* 1993**). Even straw produced on the farm will provide an important route for recycling of P and K. Where bedding materials are absent slurry is produced.

Arden-Clarke & Hodges (**1988**) also suggested that since there is little difference between the uptake of P from mineral fertilizers and organic manures, differences between P cycling in organic and conventional systems are likely to be less pronounced than for N.

In contrast to N and P, almost all of the K in cattle dung and in urine is water-soluble and therefore available for plant uptake (**Haynes & Williams, 1993**).

Smith & van Dijk (**1987**) reported preliminary results from Dutch studies indicating that K in slurry injected into grassland, unlike P, is immediately available to the following silage crops.

The C:N ratio indicates that net mineralization is likely to be the dominant process for most slurries and for poultry manures when added to soils. Solid manures from cattle, and to a lesser extent from pigs, are more likely to exceed this critical value and result in immobilization during the initial stages of decomposition (**Beauchamp, 1986**).

The efficiency of manure P utilization in the year of application is generally lower than that of inorganic fertilizer P but in the longer-term, both are considered to be equally effective (**Smith *et al.*, 1998**).

1.2.6. Commercial products

Blood meal is dried slaughterhouse waste containing about 12% nitrogen. Unless used carefully, it can burn plants with ammonia, lose much of its nitrogen through volatilization, or encourage fungal growth.
Feather meal is a common by-product of the poultry slaughter industry. Although total nitrogen levels are fairly high (7 to 10%), the nature of feathers is such that they break down and release their nitrogen much more slowly than many products of similar price.
Bone meal is so well known, especially in horticulture, that it can hardly be considered an alternative product. Typically it contains about 27% total phosphate, and nearly all of that is available. Twelve percent phosphorus is the same as 27% phosphate, and bone meal is sold under either of those (or similar) numbers; it's the same good, but expensive, product in either case.
Rock phosphates are usually derived from ancient marine deposits. They have a different composition than collodial phosphate, generally making them less available. Total phosphate is around 30% and available phosphate 1-2%.

Hard-rock phosphates are usually derived from igneous volcanic deposits and consist almost totally of the mineral apatite. Although apatite contains about 40% total phosphate, because of the mineral's composition, this phosphate is largely unavailable.

Potassium magnesium sulfate (langbeinite), Langbeinite goes from mine to field with minimal processing.
Granite dust is often sold as a "slowly available" potash source for organic production, but granite is mostly feldspar, a mineral with low solubility. Therefore, little potash fertility is derived from this material.
Basalt dust, if available at a reasonable cost, can provide a wide range of trace minerals to agricultural systems over a period of several years; as with most rock powders, transportation costs are a major factor in determining cost effectiveness. Most of the rich volcanic soils of the world are derived from basalt, which gives some indication of basalt's agronomic value, and even when too expensive for land application, basalt dust can benefit farm systems when mixed with manure in the composting process.
Lime Plant nutrient availability is strongly tied to the pH of the soil solution. Decreasing soil pH directly increases the solubility of Mn, Zn, Cu, and Fe. At pH values less than approximately5.5, phytotoxic levels of Mn, Zn or Al can be present. Liming increases soil pH, which decreases the solubility of these elements and facilitates their precipitation as solids. (**Baldwin,2001**).

1.2.7. Good Agricultural Practices for Manure Management

Animal manure and represent a significant source of human pathogens. A particularly dangerous pathogen, *Escherichia coli* O157:H7, is known to originate primarily from ruminants such as cattle, sheep and deer, which shed it through their feces. In addition, animal and human are known to harbor *Salmonella, Cryptosporidium,* and other pathogens. Therefore, the use of biosolids and manures, including solid manure, manure slurries, and manure tea, must be closely managed to limit the potential for pathogen contamination. (**U.S. Department of Health and Human Services Food and Drug Administration1998**).

Manure storage and treatment sites should be situated as far as practicable from fresh produce production and handling areas.

Consider barriers or physical containment to secure manure storage or treatment areas where contamination from runoff, leaching, or wind spread is a concern.

Consider good agricultural practices to minimize leachate from manure storage or treatment areas contaminating produce.
Maximize the time between application of manure to produce production areas and harvest.

Applying raw manure, or leachate from raw manure, to produce fields during the growing season prior to harvest is not recommended.
Maximize the time between application of manure to produce production areas and harvest.

Where it is not possible to maximize the time between application and harvest, such as for fresh produce crops, which are harvested throughout most of the year, raw manure should not be used. (**U.S. Department of Health and Human Services Food and Drug Administration 1998**).

1.2.7.1.Treatments to Reduce Pathogen Levels

Passive treatments rely primarily on the passage of time, in conjunction with environmental factors, such as natural temperature and moisture fluctuations and ultraviolet (UV) irradiation, to reduce pathogens. Holding time for passive treatments will vary depending on regional and seasonal climatic factors and on the type and source of manure.

Active treatments include pasteurization heat drying, anaerobic digestion, aerobic digestion or combination of these. Composting is an active treatment commonly used to reduce the microbial hazards of raw manure. It is a controlled and managed process in which organic materials are digested, aerobically or anaerobically, by microbial action. (**U.S. Department of Health and Human Services Food and Drug Administration 1998**).

1.2.8.Compost

Composting is an aerobic process in which microorganisms convert a mixed organic substrate into carbon dioxide (CO_2), water, minerals and stabilized organic matter. Control of environmental conditions during the process distinguishes composting from natural rotting or decomposition. (**Zucconi and De Bertoldi, 1987**). Controlled conditions, particularly of moisture and aeration are required to yield temperatures conducive to the microorganisms involved in the composting process (**Chen and Inbar, 1993**).

This first (mesophilic) stage of composting lasts 1 to 2 days, during which time mesophilic strains of microorganisms (species that are most active at temperatures of 35-40°C) initiate decomposition of readily degradable compounds. Sugars, fats, starches, and proteins are rapidly consumed, heat is given off and the temperature of the substrate rises. The pH typically decreases as organic acids are produced (**Chen and Inbar, 1993**).

The second stage is the thermophilic stage. When active composting is taking place, microbial activity in the pile should cause an increase in temperature in the center of the pile to about 60-65°C. When temperatures are within this range, specific, heat-loving (thermophilic) bacteria vigorously degrade organic material. Temperatures will remain in this range as long as decomposable materials are available and oxygen is adequate for microbial activity (**Chen and Inbar, 1993**).

Normal curing period lasts for 30 days and helps insure against any negative consequences of application of immature compost in cropping situations; e.g. inhibition of seed germination. Less heat is generated during this period and the final pH is normally slightly alkaline. Common microorganisms (pathogens and beneficials) as well as a microfauna recolonize the compost. Intense microbial competition for food takes place through both direct antagonism and production of antibiotics (**Chen and Inbar, 1993**).

It is in this competition that pathogens (e.g. *Pythium*, *Rhizoctonia*, *and Phytophthora* species) are often suppressed by beneficial microbial species (**Hoitink and Fahy, 1986**).

In the beginning, the formation of carbon dioxide and organic acids causes values of approximately 5-6, whereas as the process progresses, the pH values reaches even up to 8-8.5.This is mainly due to the decomposition of proteins (ammonia is liberated), as elimination of the carbon dioxide. (**Sharma *et al.*, 1996**).

It has been observed experimentally that, during mesophilic stage, the treatment can be accomplished at lower temperature value. The bacterial activities in such cases decrease as the temperature increase. Termophilic stage in temperature range of 60-65°C is advantageous because of increased organic removal efficiency, improved solid-liquid separation and destruction of pathogens. **(Table 2)** (**Sharma *et al.*, 1996**).

Table 2. Temperature and time interval required to destroy most common types of pathogenic micro-organisms and parasites occasionally present in wastes (**Sharma *et al*., 1996**)

Salmonella typhosa	Further growth stopped above 46;dies within 20-30 min. at 55-60°C
Salmonella sp.	Dies within 60 and 20 minutes at a temperature 55and 60°respectively
Shigella sp.	Dies within 60 minutes at t°=65°C
Escherichia coli	A large portion dies within 60 and 15-20 minutes at t°=55-60°C
Entamoeba hystolitic	Dies within few minutes at 45°C, at 55° in few seconds
Taenia saginata	Dies within few minutes at 55°C
Trichinella spiralis	Dies rapidly at 55°C and instantaneously at60°C
Brucella abortus,B. suis	Dies in 3 minutes at 62-63°C, at 55°C within an hour
Micrococcus piogensis	Dies within10 minutes at 50°C
Streptococcus piogensis	Dies within15-20 minutes at 54°C
Microbacterium tuberculosis var. hominis	Dies within 15-20 minutes at t°=66°C
Corynebacterium diphtheria	Dies within 45 minutes at t°=55°C
Nectar americanis	Dies within 50 minutes at t°=45°C
Ascaris lumbricoides	Dies within 55-60 minutes at t°>50°C

The literature reports that optimal initial moisture content for a biomass, which undergoes composting, should usually be around65%. During composting process, the humidity should be maintained between 50 and 65%. Lower humidity values reduce the microbial activities significantly, whereas the higher values rise up against the worst conditions for the process.(**Sharma *et al.*,1996**).

Considering that living organisms use, on average 30 carbons atom (as energy source)for each nitrogen atom(for synthesis means for proteins),it is considered that optimum C/N ratio should be in the range25-30. Mixing of lignocelulosic residues(C/N = 100-300) with sludge (C/N = 5-15) and allows re-equilibrium of the ratio and, thus guarantees optimal conditions for the biological transformation process (**Sharma *et al.,* 1996**) **(Fig. 5).**

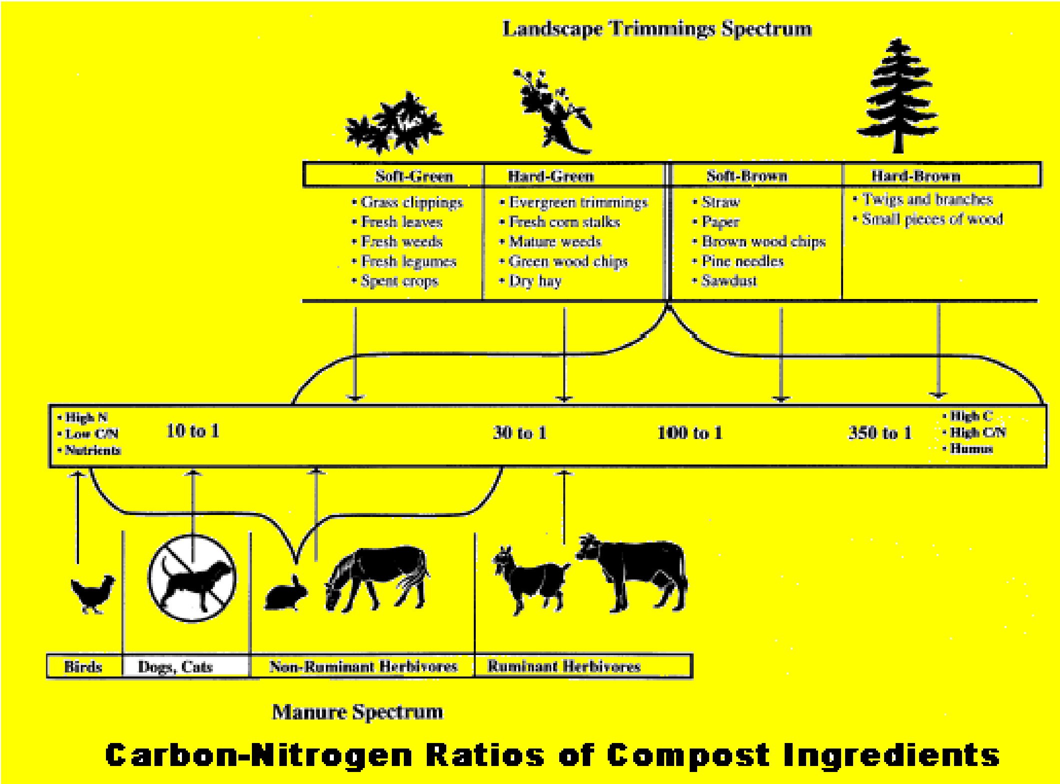

Figure 5. Organic Farming Research Foundation Project Report # 97-40: Organic teas from compost and manures by Richard Merill and John McKeon

One of the more widely used growth-dependent methods for analyzing environmental microbial communities has been that of community level physiological profiles**. (Insam *et al.*,1996**).

The investigation of phospholipid fatty acid extracted from environmental bacteria have helped to overcome former limitations and significantly improved knowledge on the function and dynamics of microbial communities during composting processes. (**Carpenter *et al.*,1998,Vander Gheynst *et al.*,2000**).

Just recently developed new DNA and RNA-based approaches, especially based on the use polymerase chain reaction (PCR) and 16s rRNA sequence analysis work have inspired numerous recent studies in environmental microbiology. Several molecular tools exist today ti characterize microbial from various habitats. (**Alfreider *et al.*,2002**).

Tiquia *et al.*,2002 reported that during composting process experiment the ammonium and nitrite oxidizers were maintained at high population sizes, suggesting a rapid oxidation of NH_4^+ to NO_3^- nitrogen .*Nitrosomonas spp*. and *Nitrobacter spp*. were dominated. Some microbial genera capable of denitrification are *Bacillus, Pseudomonas, Flavobacterium*. It seems that as the composting process proceeded, the denitrification bacteria become smaller, indicating that very little denitrification took place once the air was blown in the pile on a regular weekly basis.(**Tiquia *et al*.,2002**).

De Bertoldi *et al*.,1983, reported that fungi normally increase the remaining substrates are predominantly cellulose and lignin, which normally occurs during the process of cooling.

In present study during the cooling stage of composting actinomycetes which actively degradated hemicellulose, were so numerous that their hyphal strands caused the compost surface to take gray or white appearance. (**Tiquia *et al*.,2002**).

During the composting process unstable organic matter is oxidized to more stable and less degradable material. Stability is an important property of compost for several reasons. To avoid problem with reheating, odor production and deteriorating quality change during storage, the compost has to have the minimum level of stability **(Eggen *et al*., 2001).**

In general, the term stability is associated with the degree of microbial activity and potential for producing volatile malodorous components. The term immaturity is often associated with phytotoxicity, resulting in reduced plant growth **(Hue *et al*., 1995).**

Since phytotoxic compounds are produced by microorganisms in unstable compost **(Marambe *et al*., 1992; Saviozzi *et al*., 1992)**, the distinction between these two properties is not always clear. Compost stability is often characterized by physical, chemical and biological parameters.

Physical characteristic such as color, odor and temperature give general idea of decomposition stage reached, but give little information as regards of the degree of maturation **(Bernal *et al*., 1997**).

Some parameters (e.g. water content, pH, oxygen concentration, T) have been measured to monitor the composting process, and not necessarily to characterize the final product **(Paletski *et al*., 1995).**

Respiration rate is assumed to be as direct and reliable indicator of stability **(Lasaridy *et al*., 1998)**, methods to measure CO_2 production and O_2 consumption are time consuming and laborious **(Eggen *et al*., 2001).**

During experiment with various types of compost all of them except fish waste compost showed high correlation between water soluble TOS and respiration rate (r^2= 0.995). Measuring water soluble TOS is simple and cheep, and is suggested as an operational parameter at bio-waste composting plants.

Chanyasak and Kubota 1981, as an essential indicator of compost maturity, established water-soluble organic C/organic N ratio of 5-6.

Hue *et al*., 1995 suggested using the water soluble organic C/total organic N ratio as suitable parameter for assessing compost maturity, proposing value of < o.70 as new index of compost stability.

The degree of maturity can revealed by biological methods involving seed germination and root length (**Zucconi *et al*., 1981)**, since immature compost may contain toxic substances such as phenolic acids and volatile fatty acids **(Kirchmann *et al*., 1994).**

Respirometric studies, which determine O_2 consumption or CO_2 production, have been carried out in pure compost and in compost mix with soil in proportion compatible with agricultural use **(Iannotti *et al*., 1993**).

Insufficiently mature compost has a strong demand for O_2 and high CO_2 production rates due to intense development of microorganisms as a consequence of easily biodegradable compounds in the raw material. For this reason O_2 consumption or CO_2 production are indicative of compost stability and maturity (**Hue *et al*., 1995).**

Bernal *et al*., 1997 suggested that soluble organic C content could be used to reflect good maturation degree Cw< 1.7 %. They also suggest correction of maturity index (Cw/ N org. <0.70) established by **Hue *et al*., 1995** because it was reached for some immature samples at thermophilic stage. This limit is not valid and lower limit is required. They also recommend with little exceptions limit of Cw/ N org<0.55 as factor of stability.

