The Potential of Smoke Solutions from Vineyard Pruning Wastes to Mitigate Heavy Metal Toxicity in Grapevine Saplings

Dr. Selda DALER
selda.daler@yobu.edu.tr

Dr. Tuğba KILIÇ
tugba.kilic@yobu.edu.tr

CA22134 - Sustainable Network for agrofood loss and waste prevention, management, quantification and valorisation 'MC meeting'
January 24-25, 2023, Ancona, Italy

The grapevine is an extremely economically important plant species that is the source of many products that can provide added value by utilising them in different fields, from grapes to must, from leaves to pruning waste.

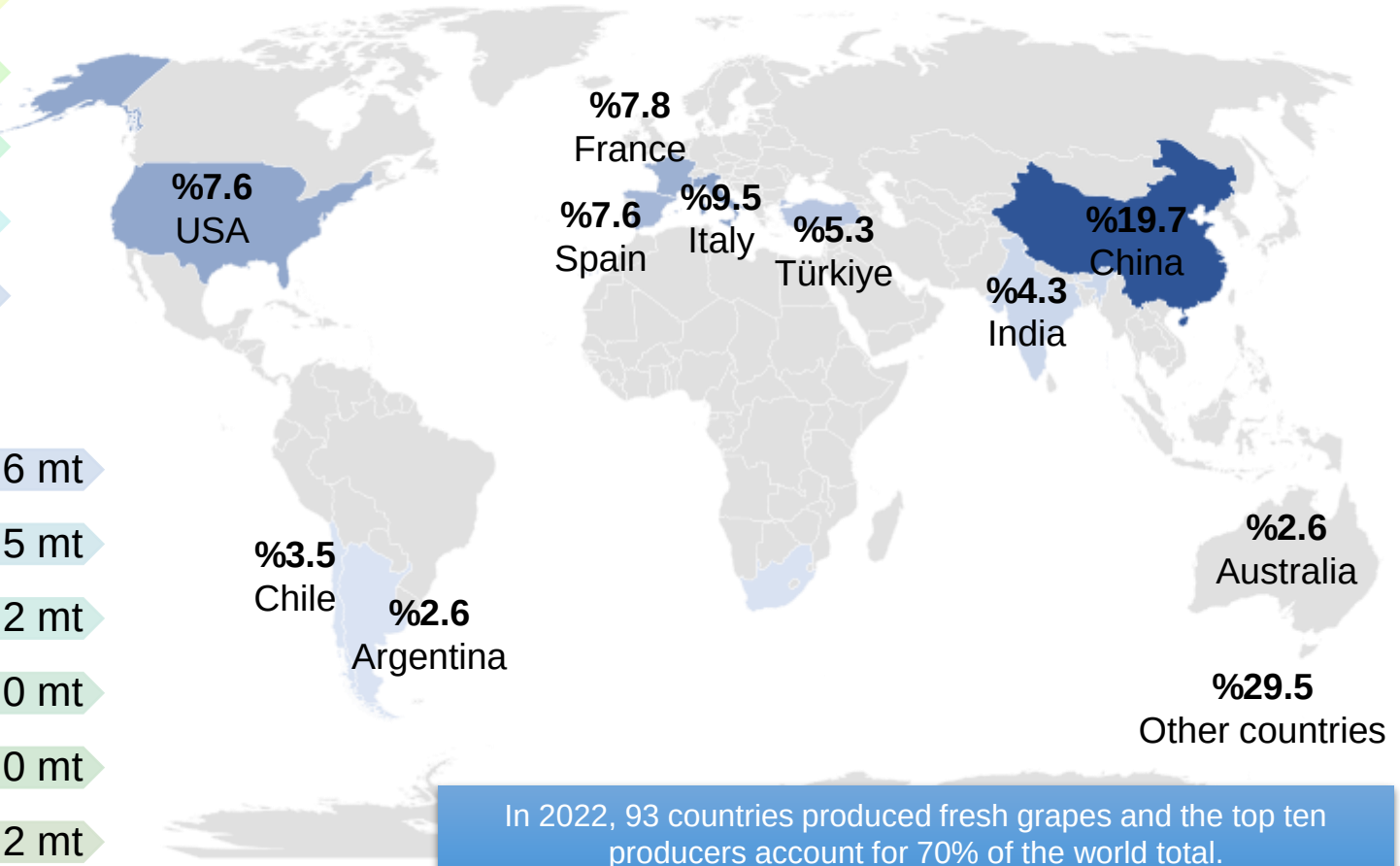
WORLD GRAPE PRODUCTION

Surface Area

Spain	955 kha
France	795 kha
China	785 kha
Italy	718 kha
Türkiye	410 kha
USA	390 kha

