UNIVERSITÀ POLITECNICA DELLE MARCHE

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Thesis title:

PLANT ROOT PLASTICITY:
Reaction to Osmotic Stress and Organic Residues Content.

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Plant roots are often called the hidden half of the plant, and their study presents practical difficulties particularly in observation and measurements of this plant organ. For this reason root growth dynamics are still not well understood among the scientific community.

Plant roots differ between species, but have a common characteristic: they grow and develop in soil. Since all soils are highly variable in space and time (for physical, chemical and biological characteristics), roots need to adapt to this changing environment. The capacity to modify morphology and physiology in order to adapt to the environment is called plasticity. Roots are not reacting only to soil characteristics, there is in fact a reciprocal interaction between soil and roots, if soil induce changing in roots, roots contribute to soil variability absorbing nutrients, releasing organic compounds as radical exudates and root turnover. The modification of the soil is the mechanism that plants use to communicate with other living organisms (micro-organisms and plants). Root-soil and root-other organisms interactions have a function in the organisation of vegetal cenosis.

Important characteristics of all plant roots, that need to be taken into account in any approach to its study, are the dynamic behaviour and the plastic development. Roots are not static structures, but the continuous growth produces a root system that is always different in reaction to the environment, to the life cycle of the plant and to the genotype.

The experimental work of this PhD thesis is organized in two main chapters. In the first one plasticity of root architecture has been studied in a model plant (*Arabidopsis thaliana* L.) as the reaction to changes in water availability of an agar substrate.

Different genotypes were tested and the results point out that there is a genotypical control of root architecture. However all genotypes showed a common response to osmotic stress (simulation of water stress) that influenced significantly root architecture. The presence of mannitol in the growing media caused a small but significant reduction of primary root growth in all the genotypes, but the greater impact has been on the number and length of lateral roots that decreased considerably. Plants grown in osmotic stress conditions had lower density of lateral roots, that were shorter than lateral roots of plants grown in standard conditions.

Osmotic stress had an effect even in localized patches. If a plant, grown in standard conditions, reaches a patch with low osmotic potential, it decrease lateral root growth only in that patch. On the contrary, if a plant passes from a low osmotic potential patch to a standard patch, it shows a compensative proliferation of lateral roots.

During results analysis it emerged a peculiar kind of root system, initially called “weak root”, because the root had smaller dimensions than the “normal kind”. A further analysis however demonstrated that the new kind of roots were not weaker than the “normal” ones, they were just more compact. The interest on these findings stands in the further research that they can lead to. Since the same kind of compact root was found in different genetic lines, analysing the differences and similarities in the genotype of compact and normal root, could lead to isolate the gene (or group of genes) responsible for this peculiar phenotypic trait.

In the second part of the thesis root plasticity was considered in olive tree (*Olea europaea* L.), a species with peculiar mechanisms of root proliferation and regeneration that are not fully understood.

In this study olive plants reaction to organic matter in the substrate was considered. The allelophathic effect of different organic materials was tested in an experiment with split-root pots. The results showed that olive mill residues (husks) had a phytotoxic effect on olive plant growth. Olive plants had a reduced growth in the pot sectors containing a substrate with 10% in volume of husks. The negative effect was recorded in the shoot only if husks were present in all the pot. If a pot sector was filled with control substrate, then the plant was able to shift root growth in the free from husks sector and shoot growth was not affected.

The initial composition of the organic matter affected the reaction of roots. If husks were mixed with hay (to simulate green mulching field conditions), husks toxic effect was mitigated.

In conclusion it is confirmed the ability of roots to react to environmental conditions with modifications that can involve genotype or just phenotype. From the results of this experimental work stands out that different genotypes can have similar reactions to the same environmental input, anyhow some interaction existing between genotype and phenotypic response can be used to improve our knowledge of the link between genes and functions.

In the other end the result of this work are confirming that plants have a growth coordination between different parts of the root system and with other organisms that live in the soil (micro-organisms and other plants). Roots identify organic residues in soil and, depending on the organic matter origin and degree of decomposition, react avoiding the patch or colonizing it. For this reason a correct plant management needs to include attention to root growth. Even if roots with a great transmigration capacity, as olive tree, are able to avoid patches that are not suitable for growth, the cost of adaptation or transmigration may affect aerial growth and hence production.

Further studies are needed to point out the dose and distribution effect that organic residues as husks can have in field in a long term period. In this way it will be possible to profit of the high fertilizing value of organic material avoiding toxic effects.