According to laws on composting in Italy (DPR 915/ 82, with modification as on 27/7/84 and National law 784/84) that at the end of the composting process, the compost obtained must be reach agronomical, while complying well within acceptable limits as presented in Tab.3.

Table 3. Limits concerning acceptability of compost(**Sharma *et al.,*1996**)

Parameters	Measuring units	Limiting values
Seeds of wild plants	No/ 50 g	Absent
PH	Units of pH	6-8.5
Arsenic	mg/kg (dry matter)	10
Cadmium	mg/kg (dry matter)	10
Chrome III	mg/kg (dry matter)	500
Chrome VI	mg/kg (dry matter)	10
Mercury	mg/kg (dry matter)	10
Nickel	mg/kg (dry matter)	200
Lead	mg/kg (dry matter)	500
Copper	mg/kg (dry matter)	600
Zinc	mg/kg (dry matter)	2.500

The compost could be used on agricultural land where different metal concentrations do not exceed the values shown in Tab.4. The quantity of compost to be used, no doubt, is function of the metal contents, but in any case, it should not exceed the limit, i.e. 300q/h, during the tree-year period.Tab.4. Limits on metal conc. in soil and quantity of metals that can be added annually through compost.

Table 4. Norm for compost application according to soil metal content (**Sharma *et al* 1996**)

Parameters	Max. concentration in the soil (mg/kg of dry soil)	Max. quantity of compost applicable(g/ha/year)
Arsenic	10	100
Cadmium	3	15
Chrome VI	3	15
Chrome III	50	2.000
Mercury	2	15
Nickel	50	1.000
Lead	100	500
Copper	100	3.000
Zinc	300	10.000

In any case, compost should not be used on soil with pH<6.It neither be used in natural forage cultivation nor in forest. (**Sharma et al.,1996**.

Stratton *et al.,*1995, reported that weed seeds are seldom a problem in properly processed compost.

1.2.8.1. Benefits from compost application

Increased plant nutrition from composted animal manure applied to soil also increased the protein content of potato (*Solanum tuberosum*). (**Srikumar and Ockerman,1990**).

Composted plant material added to soil increased the yield of sweet potato (Ipomoea batatus). (**Preston,1990, Floyd *et al*.,1988**).

Hoitnik *et al*.,1993,stated that wood waste compost was at least as effective as fungicides in controlling *Phytophtora* root rots.

Suppression of *Rhizoctonia* in compost media has been reported by several researchers (**Nelson and Hoitnik,1982, Chen *et al*.,1988, Tunlid *et al*.,1989**).

Composted manure suppressed damping off by *Rhizoctonium solani* in potting media experiments with radish seedlings (*Raphanus sativus*). (**Voland and Epstain,1994**).

A compost of blue crab and cypress (*Taxodium distichum*)sawdust suppressed population of nematodes(*Meloidogyne javanica*) in container grown tomato.(**Rich and Hodge,1993**).

Trichoderma in addition to being a strong colonizer of compostable materials, has potential to control plant diseases (**Hoitnik *et al*.,1993**).

Potting media containing high level of *Trichoderma* have been reported to suppress *Pythium* and *Rhizoctonia*.(**Papavizas,1985**).

1.2.9. Compost water extracts

Liquid extract obtained by many preparations using the compost as starting material, or in some cases described as the liquid version of the original compost is named compost tea. (**Bess, 2000**).

Water extract of compost that is actually brewed and contains soluble nutrients and diversity of bacteria, fungi, protozoa and nematodes is defined as compost tea. (**Ingham, 2001**)

Water extracts of various kinds of organic matter, rich in nutrients, organic compounds and microbes is defined as organic tea. Leachate is synonymous word. (**Merrill *et al.,* 1999**).

Compost tea, in modern terminology, is a compost extract brewed with a microbial food source like: molasses, kelp, rock dust, humic-fulvic acids. The compost-tea brewing technique, an aerobic process (usually under forced aeration extracts and grows population of microbial community. (**Diver,2002**).

Ingham, 2001 differentiated compost tea and other extract such as:

Manure tea, a water extract of manure which can contain human pathogens. Compost tea is free from this pathogens because they are killed by heat treatment during composting or by passage through earthworm digestive system in a worm compost.
Compost extract, produced by purposely adding water to compost and collecting the water that passed through the pile. This water contains soluble nutrients but very few organisms. By cycling this water through the compost a number of times to increase resource concentration in water, organisms may grow and reach adequate numbers to protect leaf and root surface.

Compost leachate, is dark-colored solution that leaches out of the bottom of the compost pile. Most likely will be rich in soluble nutrients but in early stage of composting it may also contain pathogens. It would be viewed as source of pollution if allowed to run off site.

Compost leachate needs further bioremediation and is not suitable and recommended for foliar spraying. (**Diver, 2002**).

1.2.9.1. Benefits and Effects of extracts utilization

Compost tea can improve soil quality by increasing the number of beneficial soil organisms. Plants depend on soil microorganisms for gathering and incorporating nutrients in their roots. Compost tea contains substantial quantities of them which are released into the soil when the tea is added around plants. (**Robson, 2000**)

The number of liquid materials and teas are able to provide on or more minor elements. These liquid materials may be used in irrigation systems or applied to foliage. Field trials evaluating the effectiveness of minor-element foliar applications when soil levels are already adequate do not show a consistent pattern of crop response. (**Gaskell *et al.*,2000**).

Compost extracts correctly prepared and applied will improve the life in the soil and on plant surfaces. The continuously application of these extracts will result in an increase of the number of individuals and broadening of species diversity of the communities, stem, flower, seed-surface and soil microorganisms, and will select against disease-causing or pest organisms. Thus, use of compost tea is indicated in those cases when the set of organisms in soil or on plant surfaces decreases below optimal levels for the desired plant life. (**Ingham,2001**).

Diluted liquid teas are sometimes applied to the soil or sprayed directly on the plant in an effort to improve nutrient availability but the value of these teas, as a nutrient source has not been clearly established. (**Gaskell *et al*., 2000**).

The type and amounts of nutrients in organic tea depend on the age and kind of material used during preparation. The nutrients from fresh manure teas tend to be especially macronutrients. More decomposed feedstock such as young or unstable compost contain some available nutrients not yet fixed to microbial biomass, but they provide organic compounds such as sugars and amino acids, plus chelating agents (humic and fulvic acids that carry extracted micronutrients to plants);

Organic teas also increase vigour and hardness on the plant by providing both micronutrients (building blocks of plant enzymes, vitamins and hormones) and the organic chelating agents that make them available. Teas made from fresh composts (aged less than six months) contain fewer nutrients than manures, but provide humic acids.(**Merrill and McKeon,1998**).

It was mentioned by **Norrie and Hilitz, 1999** that seaweed extract are active source of many helpful ingredients specially plant growth substances and in particular a class of plant growth regulators (PGRs) called Citokinins which are necessary compounds in plant growth and developments, and with the help of another family of PGRs, the auxins, which stimulate cell division and protein synthesis. (**Salisbury *et al*., 1992, Wareing *et al*., 1981**).

Welke, 1999 studied two types of compost effects on fresh market crops**.** Extracts from cattle compost were effective in increasing marketable number and weights of strawberries.

The same extract also increases the weight of broccoli heads. Lettuce and leaks did not show any increased harvest weights. The author reported that the effects of compost extract application were not consistent across all the crops. This study supported to the idea that different crops respond differently to extracts from a variety sources.

1.2.9.2. Extraction methods

Diver, 1998 reported that between many methods for extraction and preparation two could be distinguish as main methods: Fermented compost extract method (non aerated); Aerated extract method.

During the passive extraction (non aerated) method, substrate can go anaerobic very quickly. Also when soaking organic material is in water more than a few days, aerobic microbes in the slurry will pull all the oxygen out of the water. As a result inferior tea could be obtained with fewer available nutrients and organic acids harmful to plant growth. (**Merill *et al.,* 1998**).

Fermentation method through fermented-anaerobic system was promoted by **William, 1995,** and after developed and improved by **Heinrich, 1998**, where compost tea was obtained by covering compost with tap water at a ratio between 1:5 to 1:8 (v/v), stirred once and allowed to ferment outdoors between 15° and 20°C. After soaking period-extraction time, the solution was strained through cheesecloth and then applied with ordinary sprayers. Extraction period ranged from 2-21 days.

Merrill *et al*., 1998 mentioned that there is usually enough dissolved oxygen in clean water so that anaerobic microbes are not dominant for at least 24-48 hours under most conditions but after that, the quality of the tea begins to deteriorate.

These authors, and **Ingham, 2001,**although knowing the good results obtained with anaerobic systems by **Weltzien, 1989,** and others are reported that all types of extracting systems should be aerobic because the most studies has shown that adding air to an organic tea improves quality of extracted tea, probably because aeration extend extraction period by several days, which allow the removal of beneficial organic compounds like vitamins, enzymes, organic chelators and beneficial bacteria.

1.3. Foliar nutrition effects on plant growth

Kupper, 2000, mentioned that using foliar fertilization is not specifically an organic practice although many organic growers commonly use it. The author mentioned that the use of foliar feeding seems to be contradictory with organic notion that one feeds the soil to feed the plant. Organic growers racionalize the use of this approach on two points:

1. Foliar feeding is strictly supplemental fertilization.it is not used as a substitute for traditional soil building practices
2. Foliar fertilization is understood to increase the production of root excudates, which stimulates biological activity in rhizosphere.Soil bio-life obtain considerable benefit in this indirect way from foliar feeding.

Shalaby *et al*.,1992 studied effects of application of two sources of iron fertilizers on some growth characteristics of faba bean plants. Results showed that, all determined parameters were positively affected by foliar application, meanwhile an opposite trend was observed when they are added into the soil.

Efficiency of some organic fertilizers and its effect on plant growth and soil fertility were studied by **Zeweiny, 2001**. The best treatment regarding the effects on dry matter yield and nutrients uptake was composted mixtures of 50% farmyard manure and 50% sugarcane filter mud.

Abd. El-Shafy et al. 1998, studied effect of foliar spraying cotton plants with amino compound and potassium. The results show that spraying cotton plants with these compounds increased plant height. Application of amino compounds and potassium increased the cotton yield/fed.

In study of foliar spraying with some chelated micronutrients (Mn, Zn, Fe) as individual or in combination these results were achieved. Generally foliar spraying with some chelated microelements increased plant fresh weight, both fresh and dry weight of plant leaves, number of branches and leaf area per plant and also improved pod characters and green yield and its components. **Mohamed *et al.,* 1999**.

1.4.Introduction to Potato production and organic management effects on Potato yield and quality

Tuber initiation or tuberisation starts when tubers begin to swell at the ends of stolons. The period of tuber initiation assimilates produced by the foliage are used for stolon growth and tuber initiation. Therefore, high tuber number requires good growing conditions and field management during the tuber initiation period (1-2 weeks).
The number of tubers formed per plant is called tuber set. Early in the season, a potato plant may form 20-30 tubers; however, only 5 to 15 mature tubers are normally found on each plant at harvest. Some of the small tubers that are initially set are used by the growing plant while the remaining tubers continue to grow until harvest.(**Beukema *et al.,* 1990)**

Temperatures:

Air temperature and tuber initiation rates are inversely related. Tubers are initiated more readily under cool, moist conditions. Intermediate soil temperatures of 15-18°C are ideal for tuber set. The optimum ambient daytime temperature range for potatoes is approximately 20-25°C depending on the light intensity. As the light intensity decreases, the optimum temperature decreases as well **(Ingham 1980, Ingham *et al.* 1984, Beukema & Vander Zaag 1990, Schaupmeyer 1997).**

Tuber yield decreases about 4% for each 1 degree F above the temperature optimum. High soil temperatures also cause knobbiness and poor shape of tubers **(Peet 1997).**

Buds are sites of gibberellin synthesis and at high temperatures synthesis of gibberellins is stimulated and exported to the stolons, inhibiting tuber formation **(Menzel 1981, Simko 1990).**

Cool night temperatures are important because they affect the accumulation of carbohydrates and dry matter in the tubers. Tuber initiation is reduced substantially if night air temperature is above 20°C and inhibited above 30°C **(Schaupmeyer 1997).**

The favourable effect of low soil and air temperatures during the vegetative and tuber initiation and development phases contributed to a higher tuber yield **(Nooruddin *et al.* 1995).**

Grain (rice, barley, or wheat) straw mulch reduces soil temperature in potato fields by 2-4°C during hot seasons. This would result in faster emergence and canopy development, earlier tuber initiation, significantly higher tuber yields and a slightly higher tuber dry matter content. **(Vander Zaag *et al*. 1986).**

Moisture:

Appropriate application of water during the growing season is crucial to optimise production of the crop. Potatoes require a continuous supply of soil water and good soil aeration. Yields are greatest when soil moisture is maintained uniformly above 70% of total available capacity **(Schaupmeyer 1997).**

Having high moisture levels at the time of tuber initiation increases tuber set. An increase in the soil moisture level from 20 to 80% of water holding capacity increases the growth rate of stems, leaf area, tuber dry weight, net assimilation rate and tuber number **(Krug *et al*. 1972).**

Frequent irrigation at tuber initiation, at moisture tension of 40 kPa (-0.4 bar), gives higher yield, more tubers, higher starch content, reduced common scab infection, better cork quality and improved cooking quality for boilingand chips than with irrigation at higher moisture tension **(Jorgensen 1984, MacKerron *et al.* 1986).**

Relatively low soil moisture early in the potato growth period results in increased yields by lengthening the period ofhigh growth rate and by increasing growth rates and net assimilation. Tuber yields are highest after an initial dryperiod of around 36 days **(Krug *et al.* 1972).**
Withholding water during tuber initiation severely hinders plant physiological process (photosynthesis) and reduces tuber yield (**Costa-Dalla *et al.*1997**).

Management:

Comparisons between biodynamic and organic farming system management effects on potato production were studied in Wieseengut and Darmstadt, Germany in 1994-1997. In all three years at Wieseengut, tuber yield was slightly higher in biodynamic than in organic farming plots while in 1994 at Darmstadt yield was higher with biodynamics than organic management. The effect of manure on yield was greater on the sandy soil at Darmstadt. Plant uptake and content of potassium were increased by manure. **Kopke *et al*., 1999**.

Eight potato cultivars were cultivated by conventional and organic farming methods at two locations in Czech Republic. Several parameters to sensory and nutritional quality of potatoes were determined. Yield were about twice as high from conventional farming(52.9 t/ha compared 26.5 t/ha in organic farming). Tuber size was higher, and dry weight starch content were lower for conventionally grown potatoes. The content of most metals analyzed was higher in organically grown potatoes(Mn, Fe, Co, Cu, Se, and Ni) except Cd which content was lower. Nitrate content was lower in organic potatoes than in conventionally grown. The average glycoalkaloid content was related to cultivars rather to cultivars rather than cultural practices. **Schulzova *et al*.,1999**.

An field trial with three potato cultivars and different fertilization rate was conducted on an ecological farm Wulksfelde near Hamburg, Germany. Tuber yield increased with rate of fertilizer application(composted farmyard manure). The proportion of undersized tubers decreased with increase in fertilizer rate, whereas proportion of oversized tubers increased. Percentage of ash, potassium, crude protein, free amino acids and nitrate in tubers increased with rate of fertilizer, whereas percentage of dry matter(DM) decreased**. Bohm *et al*., 1997**

1.5. Potato pests and diseases

Pathogen: *Erwinia carotovora var. atroseptica, E. carotovora var. carotovora, E. chrysanthemi*

Conditions for Development

The mother-tuber is the main source of contamination. Cutting of infested seed-tubers can intensify the distribution of the disease in the field. The bacteria survive in plant residues remaining in the soil, are transmitted by free water, and can contaminate neighboring plants. The disease penetrates through cracks in the tubers and lenticels. The disease in the daughter tubers continues to develop in the soil, under conditions of high humidity, and in poorly-ventilated storage areas.

Control

Management: Optimal drainage and aeration of the soil; avoidance of over-watering; removing affected plants from the field and burning them; control of seed production. Sterilization of tools, sorting machinery, etc. Well ventilated storage, and thorough drying of tubers after washing.