Production

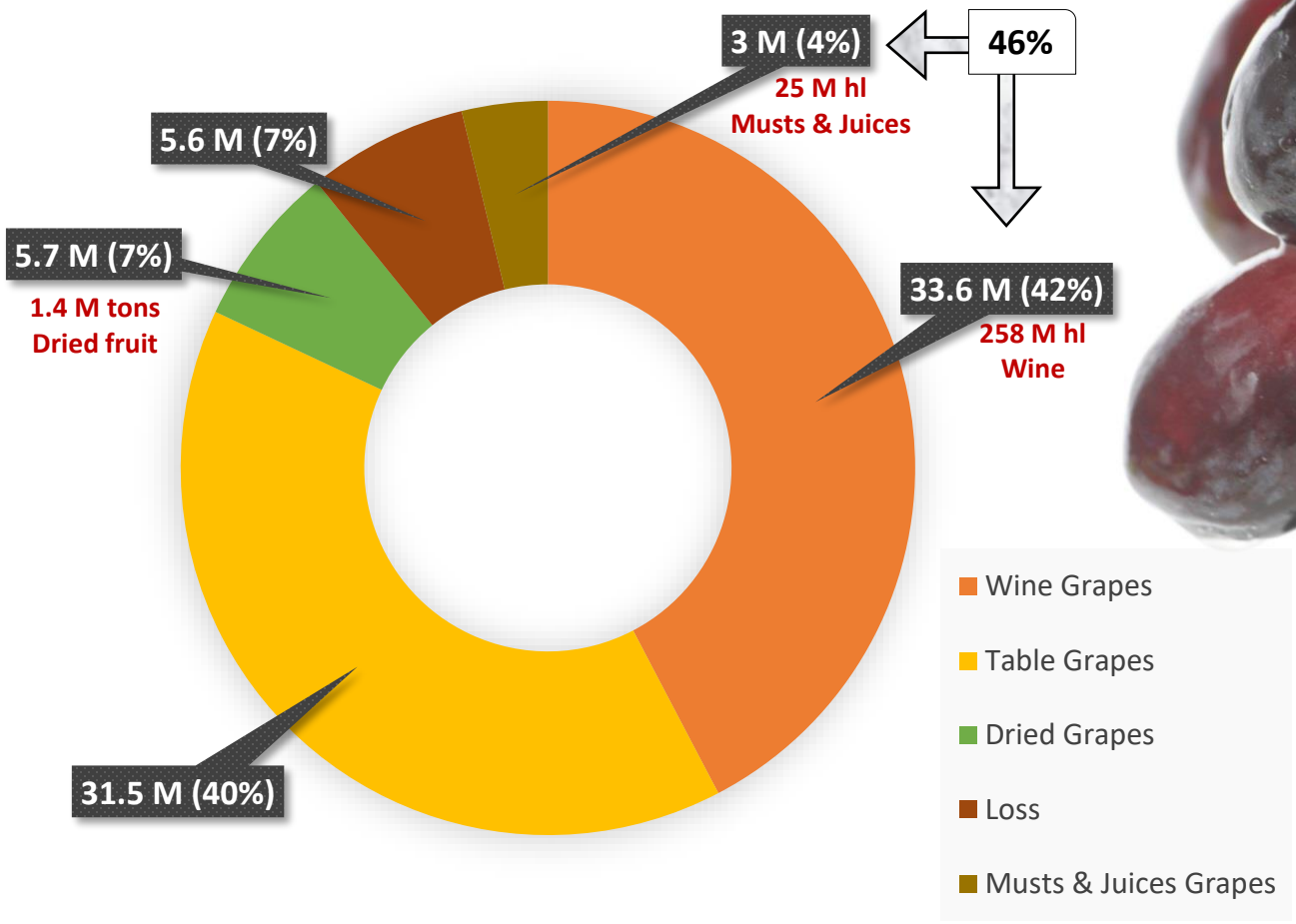
China	15.6 mt
Italy	7.5 mt
France	6.2 mt
USA	6.0 mt
Spain	6.0 mt
Türkiye	4.2 mt



In 2022, 93 countries produced fresh grapes and the top ten producers account for 70% of the world total.
The ten largest vineyards account for two thirds of the world total.

