THE UNIVERSITY OF ADELAIDE

Trung Ta Nguyen

COMPOST EFFECTS ON SOIL WATER CONTENT, PLANT GROWTH UNDER DROUGHT AND NUTRIENT LEACHING

Thesis submitted to The University of Adelaide in fulfilment of the requirements for the degree of Doctor of Philosophy

School of Agriculture, Food and Wine
Faculty of Sciences
The University of Adelaide

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Dedicated to my father Nguyễn Văn Tráng and my mother Đặng Thi Phượng

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ABSTRACT

Compost is increasingly used in agriculture as a soil conditioner and fertilizer to improve soil properties and crop production by replenishing soil organic matter and supplying nutrients and thereby improving soil physical, chemical and biological properties. However, little is known about the effect of compost on soil water content and plant growth under water deficit stressed condition and if clay added to compost or soil influences nutrient leaching from compost. This thesis includes pot, field and laboratory incubation studies with the following aims (1) to assess the effects of compost on water availability to plants and gas exchange under well-watered and drought stressed conditions, (2) to study the long term effect of mulched compost after a single application, (3) to compare effects of incorporated and mulched compost on soil water content, nutrient uptake and plant growth, and (4) to determine the effect of clay added to compost or sandy soil on nutrient availability and leaching.

To assess the effects of compost on plant growth under water-limiting conditions, two pot experiments were conducted; one with tomato and the second with capsicum.

Tomatoes (*Lycopersicon esculentum* L.) were grown in pots were grown in a sandy soil without or with mulched or incorporated compost from garden and food waste to assess water availability to plants and plant physiology under well-watered and drought stressed conditions. Both mulch and incorporated compost increased plant growth with the greater effect by incorporated compost, but only incorporated compost increased total available water and water available to plants. Compost did not affect gas exchange in well-watered and drought stressed conditions, but the incorporated compost increased the recovery of plants after drought by increasing photosynthesis and transpiration rate compared to the plants without compost or with mulched compost. This may be explained by the greater root length and mass of plants grown with the incorporated compost compared to the other compost

treatments.

Pepper (*Capsicum annuum* L.) plants were grown in pots in a silt loam which had received mulched compost once three years previously, and in a corresponding unamended control under (i) sufficient water supply and (ii) two transient drought cycles, separated by one week of sufficient water supply. Compost applied once three years previously increased soil organic C and total N, dry root mass and root length under well-watered and drought stressed conditions. The single compost application increased total available water, total water used and water availability to plants grown in well-watered condition, but did not affect gas exchange and had no effect on water use efficiency and the capacity of plants to recover after drought. As in the previous experiment with freshly applied compost, mulched compost applied once three years previously increased the ability of plants to take up water by stimulating root growth.

To investigate effects of compost on soil water content and plant growth under field conditions, compost from garden and food waste was incorporated or mulched in a vineyard (*Vitis vinifera* cv. Merlot) at a rate of 100 m^3 ha^{-1} with normal irrigation during spring and summer. The compost was applied three months before the start of the first soil water content measurement. Only mulched compost increased soil water content at 10 cm depth and the rate of photosynthesis per plant at flowering, pea sized berries and maturity (about 13 months after application). Compost amendment, particularly mulch, increased yield, specific berry weight, and leaf N and P concentrations, and reduced the number of chlorotic leaves at harvest. It can be concluded that mulched compost has a positive effect on grapevine yield and can be used as an alternative fertiliser for vines with no adverse effect on berry quality.

Incubation experiments were carried out to assess effects of clay addition to compost or sandy soil on nutrient leaching. In the first incubation experiment, a fine-textured soil (34% clay) was added at 5% or 20% (w/w) to compost and this mix was incorporated into a sandy

soil. Compost addition increased nutrient availability and leaching. Addition of the fine-textured soil to compost reduced nutrient leaching, especially N and P from compost. In a second incubation experiment, clays isolated from a surface soil and subsoil were added to a loamy sand (98.1 g clay kg^{-1}soil) and different concentrations of water-extractable organic C (WEOC) from compost was added. Clay addition reduced C loss (mg C per kg soil) via leaching and respiration and increased the WEOC sorption capacity of the loamy soil. The clay properties such as mineralogy, surface area, cation exchange capacity and exchangeable Ca concentration cannot explain differences in C sorption and loss. However, clays with a high C sorption capacity had low indigenous organic C and high Fe/Al concentrations. It can be concluded that clay addition to compost or soil reduces the risk of entrophication and increase C sequestration by decreasing C loss via leaching and respiration if the added clays have low total organic C and high Fe/Al concentrations.

DECLARATION

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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Trung Ta Nguyen

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