Figure 6: *Erwinia carotvora*

Symptoms

Blackening and rotting at the base of the stem; hollowing above the blackened area; stunting and yellowing of the foliage, and upward curling of leaflets. As the disease progresses, the plant wilts and dies. In the tubers, soft black rot begins to develop, usually from the stolon, and develops until the tuber disintegrates. The ability of the tuber to bud is impaired. There is a characteristic foul odor. Rot may also develop on the sides of the tuber lenticels and wounds.

Damage

Plant death and substantial yield loss. Rotting develops in the soil or during storage. Infestation may be latent, and be expressed after planting or during storage.

Pest *: Leptinotarsa decemlineata var. Say* (Colorado beetle)

Description

- Adult: Oval body, very convex, 10 to 11 mm long. The prothorax of a brown red coloration, as is the head, bears several black spots. The yellow elytra are decorated with 10 characteristic black longitudinal bands.

- Eggs: orangy yellow, ovoid, 1.5 mm in length, they are fixed in clusters of 10 to 30 on the underside of the leaves.
- Larva: after hatching, it is orangy red and measures 1.5 to 2.0 mm in length. Once development is complete it measures 11 to 12 mm in length, it is soft and plump, of a more or less dark red colour. The head and legs are black as well as 2 rows of obvious plates on the side of the body.
- Pupa: in the ground, pinkish, 1 cm long.

Biology

- Host plants: exclusively *Solanaceae*, especially potato; otherwise, egg-plant, tomato and wild *Solanaceae*:black nightshade(*Solanumnigrum*),woody nightshade(*Solanumdulcamara*).
- Adult: hibernates in the ground at a depth of between 25 and 40 cm. It emerges out in spring after rain and once the ground temperature reaches 14 °C at its hibernation depth. It then feeds on the young potato leaves. After mating, the female immediately starts to lay eggs.

Fecundity: 700 to 800 eggs.
Lifespan: 1 to 2 years.

- Egg: embryonic development lasts 4 to 10 days.
- Larva: feeds on foliage, moults 3 times and completes its development in 15 days. It then buries itself in the ground at a depth of between 2 and 20 cm to pupate.
- Pupa: development lasts 8 to 15 days.

Life Cycle

- 1 generation, a second generation sometimes incomplete in temperate and meridional zones. The total length of the cycle is about 5 to 6 weeks.
- The adults appear at regular intervals from April onwards; the first generation adults appear in July and feed abundantly. Some of them reproduce, the other bury themselves in the ground and enter diapause.
- As a result of the adult lifespan, the annual generations superimpose themselves and all the instars can be simultaneously observed in the fields.
- End of August beginning of September, the surviving adults bury themselves in the ground to hibernat


Figure 7:L.decemlineata var.Say,adult


Figure 8: L.decemlineata var.Say,larvae

Damage

The adults and the larvae destroy partially or totally the foliage of potato or other host *Solanaceae*. In the event of a major invasion, the harvest is greatly reduced.

Remark/A

Originating from America, this pest was introduced to France in 1922 in the Bordeaux region, before it invaded all France and Europe mainland from 1940 onwards.

Common Names

DE: Kartoffelk r ES: Dorifora FR: Doryphore IT: Dorifora della patata PT: Escaravelho da batateira GB: Colorado beetle

Control

A beetle pest (*Coleoptera*, *Chrysomelidae*) of potatoes. *Leptinotarsa decemlineata* can be controlled by the bacteria *Bacillus thuringiensis var tenebrionis* and *Bacillus thuringiensis* var *sandiego.*

Various beneficial insects, including *Hymenoptera*, *Diptera*, *Coleoptera* and *Neuroptera*, as well as nematodes, have been investigated as natural control agents.

Chapter 2.

Materials and methods

In order to investigate and evaluate the potential of using compost extracts for organic farming systems, two main experiments were carried out in the season 2002/2003. The first one, the green house experiment, aimed to study the phytotoxicity of composts water extracts; the second one, the field experiment, aimed to study the effects of using these extracts resulting from the extraction procedure on the potato plant and soil fertility.

2.1. Extraction experiment

Extraction processes were conducted simply to achieve following objectives:

- To compare quality between two different types of compost (farm and commercial) that can be used as water extracts through fertigation
- To evaluate the most suitable-preferred extraction ratio for ferigation

Two different organic substances were used to carry on the experiment to submit the water extracts (in 8 days) to the following treatments:

1. Farm compost (FC) + water (1:5)
2. Farm compost (FC) + water (1:10)
3. Farm compost (FC) + water (1:20)
4. Commercial compost (CC) + water (1:5)
5. Commercial compost (CC) + water (1:10)
6. Commercial compost (CC) + water (1:20)

The chemical characteristics of the selected materials for the extraction are listed below in Tables(5 and 6).

Table 5. Farm Compost properties

Organic Material	Humidity %	EC	PH	C org.	N	P_2O_5	K	Ca	Mg	Fe	C/N
		(1:10)	(1:10)	%	%	Total g/kg					
Compost (FC)	22	4.5	6.2	32.6	2.6	1.95	5.8	48.7	3.2	8.1	12.5

Table 6. Commercial compost properties

Organic Material	Humidity %	EC	pH	C	N	P2O5	K2O	Ca	Mg	Fe	C/N
		(1:10)	(1:10)	%	%	g/kg					
Compost (CC)	29.8	4.3	7.6	37.1	2.8	1.3	21.5	34	21	1.7	13.2

2.1.1.Farm compost

The farm compost was obtained from mixture of animals manure and green residues (from grape, olive trees, etc) composted for a period of 90-120 days. The origin of these materials is a farm in Castellaneta (TA).

2.1.2. Commercial compost

The biological line of Bonollo Company in Formigine 41 043 (MO)-Bonagri@Bonollo.com, Italy, produced the mixture of soil amendment and compost under commercial name “Terrapiu”. It was obtained from vegetal residues of different kind of trees according to the local Italian law (MIPAF N.8 del 13 September 1999).

2.1.3. Extraction model

The extractor consists of a permeable Burlap bag placed in 100-liter plastic tank. An appropriate homogeneous amount of different used materials (FC, CC) were putted inside the bags to obtain the required ratio on a fresh matter basis (Table 6) (Figure 9). Each material was treated with 50 liters of tap water (Table 7). The mixture was shaken manually every day during the extraction period and tanks were placed in the shadow in the field.
In treatment **FC5**, farm compost was used for the extraction by water with the ratio 1:5; in treatment **FC10**, farm compost was extracted by water with the ratio 1:10; in treatment **FC20**, farm compost was extracted by water with the ratio 1:20; in treatment **CC5**, commercial compost was extracted by water with ratio 1:5;**CC10**, was prepared in ratio 1:10;last one **CC20**, was obtained in ratio1:20;, as indicated in Table 3.2.

Table 7. Details of the extraction procedure

Treatment	Feedstock	(Compost: water*) Ratio**	Extraction period
FC5	Farm compost	1:5	8days
FC10	Farm compost	1:10	8days
FC20	Farm compost	1:20	8days
CC5	Commercial compost	1:5	8days
CC10	Commercial compost	1:10	8days
CC20	Commercial compost	1:20	8days

Water volume for each treatment is 50 liter.
****Treatments are based on (Weight/Volume) ratio**

50 ml were taken from each extract to run the chemical analysis. Prior to sampling, solutions were mixed in order to obtain a representative sample. Samples were taken from the liquid part above the sludge. They were filtered using normal filter paper (Whatman filter paper) and analyses of pH and EC was immediately carried out (Tables 8 and 9).
Prior to the nutrients analysis, 5 ml from the sample were digested using 10 ml of concentrated H_2SO_4 and $HClO_4$ and the mixture kept for 24 hour before heating on hot plate according to procedure described by FAO (1980).

Table 8. Properties of commercial compost dilutions

		CC 5 I	CC 5 II	CC5 III	CC10 I	CC10 II	CC10 III	CC20 I	CC20 II	CC20 III
pH		7.1	6.7	6.6	6.9	6.9	6.9	7.2	7.0	6.9
EC 25ºC	dS/m	12.4	9.8	9.9	6.0	5.8	5.4	3.6	3.8	3.6
DOC	g/l	3.3	-	-	1.2	-	-	0.6	-	-
N tot.	g/l	0.46	0.43	0.41	0.24	0.22	0.21	0.11	0.10	0.11
N amm.	g/l	0.40	0.32	0.31	0.18	0.12	0.11	0.07	0.08	0.06
P_2O_5 total	mg/l	114	110	91	91	90	21	59	60	7
K.	mg/l	2790	2700	2430	1412	1391	456	783	752	37
Ca	mg/l	958	960	9302	356	374	336	218	210	23
Mg	mg/l	191	185	165	83	86	58	48	47	5
Fe	mg/l	0.8	1.3	1.6	0.5	0.7	0.2	0.4	0.4	0.8

Table 9. Properties of farm compost dilutions

		FC 5 I	FC 5 II	FC5 III	FC10 I	FC10 II	FC10 III	FC20 I	FC20 II	FC20 III
pH		5.99	5.9	5.6	5.7	5.7	5.7	5.8	5.8	5.9
EC 25ºC	dS/m	9.01	7.8	9.2	5.9	6.2	5.9	3.8	4.2	4.1
DOC	g/l	9.3	-	-	3.0	-	-	0.6	-	-
N tot.	g/l	0.86	0.94	1.0	0.46	0.45	0.48	0.25	0.28	0.3
N amm.	g/l	0.51	0.45	0.51	0.29	0.19	0.18	0.16	0.16	0.14
P_2O_5 total	mg/l	229	220	216	101	104	100	76	71	73
K.	mg/l	458	440	367	233	229	175	116	118	123
Ca	mg/l	2437	2390	1990	1525	1508	1062	608	690	692
Mg	mg/l	234	230	216	139	138	115	75	75	72
Fe	mg/l	158	150	123	83	79	60	33	32	37

2.1.3.1. pH and EC

Extracts pH was measured in the filtered solutions using a glass electrode pH – meter (Rhoades et al., 1982).
Total soluble salts in the water extracts were measured using electrical conductivity meter to obtain EC values in dS/m at 25^oC.

2.1.3.2. Total nitrogen

The total nitrogen content in the digested extracts samples, using H_2SO_4 and $HClO_4$, was determined by the standard semi micro-Kjeldahl procedure (Jackson, 1967).

2.1.3.3 Total phosphorus

Phosphorus content of the digested extracts samples, using H_2SO_4 and $HClO_4$, was determined colorimetrically by the spectrophotometer using stannous chloride method, as described by Jackson (1958).

Figure 9: Extraction containers and its components

2.2. Field experiment

2.2.1 Layout of the experiment

A field experiment was carried out in a farm with clay soil at the Mediterranean Agronomic Institute of Bari (I.A.M.B). This farm is located in the Apulian region in the south of Italy, characterized by Mediterranean climate. On March 28, 2003, a trial was conducted to evaluate the effect of the water extracts from two different compost (obtained from the first experiment) on the growth of a Holland variety of potato crop (cv. draga) and on soil fertility.

According to some preliminary results from pot experiments, the most suitable number of applications, frequencies and dilutions of the extracts were used in the open field trial.

Representative soil samples were collected from the experimental area selecting at depth (0-30 cm,) in each plot. Soil samples were prepared for physical and chemical analysis as shown in (Table 10) representative water sample was taken from the main source of irrigation water and chemically analyzed to evaluate the suitability for potato irrigation according to US salinity laboratory classification (U.S.S.L 1954) (Table 11).

Table 10. Chemical and physical characteristics of the soil in open field treatment

Soil depth (Cm)	CaCO3		O.M	Gravels		Sand		Silt	Clay	Texture	
	%										
00-30	2.8		1.6	8.5		26.7		28.4	44.9	Clay	
Soil depth (Cm)	pH in H_2O	pH in KCl	EC dS/m	C org %	N tot mg/Kg	C/N	P_2O_5 ass.	Na	K	Ca	Mg
							mg/kg				
00-30	8.0	7.2	0.17	0.93	1.2	7.8	73	67.2	315	6200	186

Table 11. Water chemical analysis for extraction and open field experiments.

pH	EC dS/m	P	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	CO_3^{--}	SO_4^{--}	SAR
		meq/l									
7.44	1.1	-	2.0	0.26	5.4	2.75	3.7	6.0	-	2	0.99

2.3. Soil and water chemical analysis

2.3.1. Soil analysis

The mechanical analysis for textural distribution was carried out by the hydrometer method using sodium hexametaphosphate as a dispersing agent using the method described by Champon and Pratt (1961). Soil pH was determined in 1:2.5 soil water (weight/volume) suspensions, using a glass electrode pH – meter (Rhoades, 1982). Soil organic matter content was analyzed by means of the Walkley and Black method (Jakson 1967). The total soluble salts were estimated in the soil saturation extract and cations were measured as follows:

1. Carbonates and bicarbonates were estimated volumetrically by titration using a standard solution of sulphuric acid and phenol phethaline and methyl orange were used as indicators.

2.Chloride was determined with silver nitrate according to U.S.S.L. (1954).

3.Calcium and magnesium were estimated by titration with Versenate method, using ammonium purporate as an indicator for calcium and eriochrome black T as an indicator for calcium and magnesium according to U.S.S.L. (1954).

4.Sodium and potassium was determined using flame photometer according to Black et. al. (1982).

5.Sulfate was estimated by difference between total cations and total anions.

Available phosphorus was determined by shaking 5 g of soil with 100 ml of $NaHCO_3$ 0.5 M for 1 hour; pH was adjusted to 8.5. Phosphorus was determined in 10 ml of the filtered extract colorimetrically by spectrophotometer using the stannous chloride method described by Jackson (1958).
Available N was determined by shaking 10 g of soil with 100 ml of K_2SO_4 for one hour. An aliquot of 50 ml of the filtered extract was subjected to steam distillation with MgO and Devarda alloy to determine N according to the procedure described by Keeny and Nelson (1982).

2.3.2. Irrigation water analysis

The irrigation water was chemically analyzed for its total soluble salts, soluble anions and cations following the same procedures used for the soil analysis.

2.3.3. Experimental design and treatments

The experimental area was divided into three blocks. Every block consists of seven plots (six devoted to treatments and one to the control).
The experimental plots (3×3 m) were arranged in the open field according to the randomized block design with three replications and resulting in twenty-one experimental plots (Figure 12). The spacing between the plots is 2m. The experimental area was irrigated with drip irrigation system. The soil was cultivated and prepared for potato tubers planting.
During seedbed preparation, the experimental plots received 200kg of commercial compost. This amendment were distributed and incorporated in the 30 cm surface layer of the soil in amounts according to the nutrient level content in it. This amount was equal as 4 tones of compost applied on one hectar.
The potato seeds (cv. Draga) were planted at a depth of 20 cm and the spacing among seeds was 30 cm in row and between row distance was 60 cm. The aforementioned extracts were applied three times at the experimental field (Figure 10) during the growth season according to the phenological stages.(tuber formation, tuber enlargement, tuber bulking).

Figure 10. Potato experimental field with drip irrigation system

2.3.4.Extracts application

Extracts were applied three times, with distance from ten days between each treatment. Treatments application started at 16 may, with buds appearing what was sign for beginning of tuber formation. At each application, 10 liters of the extract were diluted with water (1:5 ratio) to obtain 50 liters per plot. (6.5 liters/m^2). Last application is done at 12 th Jun.
Treatments were applied as foliar spray using backpack sprayer that was rinsed thoroughly with water before and after each type of extract (Figure11). Normal irrigation was carried using drip irrigation system (Figure 10).

Figure11. Backpack sprayer

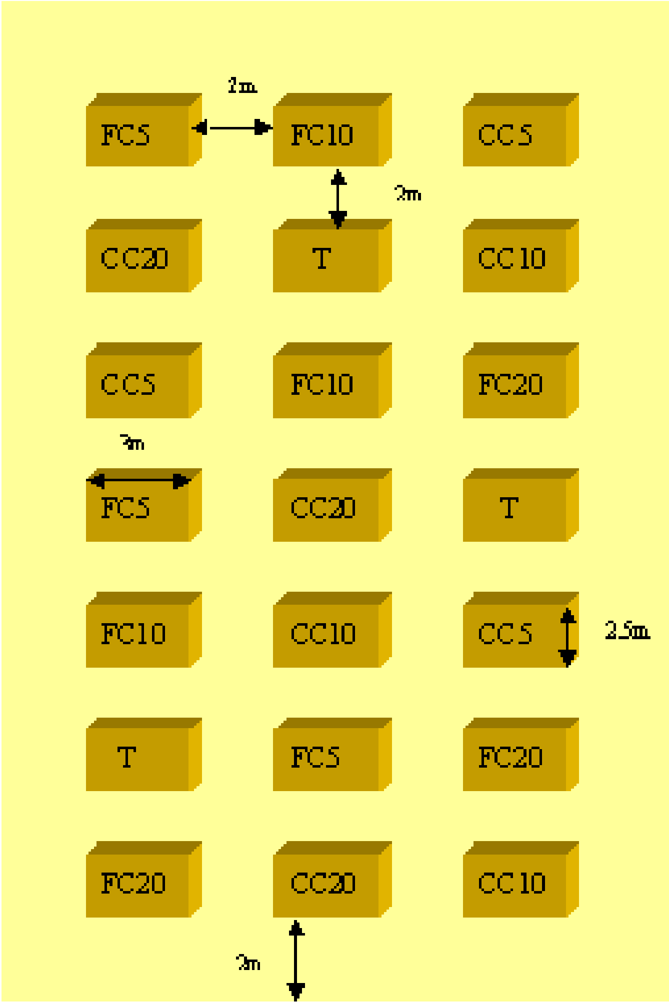

Figure 12. Experimental field design

3.1. Potato plant analysis

3.1.1 Morfological characters

Representative plant (Twelve) samples were taken from each treatment for measuring the agronomic parameters for potato crop at 84day after plantation.
After collecting plant samples, they were divided into their components of leaves, stems. Fresh weight was recorded for each plant part. The plant parts were then oven dried at 70° C until constant weight and the dry weight (g) of each component was recorded afterwards.
The height (cm) of representative plants per treatment was measured after roughly 90 day in order to follow plant development. Plant height (cm) was measured from soil surface to top of the canopy.
Leaf area surface (cm^2/plant) was measured by using Licor-3100 area meter.

3.1.2.Yield quantity

At 90 days from planting, the plants were harvested. The tubers were collected, the number of tubers for each treatment and replicate was counted, and the crop yield was weighted (g/plant) and recorded. The average weight of tuber per treatment and the average dry weight, as an indication of moisture content (%), were calculated.

All the data were analyzed using the General Linear Models Procedure (SAS Institute, Inc. 2001). Mean separations among lines were accomplished using the Duncan Multiple Range Test.

4.1. Phytotoxicity test

Viability test -Tetrazolium

Prior to the phytotoxicity test, viability test with wheat-*Triticum durum* were performed to show the viability of the seeds.

The Tetrazolium Test (TZ Test) is a rapid means of determining the potential germination of a seed sample. It is particularly useful in evaluating dormant seed at harvest and seed prior to dressing and the application of appropriate chemical seed treatments.
The TZ Test is based on the principle that all living tissue contains active dehydrogenase enzymes that catalyse chemical reductions. In the presence of dehydrogenase enzymes the colorless tetrazolium salt is transformed into the red non-diffusible dye formazan.

Seeds are first be conditioned by providing water for imbibitions. This enlarges tissue, activates enzyme systems, and allows clean cutting and uniform absorption of TZ. Seeds are prepared for absorption of tetrazolium by methods appropriate for the kind involved. Cereals and large-seeded grasses are cut longitudinally through the centre of the embryo to expose embryo leaves and root nodes. Fine-seeded grasses should be punctured or cut crosswise immediately behind the scutellum. Seeds of legumes and other crops, which absorb tetrazolium through
their seed coats, are stained after imbibition without physical alteration.

It is a relatively straightforward test and the means of evaluation are reasonably simple.

Live tissue + Colourless Tetrazolium → Red Stained Tissue

Deteriorated tissue + Colourless Tetrazolium → Deep or mottledStaining withflaccid texture

Dead tissue + Colourless Tetrazolium → Unstained Tissue

Figure: 13. Treatment with tetrazolium applied on *Triticum durum* seeds

The effects of compost water extracts were evaluated in phytotoxicity test that was conducted in labaratory.
The plant specie that were used: Durum wheat-*Triticum durum*

This plant is on the list of plant species recommended by the Food and drug organization(FDA), and Organization for cooperation and development (OECB).
The test was conducted using 100mm disposable petri dishes and whatman#1 filter paper. For each treatment 60 seeds were used.

Seeds were employed and placed uniformly on the surface of the filter paper at the bottom of each dish, which contained 5ml of diluted compost extracts. Each extract (six previously obtained from composts in ratios 1:5,1:10,1:20) was diluted with deionized water in ratio 1:5. For the control test deionized water is used. (**Wang, 1991**)

Six replications were set for each concentration, including control test; in every dishes 10 seeds were placed.

All dishes were incubated in a temperature constant incubation chamber at 20±1C°, for five days. The phytotoxicity tests were performed under the same conditions as the control test.

After five days of incubation in dark seed germination, root-elongation and germination-index (G1, a factor of relative seed germination and relative root elongation) were determined (Table 12).

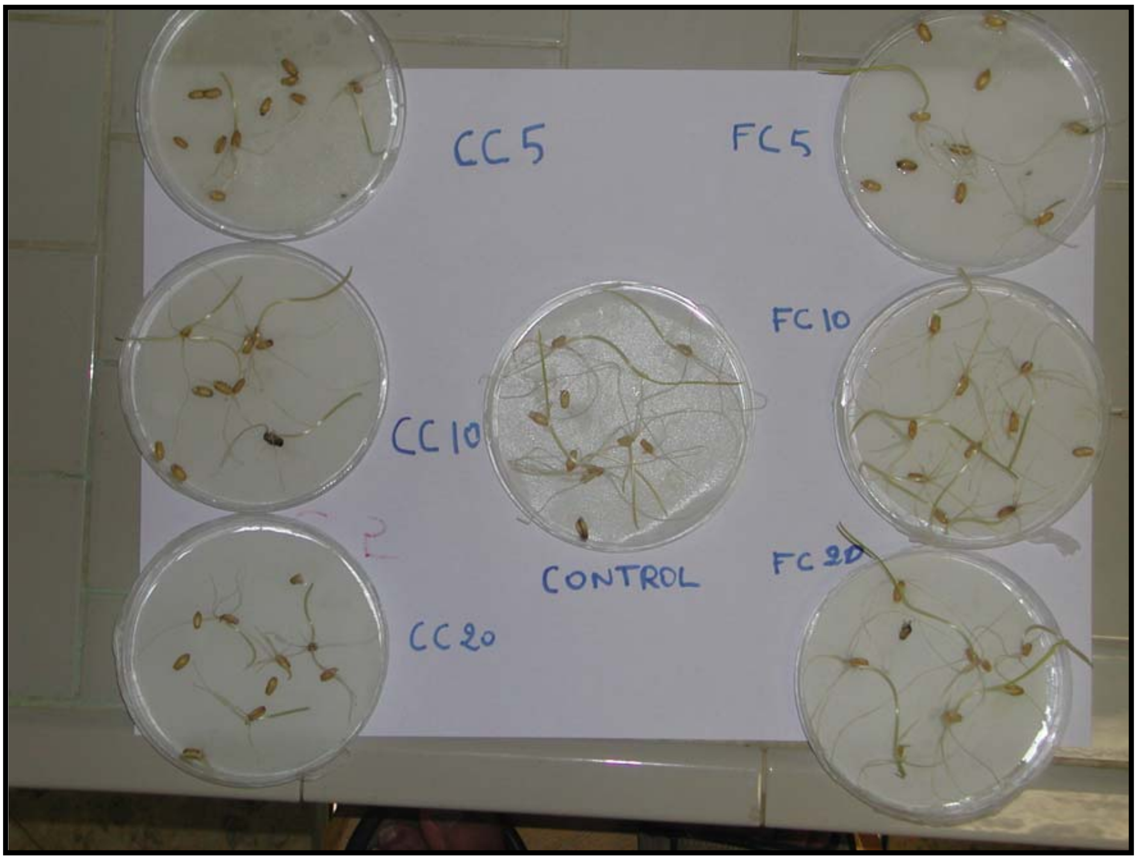

Figure: 14. Phytotoxcicity seeds germinated in petrie dishes.

Table 12. Seed germination test condition

1.Test species	*Triticum durum*
2.Test type	Static
3.Temperature	20±1° C
4.Light	None
5.Test vessel	Petri dishes
6.Test volume	5ml/ dish
7.Number of seeds	420
8.Replicates	6 + Test
9.Control	Distilled water
10.Test duration	5 days
11.End point	Seed germination (root 5mm or more)
12.Acceptance	80% and more

Relative seed germination (%)

$$\frac{\text{No. of seeds germinated in compost water extracts}}{\text{No. of seeds germinated in control}} \text{ x } 100$$

Relative root growth

$$\frac{\text{Mean root length in compost extract}}{\text{Mean root length in control}} \times 100$$

Germination index

$$GI = \frac{(\text{\% of germination}) \text{ x } (\text{\% of root growth})}{100}$$

Root length-Length from the tip of the root to the radicle

Seed germination-Root length of 5mm or more

Acceptable *GI* value-80% and more

Chapter 3.

Objectives

This work is the ideal continuation of the research program started by Mr. Ahmed El Nagger for his Master thesis at the Mediterranean Agronomy Institute. The reason for the development of the study resides in the need of confirming and/or correcting previous conclusions.

The main conceptual idea of the research plan is to study the influence of compost water extracts on a number of different soil, plant and crop properties.
In order to achieve these goals a study on the effect of compost water extracts onto potato plants has been performed in the laboratory and in the open field.
The experimental protocol of the work is focused to four main objectives:

1. the effect of compost extracts to seed germination and plant growth processes (*phytotoxicity tests* in laboratory on wheat seeds);
2. the (*extraction experiment*);
3. the influence of these different solutions on crop agronomic parameters (yield, n. of tubers per plant, etc.) (*open field experiment*); and
4. the effect of the different solutions onto soil main chemical parameters (*soil analysis*).

The experimental protocol has ben very difficult to be performed because of a number of inconveniences of different kind: climatic, pathological, agronomical. I have noticed some controvercies for some data but the overall results confirm the need of additional studies in the field and especially for the testing of various compost type and quality but also for the micro nutritional capability of the extracts.

Chapter 4.

Results and Discussion

4.1. Phytotoxicity tests.

The aim of this experiment was to test the influence of the two compost extracts (two different origin), diluted to 1:5, 1.10 and 1.20 ratios, on the germination activity of wheat seeds. The information available to date about this topic is rather poor and confused and additional experiments are needed in this field.

The results show clearly that both compost extracts produced a decrease in seed germinability with respect to the control. This effect is observed in all cases with the exception of solutions CC10 and CC20 (n. of germinated seeds and relative germination %, Table 13 and 14 - Figure 15 and 16). At the same time, it very interesting to note that the dilution factor is directly related to number of germinated seeds. In other words, concentrated extracts seriously affect germinability of wheat seeds.

Similar results are observed when examining the relative root growth (%) (Table 15 and Figure 17) where it clearly appears that the dilution of the extracts produces an increase in the average growth of the root.

Results are confirmed for the germination index where CC10 and CC20 tops roughly 100% of value (Table 16 and Figure 18). In all cases the commercial compost extracts provided better effects than the farm compost ones.

Table 13. Number of germinated seeds in treatments and control

	FC5	FC10	FC20	CC5	CC10	CC20	T
N° of germinat. seeds	17	22	27	29	32	48	39

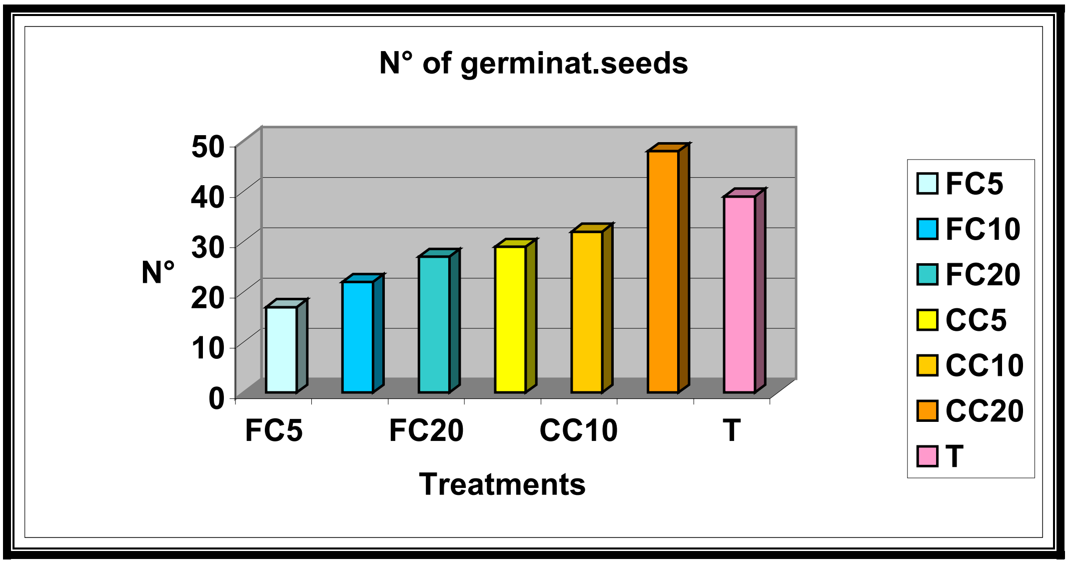

Figure15: Number of germinated seeds

Table 14. Relative seed germination (%)

	FC5	FC10	FC20	CC5	CC10	CC20
Relative seed germin(%)	43.6	56.4	69.2	74.4	82.1	123.1

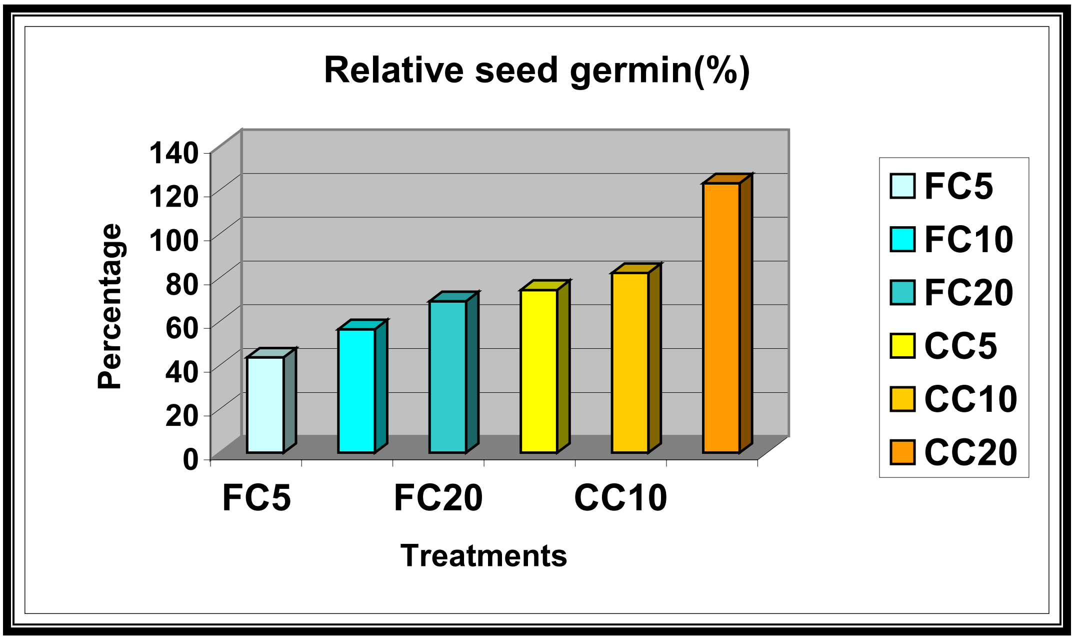

Figure16: Relative germination seed (%)

Table 15. Relative root grow (%)

	FC5	FC10	FC20	CC5	CC10	CC20
Relative root growth (%)	27.81	44.62	59.15	35.70	99.21	85.06

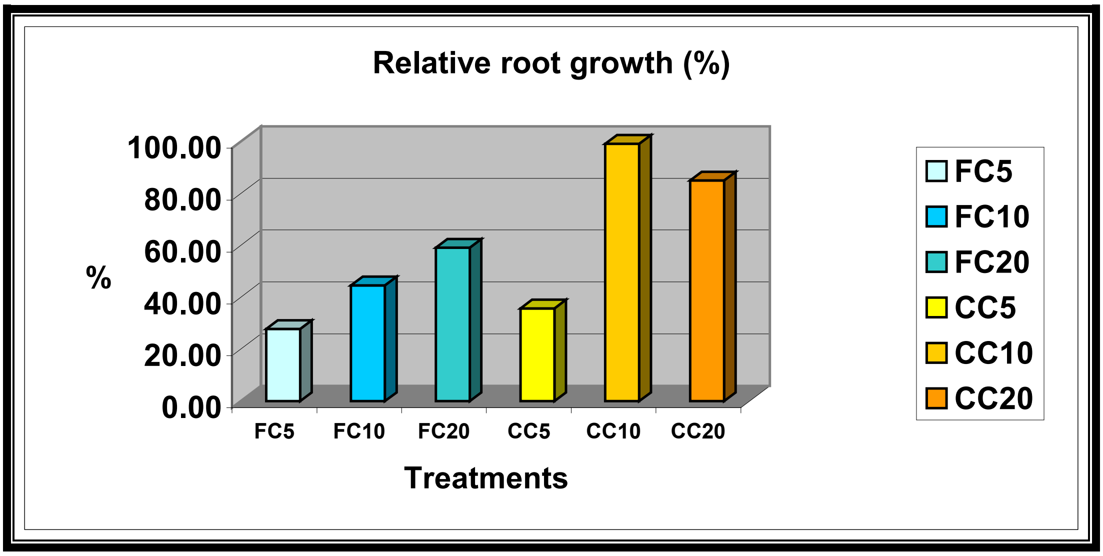

Figure 17: Relative root growth (%)

Table 16: Germination index

	FC5	FC10	FC20	CC5	CC10	CC20
Germination index	12.1	25.2	40.9	26.5	81.45	104.7

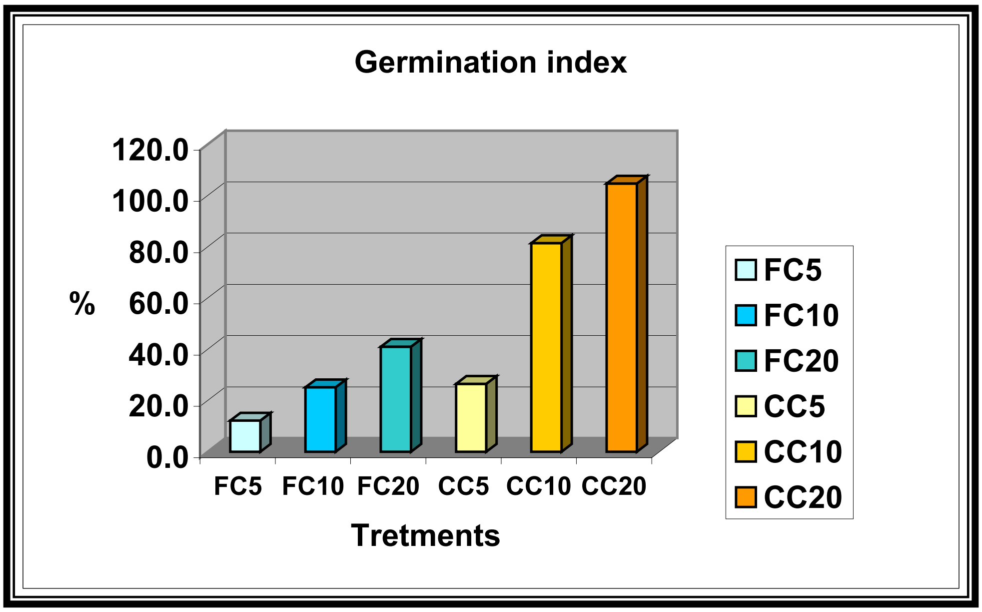

Figure 18. Phytotoxicity expressed throught germination index

4.2. Extraction experiment

There is deficiency of information about the nutritional content of compost and organic extracts ”teas”. It concerns mainly the release rate of nutrients with time and dilution factor and their relative chemical parameters (pH, ECe, etc.).

This experiment was carried out to explore the basic chemical characteristics of the extracts during the extraction process of two selected composts, and successively their effect on plant growth in the open field. Main chemical characteristics of the compost used in the experiment are listed in (Table 17).

Table 17. Compost main chemical parameters.

		FC	CC
Moisture	%	22.2	29.8
pH (1:10)		6.2	7.6
EC (1:10 25°C)	dS/m	4.5	4.3
C org.	%	32.6	37.1
N total	%	2.6	2.8
C/N		12.5	13.2
P_2O_5 total	%	1.95	1.30
K_2O total	g/kg	5.8	21.5
Ca total	g/kg	48.7	34.3
Mg total	g/kg	3.2	2.1
Fe total	g/kg	8.1	1.7

Results listed in (Table 17) clearly demonstrate a close similarity of main chemical parameters between the two compost, which will be possibly reflected into the different extracts. In particular, commercial compost expresses a slightly higher content of organic C and almost four times the amount of total K with respect to the farm compost. At the same time, the farm compost shows a higher content of Ca and roughly four times the total content of iron. Of course, only a minor portion of the total amount of the main chemical element will be released into the different extracts.

The observed differences are dependent both on to the original matrices included in the composting processes and on the different process applied to obtain the final product.

Three different dilution were obtained from each compost and are labeled according the following scheme:

1. Farm compost + water (1:5) (**FC5**)
2. Farm compost + water (1:10) (**FC10**)
3. Farm compost + water (1:20) (**FC20**)
4. Commercial compost + water (1:5) (**CC5**)
5. Commercial compost + water (1:10) (**CC10**)
6. Commercial compost + water (1:20) (**CC20**)

Data related to the different compost extractions are reported in Table 18 and Table 19. It is noteworthy to mention that the data may also reflect the changes of the climatic conditions under which the experiments have been conducted and the time occurred for preparing the extracts.

Most chemical parameters of the compost extracts generally reflect the chemical composition of the starting materials. In facts, FC extracts show in average a lower pH, lower salinity (EC_e, for lower dilutions), and K concentration but a relatively higher N, P, Ca and Mg concentrations than CC extracts.

Iron concentration is two orders of magnitude higher in FC. A particular effect is observed for the dissolved organic Carbon (DOC) which results to be relatively higher in FC than in CC extracts, especially at lower dilution whereas the total concentration in the original compost shows the opposite. With increasing dilution the values tend to match more closely (Tables 18 and 19).

Table 18. Chemical parameters of commercial compost extractions

Commercial compost		CC 5 1° ext.	CC 5 2° ext.	CC 5 3° ext.	CC 10 1° ext.	CC 10 2° ext.	CC 10 3° ext.	CC 20 1° ext.	CC 20 2° ext.	CC 20 3° ext.
pH		7.1	6.7	6.6	6.9	6.9	6.9	7.2	7.0	6.9
EC 25 °C	dS/m	12.4	9.8	9.9	6.0	5.8	5.4	3.6	3.8	3.6
DOC	g/l	3.3	---	---	1.2	---	---	0.6	---	---
N tot.	g/l	0.46	0.43	0.41	0.24	0.22	0.21	0.11	0.10	0.11
N (NH_4^+)	g/l	0.40	0.32	0.31	0.18	0.12	0.11	0.07	0.08	0.06
P_2O_5 total	mg/l	114	110	91	91	90	21	59	60	7
K	mg/l	2790	2700	2430	1412	1391	456	783	752	37
Ca	mg/l	958	960	930	356	374	336	218	210	23
Mg	mg/l	191	185	165	83	86	58	48	47	5
Fe	mg/l	0.8	1.3	1.6	0.5	0.7	0.2	0.4	0.4	0.8

Table 19. Chemical parameters of farm compost extractions

Farm compost		FC 5 1° ext.	FC 5 2° ext.	FC 5 3° ext.	FC 10 1° ext.	FC 10 2° ext.	FC 10 3° ext.	FC 20 1° ext.	FC 20 2° ext.	FC 20 3° ext.
pH		5.99	5.9	5.6	5.7	5.7	5.7	5.8	5.8	5.9
EC 25 °C	dS/m	9.01	7.8	9.2	5.9	6.2	5.9	3.8	4.2	4.1
DOC	g/l	9.3	---	---	3.0	---	---	0.6	---	---
N tot.	g/l	0.86	0.94	1.0	0.46	0.45	0.48	0.25	0.28	0.3
N (NH_4^+)	g/l	0.51	0.45	0.51	0.29	0.19	0.18	0.16	0.16	0.14
P_2O_5 total	mg/l	229	220	216	101	104	100	76	71	73
K	mg/l	458	440	367	233	229	175	116	118	123
Ca	mg/l	2437	2390	1990	1525	1508	1062	608	690	692
Mg	mg/l	234	230	216	139	138	115	75	75	72
Fe	mg/l	158	150	123	83	79	60	33	32	37

In spite of individual and bizarre results observed in Table 18 (CC) and Table 19 (FC), especially for the 3rd extraction, the actual data are rather consistent. The variability among the different extraction replicates is limited whereas the parameters show decreasing values with increasing the dilution ratios of the extracts. The values of pH remain relatively stable across the three dilution steps. In CC samples most of the N occurring in the extract is due to ammonium chemical forms whereas the FC compost shows higher values where the ammonium accounts for as roughly 50% in average.

It is likely that the chemical parameters and the major elements included in the compost teas will markedly affect the agronomic parameters of the potato crop.

4.3. Open field experiment

Field experiment was carried out on potato plant (Cv. Draga) using the extracts obtained from the following treatments:

1. Farm compost + water (1:5) (**FC5**)
2. Farm compost + water (1:10) (**FC10**)
3. Farm compost + water (1:20) (**FC20**)
4. Commercial compost + water (1:5) (**CC5**)
5. Commercial compost + water (1:10) (**CC10**)
6. Commercial compost + water (1:20) (**CC20**)

The extracts were distributed in three different replicates (plots) in the experimental field at the Mediterranean Agronomic Institute in Valenzano according the scheme presented in the Material and Methods section.

With respect to the control (T) only the basic recommended amendment was used in the beginning of plantation. The field experiment was performed to evaluate the influence of the extracts obtained from the mentioned treatments on the following growth parameters of potato plant: plant height, leaf surface, number of stems per plant, stem height, leaves fresh and dry weight, stems fresh and dry weight, yield and number of tubers.

4.3.1. Stem height

The potato stem height (cm) under the influence of the investigated extracts is given in Table 20 and Figure 19.

The maximum values are reached by the application of FC and are in all cases higher than the control and than the CC plots. Highest values are observed in the order: FC10 (37.0) > CC5 (34.0) > FC20 (33.0) > FC5 (32.0). The lowest value of stem height was obtained with the application of CC 20 (27.0).

The observed data demonstrated a noticeable variation in potato plant height due to the variation in nutrients contents in the tested extracts and to the open field parameters.

The lower nitrogen level in CC extracts follows lower stem height with same treatments in comparison with Farm Compost. Exception is results obtained with FC 5 probably because of a slight phytotoxicity effect.

The results are in harmony with those obtained by Nassar (2000) on potato plant and also the findings of Kandil (2001) on faba bean plant, in addition to Abd El-shafy et al (1998) and Sawan et al. (1989) and on foliar spraying of cotton plants and El Naggar(2002) on potato plant.

Table 20. Effect of using different organic extracts on potato stem height (cm)

Treatment	T	CC 5	CC 10	CC 20	FC 5	FC 10	FC 20
stem height (cm)	30.0cd	34.0ab	30.0cd	27.0d	32.0bc	37.0a	33.0bc

Means followed by the same letter are significantly different at P ≤ 0.05 (Duncan Test)

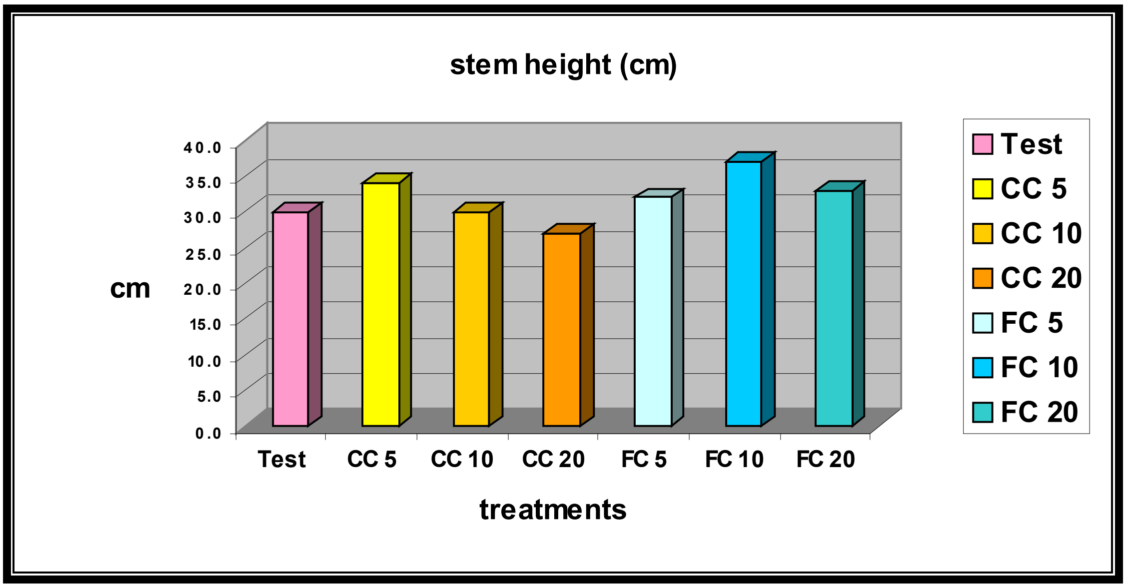

Figure 19. Effect of applying different compost extracts on potato plant height

4.3.2 Leaf surface

Data presented in Table 21 and Figure 20 shows the leaf area surface (cm^2/plant) for the potato plant treated with the tested extracts.

The leaf area surface were 2167, 2009, 1941, 1699, 1451, 1091 cm^2/plant as mean values of 3 replicates per plot fertigated with CC10, CC5, FC20, FC10, FC5, CC20, respectively, whereas leaf area surface of plants grown in the control plot was approximately 1250 cm^2/plant.

Generally speaking, results indicate a large variability of the effects of extract applications. The tested extracts varied in their function on potato plant and the variation in leaf area could be attributed to the variation in the nutrients content of the investigated extracts.

In particular, commercial compost extracts showed a higher influence on leaves development (more evident for lower dilutions) than the farm compost solutions. The leaf surface parameter was directly related to the dilution ratio but in opposite ways for the two types of extract.

On the other hand FC 20, very similar in nitrogen level with CC10, which provided best results, was the best between farm compost treatments. The lowest leaf surface with FC 5 treatment is probably due to phytotoxic effects. The optimum nitrogen levels in dilutions were from 0.23g/ to 0.46g/l.

These results are in harmony with those reported by Nassar (2000) on using different nitrogen rates and fertigation system in growing potato plant. Also the results are in agreement with findings of Mohamed and Helal (1999) on using foliar spraying with some chelated microelements (Fe, Mn and Zn) added individually or in combination. Their investigation revealed an increase in leaf area/plant in addition to a marked improvement in the treated broad bean plants.

Table 21. Effect of using different extracts on potato plant leaf area surface (cm^2/plant)

Parameter	**Test**	**CC 5**	**CC 10**	**CC 20**	**FC 5**	**FC 10**	**FC 20**
Leaf surface (cm^2)	**1,250**DE	**2,009**AB	**2,167**A	**1,091**E	**1,451**CD	**1,699**C	**1,941**B

Means followed by the same letter are significantly different at P ≤ 0.01 (Duncan Test)

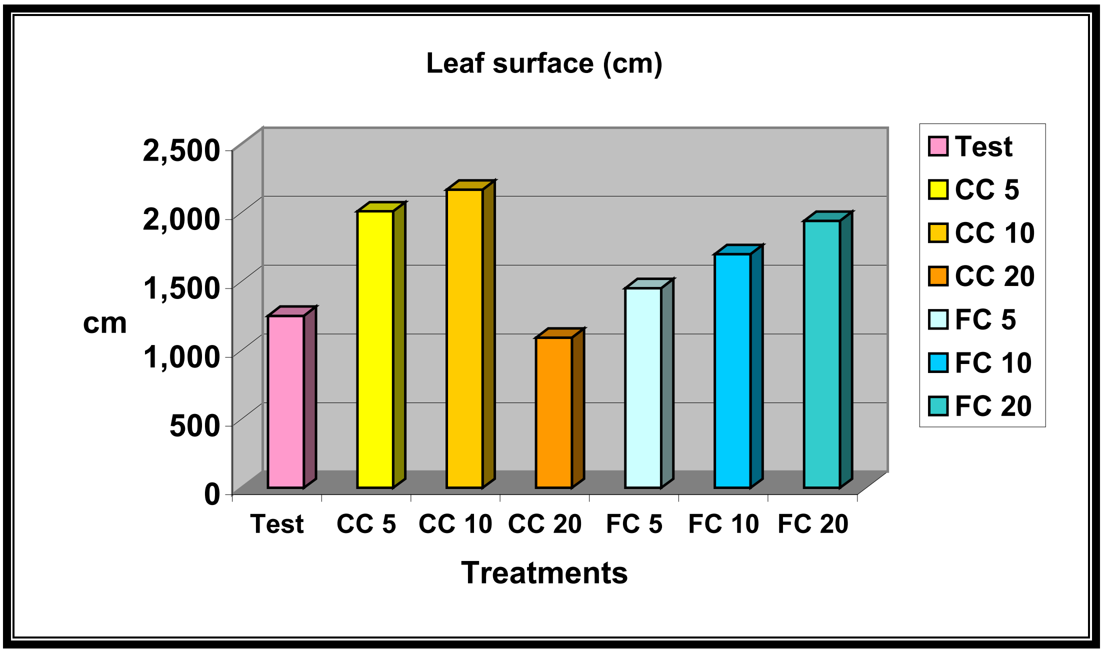

Figure 20. Effect of using different extracts on potato plant leaf area surface (cm^2/plant)

4.3.3 Stems number

The number of stems of potato plant treated with the investigated extracts is given in Table 22 and Figures 21.

In general, the recorded data show a significant increase in stems number obtained with all tested extracts in comparison with the control treatment. The numbers of stems per potato plant were 2.9, 2.7, 2.6, 2.4 and 2.2 with the extracts of FC10-CC5, FC5, CC10, FC20 and CC20 respectively, whereas the stems number was 2.2 for the control treatment after roughly 90 days from plantation.

In particular, it is important to note that the number of stems decreased with increase of dilution in CC extracts whereas the results were less correlated for FC solutions.

The observed data revealed that the tested extracts produced different values for numbers of potato stems due to the variation in nutrients contents of the investigated extracts. These results are in agreement with those observed by Biemond and Yos (1992), Nassar (2000) and Kandil (2001) and El Naggar (2002).

Table 22. Effect of using different extracts on number of potato stems per plant

Parameter	Test	CC5	CC10	CC20	FC5	FC10	FC20
stems/plant (n)	**2.2**d	**2.9**a	**2.6**bc	**2.2**d	**2.7**ab	**2.9**a	**2.4**cd

Means followed by the same letter are significantly different at P ≤ 0.05 (Duncan Test)

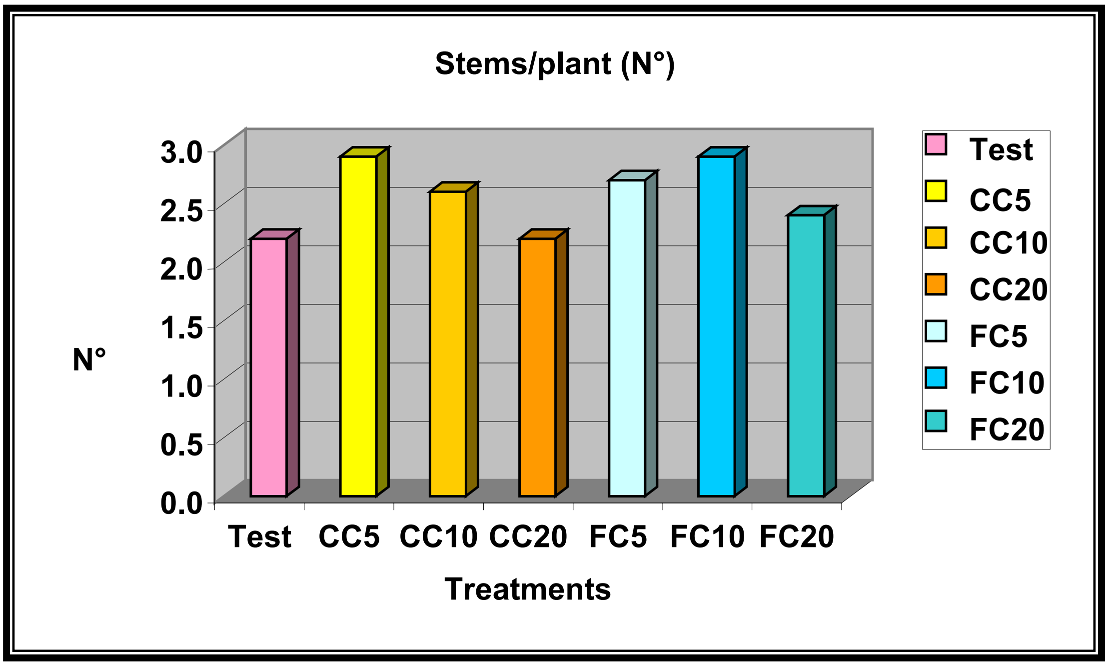

Figure21. Effect of using different extracts on number of potato stems per plant

4.3.4 Fresh, dry weight and water content of different plant parts

Data presented in Table 23 and Figures 22, 23, 24 and 25 show the influence of the extracts obtained from the different extraction experiments on the potato leaves fresh and dry weight (g/plant) and water content (%).

Potato leaves

Results revealed significant increases in fresh and dry weight of the potato leaves for all treatments in comparison with the control treatments, except for the treatment CC20 that is not significantly different, due to low nutrient value (1:20=2.5 kg of compost in 50 l of water).

Leaves fresh weight (g/plant) reached 107.6, 106.6, 104.3, 92.1, 92, 77.5 g/plant after the application of the extracts FC20, CC10, FC10, CC5, FC5, and CC20, respectively, roughly 90 days from plantation. The control plot showed an average value of 78.9 g/plant. Approximately the same trends were observed for potato leaves dry weights.

Results indicate that in all CC extracts the fresh and dry weight of potato leaves decreases according to the increase of dilution, that is the decrease of nutrient content of the investigated extracts. In other terms, it appears that the increasing of the dilution enhances leaves water content (as shown in Table 23 and Figure 22. The trend in all FC extracts does not appear to be regular.

Nassar (2000) reported that dry weight of potato leaves varied according to the variation in the nitrogen rates using fertigation system. Also, Mohamed and Helal (1999) revealed an increase in both fresh and dry weight of broad beans plant leaves when using foliar spraying with some chelated micro elements (Fe, Mn and Zn).

Table 23. Effects of different extracts on the potato leaves weight (g) and leaves water content (%)

Parameter	Test	CC 5	CC 10	CC 20	FC 5	FC 10	FC 20
Leaves fresh weight (g/p)	**78.9**C	**92.1**B	**106.6**A	**77.5**C	**92.0**B	**104.3**AB	**107.6**A
Leaves dry weight. (g/p)	**16.0**c	**18.6**bc	**22.8**a	**17.6**bc	**17.9**bc	**20.5**ab	**19.5**ab
Leaves dry weight (%)	***21.4***ab	***20.2***b	***21.0***ab	***22.7***a	**17.9**c	***19.9***b	***19.2***bc
Leaves water (%)	***78.6***	**79.8**	**79.0**	**76.0**	**82.1**	***80.1***	***80.8***

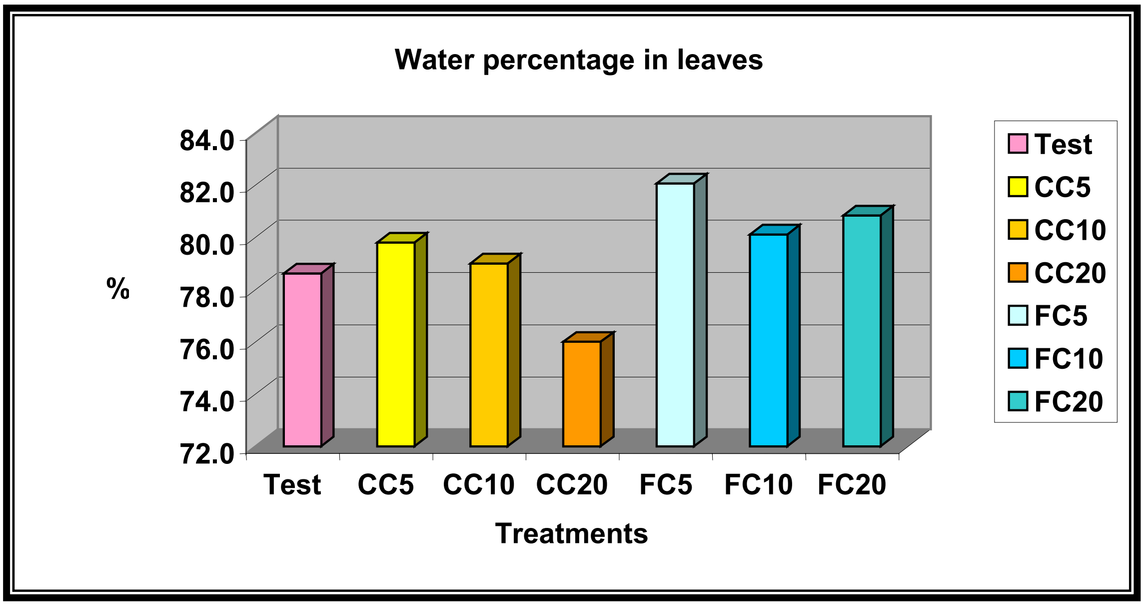

Figure 22. Effect of different extracts on water content (%) of potato leaves

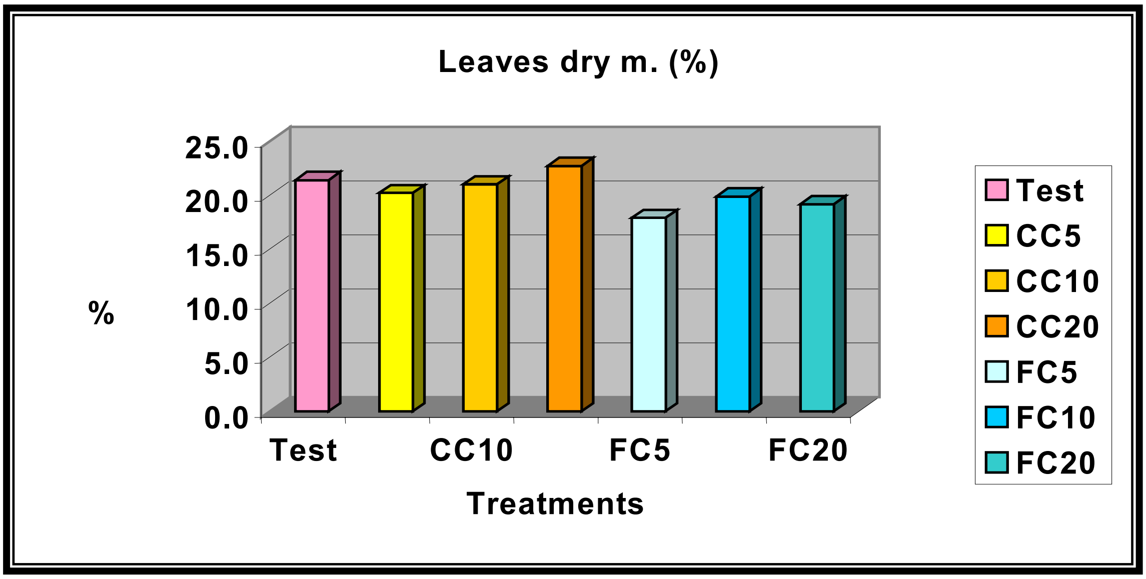

Figure 23. Effect of different extracts on potato leaves dry matter (D.M. %)

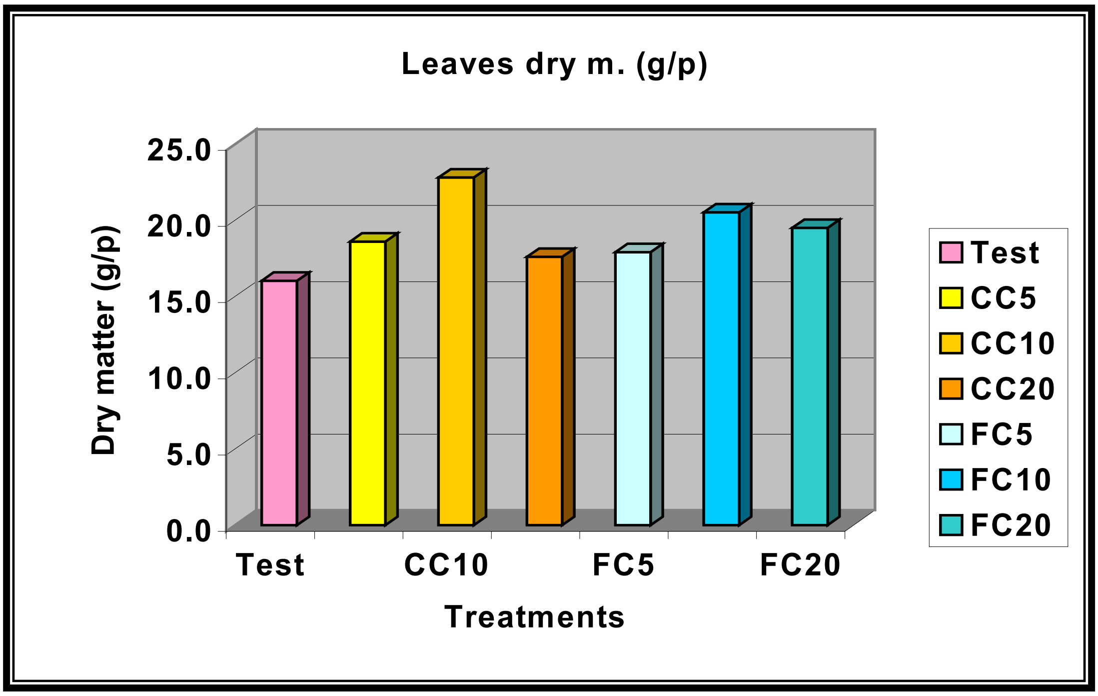

Figure 24. Effect of different extracts on dry weight of potato leaves

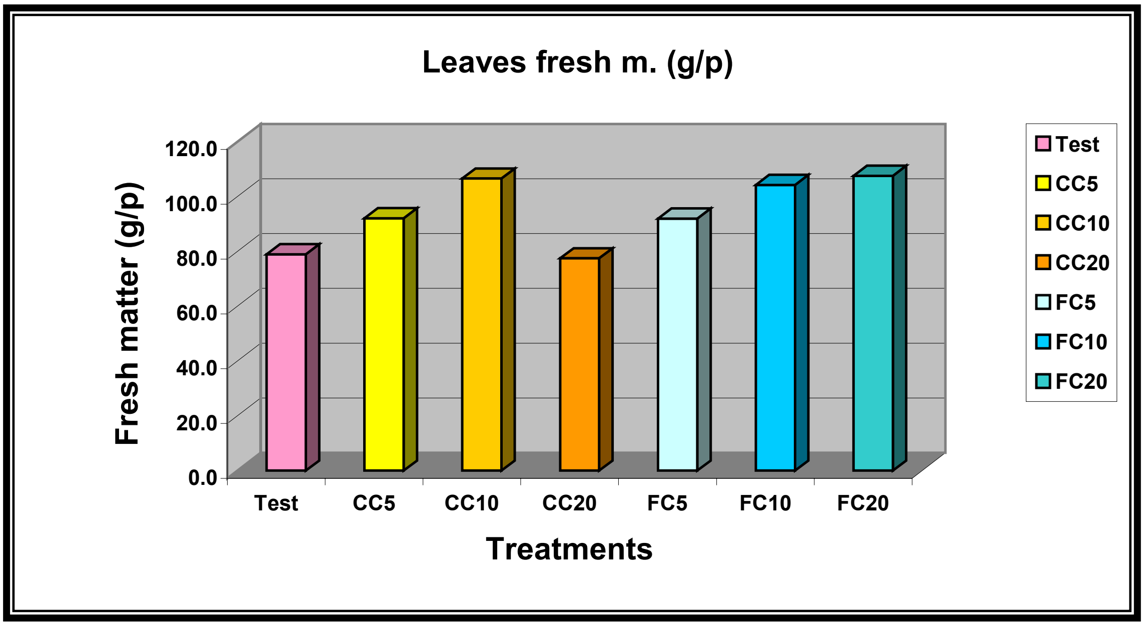

Figure 25. Effect of different extracts on fresh weight of potato leaves (g)

Potato stems

Fresh weight, dry weight and water contents of potato stems for the different extracts are given in Table 24 and Figures 26, 27, 28 and 29. The application of FC extracts led to a significant positive effect on stem fresh and dry weights in comparison with the control even though the extract FC10 produced the best result for the fresh weight and FC5 for the dry weight (see Table 24 and Figure 27) after roughly 90 days from plantation with respect to 42.2 g/plant of the control. CC extracts produces more irregular results showing in addition the lowest values for dry and fresh weight with extract CC10.

Table 24. Effects of different extracts on the potato stems fresh and dry matter

Parameter	Test	CC5	CC10	CC20	FC5	FC10	FC20
stem fresh m. (g/p)	42.2CD	44.2C	39.2D	45.3C	56.0B	63.8A	54.9B
dry m. (g/p)	5.4CD	7.0BC	4.5D	9.4AB	11.0A	9.6A	6.3C
dry m. (%)	12.8C	15.8B	11.5C	20.7A	19.6A	15.0B	11.5C
water (%)	87.1	84.4	88.4	79.4	80.6	85.0	88.3

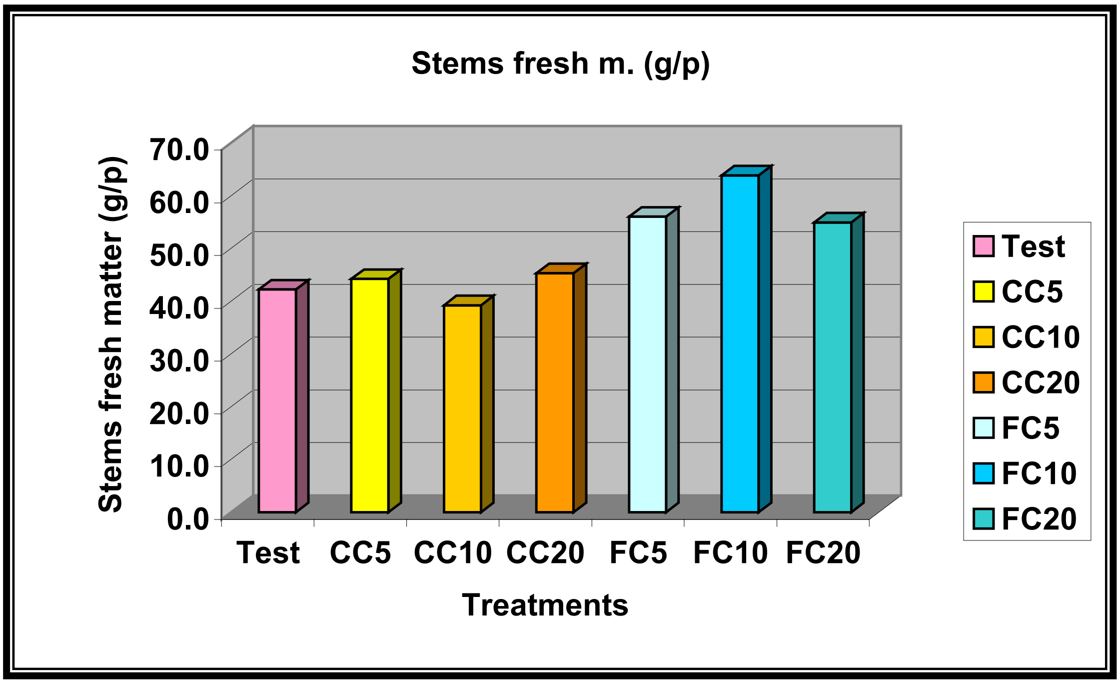

Figure 26. Effect of different extracts on fresh weight of potato stems

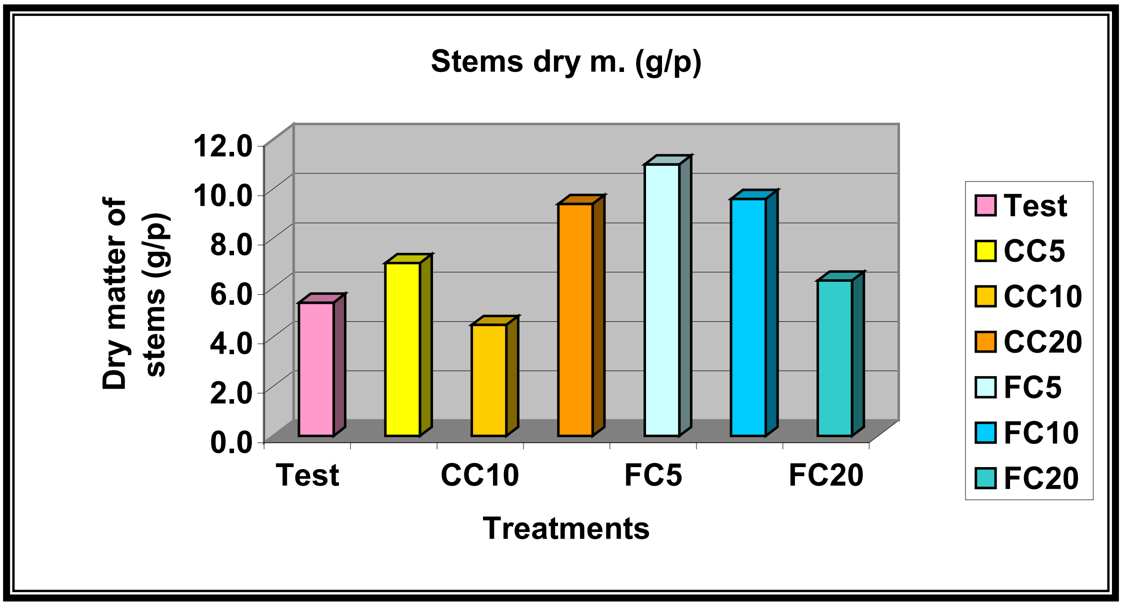

Figure 27. Effect of different extracts on dry weight of potato stems (g)

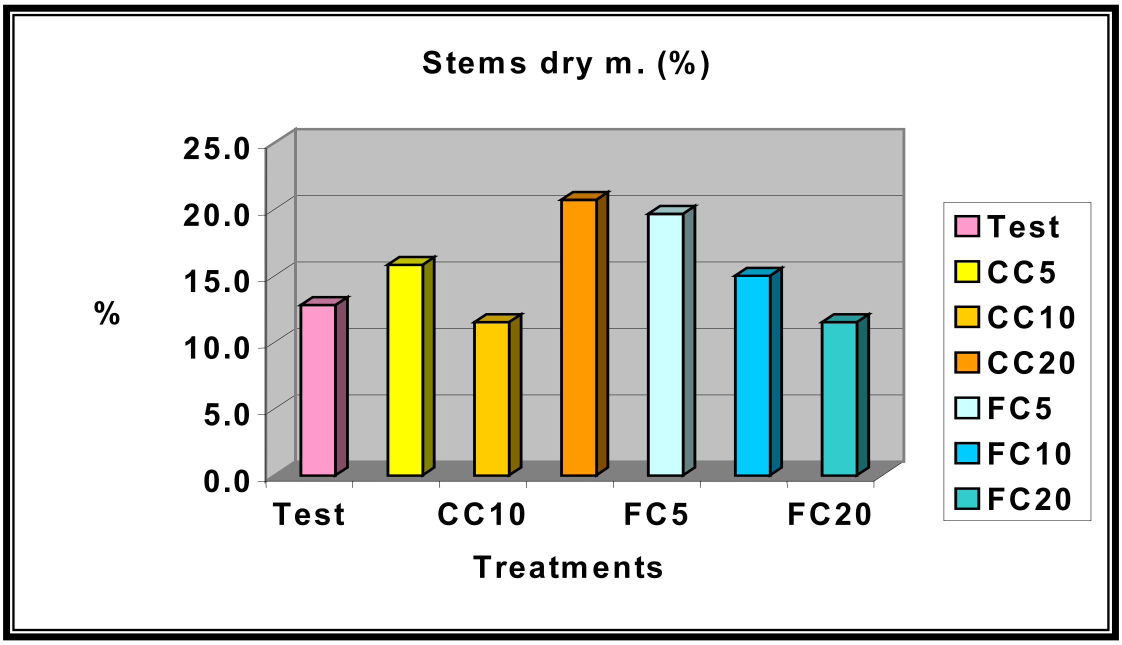

Figure 28. Effect of different extracts on potato stems dry matter (D.M. %)

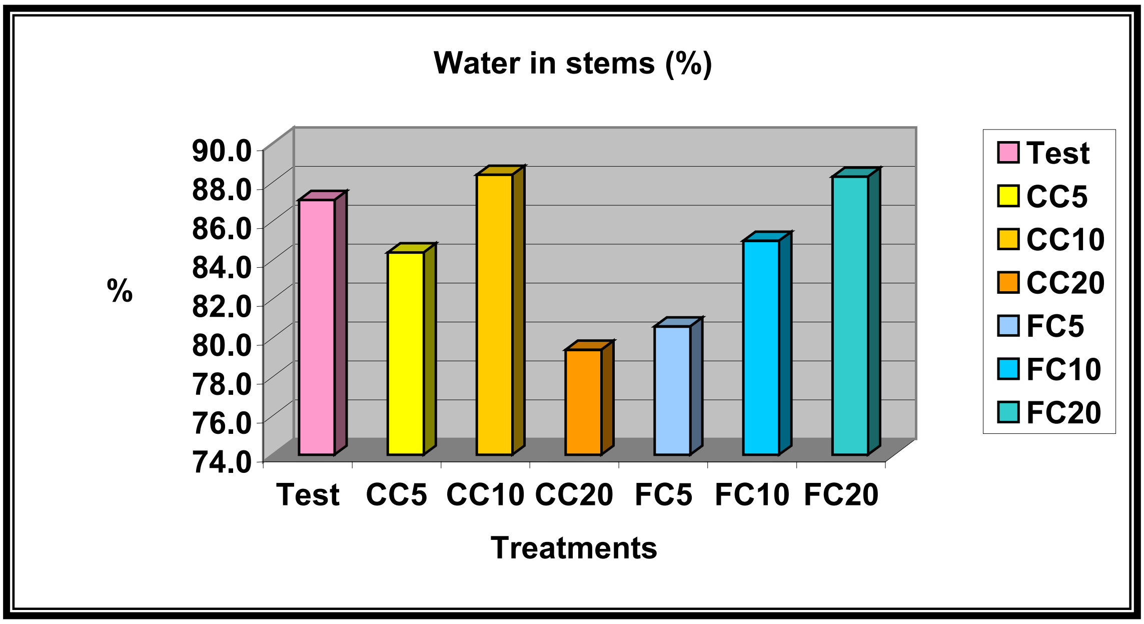

Figure 29. Effect of different extracts on water content (%) of potato stems

4.3.5 Potato yield

Potato harvesting was carried out after approximately 90 days from plantation. Each experimental plot was harvested individually. The potato crop yield obtained from the different extracts under investigation was evaluated through some parameter calculations.

The tuber weight (g/tuber), the number of tubers per plant (tubers/plant), the plant production (tuber g/plant) and the average yield (t/ha) were recorded and calculated on the basis of three replicates for each plot.

The data reported in Table 25 refer to the yield/plant (g), the number of tuber per plant, the tuber mean weight (g) and the total yield expressed per hectare (t/ha).

In general, the extracts application show a sort of depressing activity with respect to the control plot where only water was applied. This result clearly combines with the effect of dilution of the solutions. In facts, the yield/plant values increase with increasing dilutions. In other terms, the more diluted is the extract, the higher is the yield both for FC and CC compost water extracts (Figure 30). The lowest value of yield per plant is observed for the extract CC5.

The number of tubers per plant (Table 25) is not significantly different among the various extracts and the control plot, with the only exception of CC5, which produced the highest number (7.0) (Figure 31).

On the opposite, CC5 extract showed the lowest tuber mean weight value (Figure 32 and Table 25) whereas the rest of the extract did not exhibit any significant variation also with respect to the control. Also, a slight trend can be observed among the extracts in that there is slight direct relationship between increase in dilution and increase in tuber mean weight which ends up to values expressed by FC20 and CC20 very similar to the control one.

A sort of field depressing effect is observed for the tuber weight following the application of the extracts. This phenomenon matches the effect to the seed germination seen in section 5.1. Very diluted solutions approximate the effect of simple water application even though the number of tubers may increase with the application.

The total yield per hectare does not really show major differences except the overall trend already observed in the previous sets of data. A slight increase of yield is observed as the dilution of extracts increases (Figure 33).

Table 25. Effects of different extracts on the potato production

Parameter	Test	CC5	CC10	CC20	FC5	FC10	FC20
Yield/plant (g)	**469.7**	**322.6**	**416.7**	**421.1**	**376.0**	**404.9**	**463.8**
tubers /plant (n)	**6.3**	**7.0**	**6.1**	**6.2**	**6.1**	**6.1**	**6.4**
Tuber mean weight (g)	**74.8**A	**46.1**D	**68.5**AB	**68.0**AB	**61.2**C	**66.3**BC	**72.9**AB
yield/ha (t)	**22.21**A	**18.56**CD	**20.27**BC	**20.32**BC	**16.03**D	**17.44**D	**21.03**AB

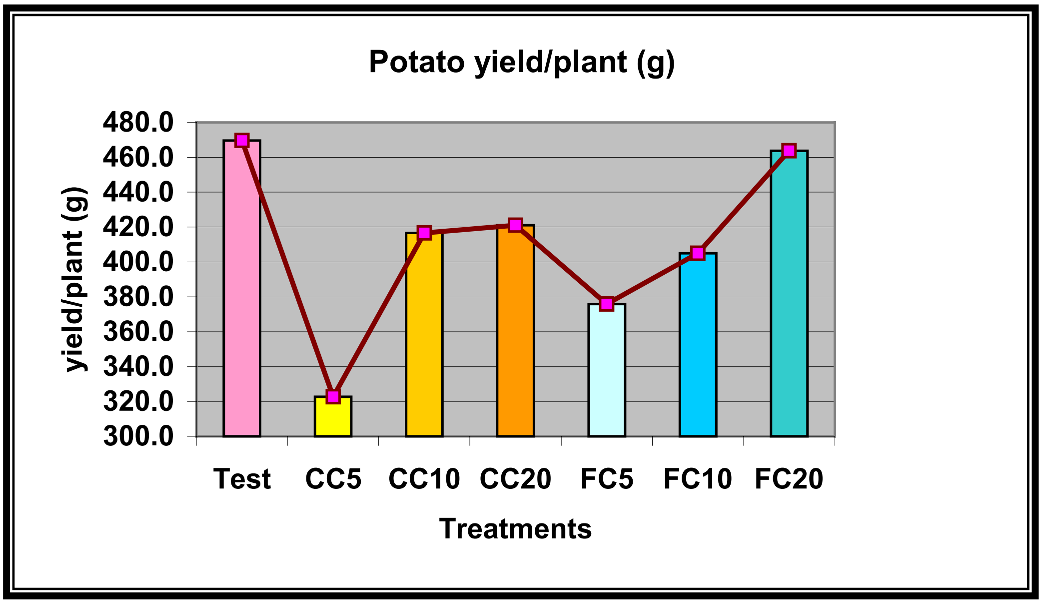

Figure 30. Effect of different extracts on the potato tuber weight (g/tuber)

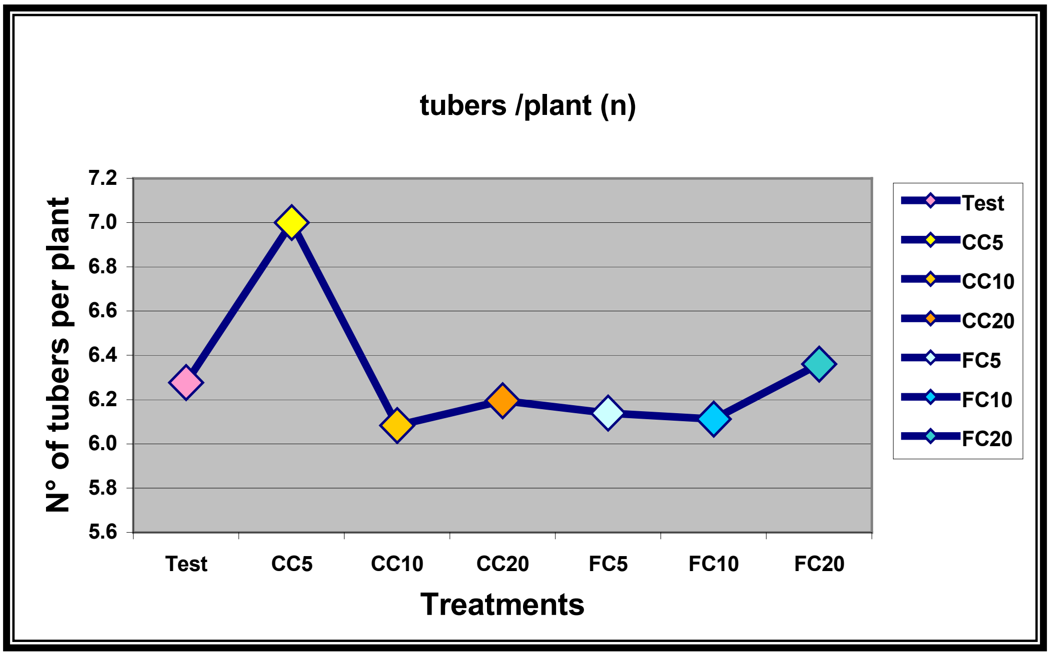

Figure 31. Effect of extracts on the number of tubers per plant

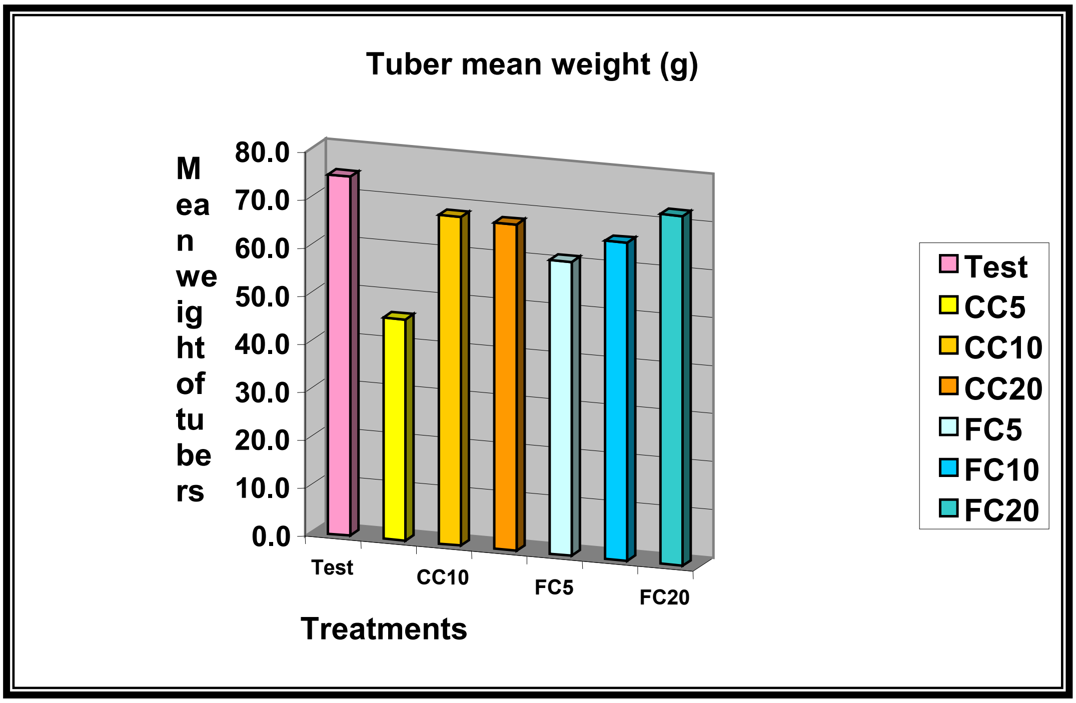

Figure 32. Effect of extracts on the tuber production (g/plant)

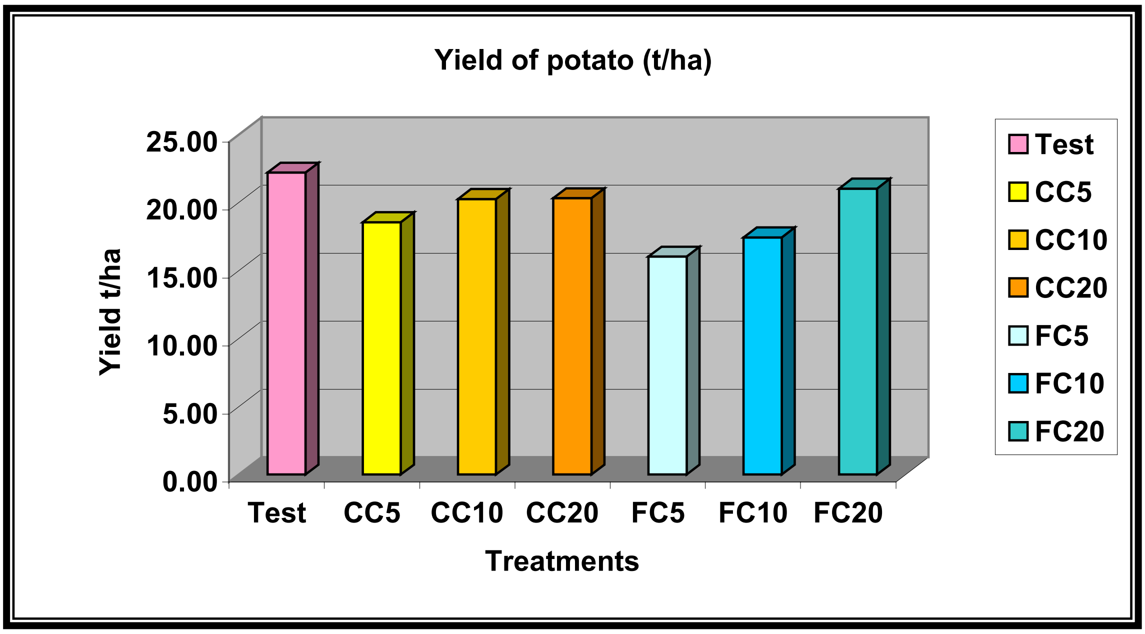

Figure 33. Effect of extracts on the tuber production (t/ha)

4.4. Soil Analysis

In Table 26 main chemical parameters of the soil of the experimental field are reported. The soil present parameters very common in the area of the Institute, showing a clay textural class, a sub-alkaline pH as measured in water, a rather low content in carbonates and a very common content of organic matter for our region (1.6%). The nutritional background shows abundance in Ca content and a relatively high concentration of K ion.

In Table 27 soil data after the harvest and three extract applications are reported as the average values measured out of the three plots. In other words, individual samples from each of the three replicate plots were selected and then mixed to make one analytical homogeneous sample and then soil analysis were performed. Data related to the compost extracts applied to soils are reported in section 5.2.

Gravels	%	8.5	N total	g/kg	1.2
Sand	%	26.7	C/N		7.8
Silt	%	28.4	P_2O_5 av.	mg/kg	73
Clay	%	44.9	Ca	mg/kg	6200
Textural class		A	K	mg/kg	315
pH in H_2O		8.0	Mg	mg/kg	186
pH in KCl		7.2	Na	mg/kg	67
EC (1:2 - 25°C)	dS/m	0.17			
$CaCO_3$ total	%	2.8			
C org	%	0.93			
O.M.	%	1.6			

Table 26. Main soil analysis before experiment (control soil)

Soil main parameters measured on the soils plots are rather similar to the original soil, especially for main parameters. In facts, pH values measured both in water and in KCl are very close to the original soil pH showing only a very light increase mainly visible in the water extract. Soil electrical conductivity also did no change very much with the extract application possibly because it is a parameter strongly affected by climatic conditions. The major changes observed as a function of the applications and affecting somewhat the soil fertility were organic C, K and P content.

The organic C values appear markedly different with the application. In facts, the values were generally higher with respect to control (Table 27). In particular, the organic C was higher in the plots were FC was applied with respect to the CC ones. This difference is more evident for the more concentrated solutions (1:5) possibly due to higher amount of organic extract present in the solutions. The average amount of DOC measured in FC5 extracts was roughly three times higher than CC ones (section 5.2). Exchangeable potassium was higher than the original soil but very close to the control plots after harvest. The values of K did not really show any significative difference according to the extract quality even though the amount of K in CC samples was approximately six times the one in FC ones. Available phosphate appear markedly higher in CC plots with respect to control but lower than FC plots, in which FC5 extract reached the value of 119 mg/kg of soil. Total phosphates in FC extracts are twice higher than CC ones and this is clearly visible in soil plots after harvest. The chemical data of soil plots before and after extract application are just preliminary results which need to be checked more properly and again in the future order to find additional details and explanation of the described phenomena. Adsorption and exchange phenomena, the effect of plant roots and physiological phases, the climatic variations and general parameters all play a paramount role in regulating the chemistry and the biochemistry of soils.

Table 27. Main soil analysis after experiment (averages of three soil plots)

		Control	CC 5	CC 10	CC 20	FC 5	FC 10	FC 20
pH in H_2O		8.2	8.2	8.3	8.3	8.3	8.3	8.4
pH in KCl		7.0	7.0	7.1	7.0	7.0	7.0	7.0
EC (1:2 -25°C)	dS/m	0.17	0.18	0.19	0.18	0.15	0.16	0.17
C org	%	0.85	1.01	0.85	0.85	1.02	0.95	0.89
N total	g/kg	1.15	1.20	1.17	1.17	1.26	1.20	1.15
C/N		7.4	8.4	7.3	7.3	8.1	7.9	7.7
P_2O_5 av.	mg/kg	75	98	96	94	119	102	90
K exchang.	mg/kg	397	408	410	405	405	400	398
Mg exchang.	mg/kg	208	204	188	209	212	200	200

Table 28. Summary of ***ANOVA*** for the studied characters- Significance of treatments and error variance with the respective degrees of freedom

Characters	Treatments	Error
Leaf surface(cm^2)	**	171.873
Stem/plant (N°)	*	0.248
Stem height (cm^2)	*	42.165
Fresh matter (leaves) (g/p)	**	390.672
Dry matter (leaves) (g/p)	*	273.631
Dry matter (%)	*	34.417
Fresh matter (stems) (g/p)	**	52.507
Dry matter (stems) (g/p)	**	14.352
Dry matter (%)	**	10.852
Tubers/plant (N°)	ns	2.296
Tuber mean weight (g)	**	97.668
Tubers yield (t/ha)	**	11.964

ns- non significant; *- significant at .05 P level; **- significant at .01P level

Conclusions

The current study was carried out to investigate the possibility of using compost water extracts as supplementary fertilizers, in addition to their effects on soil fertility and potato growth under organic farming system.

The experiments were conducted in season 2002/2003 on the experimental field and in laboratories that are properties of Mediterranean Institute-Bari.

The first experiment followed compost extract effect on seed germination. The extraction experiment had aim to study different compost to water extraction ratios and their chemical characteristics. The influence of these different solutions on crop agronomic parameters (yield, n. of tubers per plant, etc.) was followed by the field experiment and as the last part soil analysis which aim was to study, the effect of the different solutions onto soil main chemical parameters.

The phytotoxicity test

The results show clearly that both compost extracts produced a decrease in seed germinability with respect to the control. This effect is observed in all cases with the exception of solution CC20 (n. of germinated seeds and relative germination %).

Similar results are observed when examining the relative root growth (%) where it clearly appears that the dilution of the extracts produces an increase in the average growth of the root.

Results are confirmed for the germination index where CC10 and CC20 tops roughly 100% of value. In all cases the commercial compost extracts provided better effects than the farm compost ones

Extraction experiment

Results listed clearly demonstrate a close similarity of main chemical parameters between the two compost, which will be possibly reflected into the different extracts.

In particular, commercial compost expresses a slightly higher content of organic C and almost four times the amount of total K with respect to the farm compost.

At the same time, the farm compost shows a higher content of Ca and roughly four times the total content of iron.

Most chemical parameters of the compost extracts generally reflect the chemical composition of the starting materials.

FC extracts show in average a lower pH, lower salinity (EC_e, for lower dilutions), and K concentration but a relatively higher N, P, Ca and Mg concentrations than CC extracts.

A particular effect is observed for the dissolved organic Carbon (DOC) which results to be relatively higher in FC than in CC extracts, especially at lower dilution whereas the total concentration in the original compost shows the opposite.

In CC samples most of the N occurring in the extract is due to ammonium chemical forms whereas the FC compost shows higher values where the ammonium accounts for as roughly 50% in average.

It is likely that the chemical parameters and the major elements included in the compost teas will markedly affect the agronomic parameters of the potato crop.

The field experiment

Potato plant height

The observed data demonstrated a noticeable variation in potato plant height due to the variation in nutrients contents in the tested extracts and to the open field parameters.

The lower nitrogen level in CC extracts follows lower stem height with same treatments in comparison with Farm Compost.

Exception is results obtained with FC 5 probably because of a slight phytotoxicity effect.

Leaf surface

In particular, commercial compost extracts showed a higher influence on leaves development (more evident for lower dilutions) than the farm compost solutions.

On the other hand FC 20, very similar in nitrogen level with CC10, which provided best results, was the best between farm compost treatments

The lowest leaf surface with FC 5 treatment is probably due to phytotoxic effects.

Stems number

In general, the recorded data show a significant increase in stems number obtained with all tested extracts in comparison with the control treatment.

The numbers of stems per potato plant were 2.9, 2.7, 2.6, 2.4 and 2.2 with the extracts of FC10-CC5, FC5, CC10, FC20 and CC20 respectively, whereas the stems number was 2.2 for the control treatment after roughly 90 days from plantation.

Fresh, dry weight and water content of potato leaves

Results revealed significant increases in fresh and dry weight of the potato leaves for all treatments in comparison with the control treatments, except for the treatment CC20 that is not significantly different, due to low nutrient value (1:20=2.5 kg of compost in 50 l of water).

Fresh, dry weight and water content of potato stems

The application of FC extracts led to a significant positive effect on stem fresh and dry weights in comparison with the control even though the extract FC10 produced the best result for the fresh weight and FC5 for the dry weight.

Potato yield

In general, the extracts application show a sort of depressing activity with respect to the control plot where only water was applied.

This result clearly combines with the effect of dilution of the solutions.

In facts, the yield/plant values increase with increasing dilutions. In other terms, the more diluted is the extract; the higher is the yield both for FC and CC compost water extracts.

The number of tubers per plant is not significantly different among the various extracts and the control plot, with the only exception of CC5, which produced the highest number.

On the opposite, CC5 extracts showed the lowest tuber mean weight value whereas the rest of the extract did not exhibit any significant variation also with respect to the control.

Also, a slight trend can be observed among the extracts in that there is slight direct relationship between increase in dilution and increase in tuber mean weight which ends up to values expressed by FC20 and CC20 very similar to the control one.

The total yield per hectare does not really show major differences except the overall trend already observed in the previous sets of data.

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The organic C values appear markedly different with the application. In facts, the values were generally higher with respect to control (Table 27). In particular, the organic C was higher in the plots were FC was applied with respect to the CC ones.

Total phosphates in FC extracts are twice higher than CC ones and this is clearly visible in soil plots after harvest.

The chemical data of soil plots before and after extract application are just preliminary results which need to be checked more properly and again in the future order to find additional details and explanation of the described phenomena.

Adsorption and exchange phenomena, the effect of plant roots and physiological phases, the climatic variations and general parameters all play a paramount role in regulating the chemistry and the biochemistry of soils.

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