	Vineyard area	Production quantity	Yield
World (OIV, 2022)	7.3 mha	79.4 mt	1.1 tons/da
Türkiye (OIV, 2022)	410 kha	4.2 mt	1.2 tons/da

Global Grape Production



* OIV 2022

Vineyard management

In order to obtain high quality products from vineyards in a continuous and sustainable manner, vineyard management practices including cultural operations such as pruning and training are of great importance in terms of cultivation.

Waste from vineyard

As a result of viticulture activities, a large amount of waste is generated, and this situation is a serious environmental problem.

The issue of "waste" in relation to environmental sustainability has recently attracted the attention of regulatory authorities (e.g. European Commission Directives 1999/31/EC and 2008/98/EC).

Vineyard pruning waste

Pruning wastes remaining in the vineyards after pruning pose a significant problem in terms of both tillage and pest and disease control.

Therefore, it is a necessity to find environmentally friendly solutions to reduce the amount of waste, including recycling and reuse of resources.

Worldwide, vineyard pruning waste

represents an average volume of 2.5 tons per hectare each year.

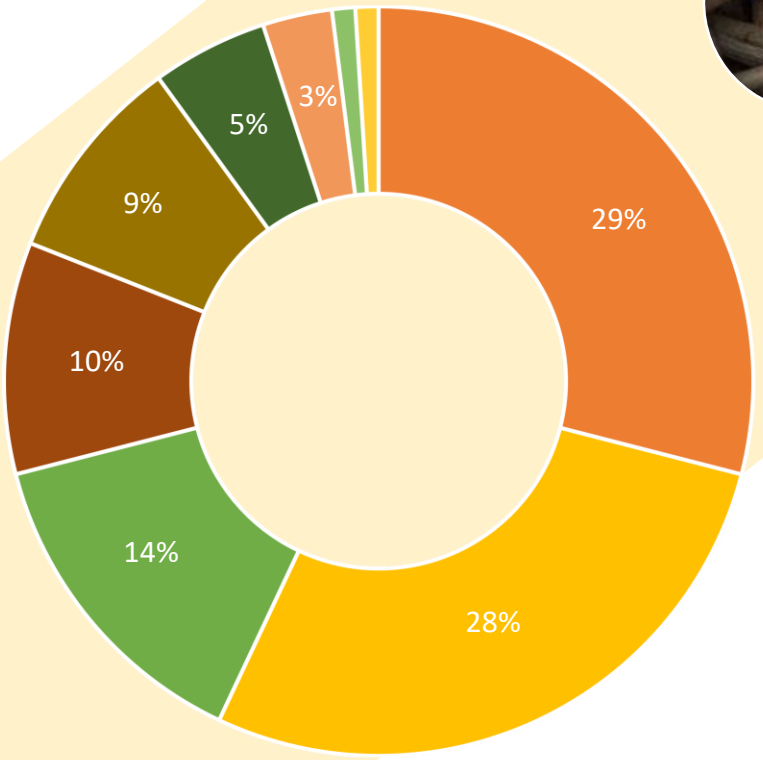
In Turkey, an average of 2.3 million tons of vineyard pruning waste is generated from vineyard areas every year.

Repurposing of by-products from viticulture

In recent times, there has been a notable surge in interest regarding the repurposing of by-products from viticulture.

This trend stems from a dual objective: mitigating environmental repercussions and fulfilling the increasing need for sustainable materials, replenishable nutrient reservoirs, and bioactive compounds essential for the food and feed sectors.

Content of vineyard pruning wastes



- Cellulose
- Lignin
- Hemicellulose
- Volatile matter
- Extract
- Acetyl
- Fixed carbon
- Moisture
- Ash

Cadmium (Cd) pollution

Cd stands as one of the most hazardous heavy metals and pollutants that accumulate in soil and water, causing severe toxic effects on various living organisms.

Soil and water cadmium (Cd) levels rise due to:	More factories and industries
	Using too many chemical fertilizers and pesticides without care
	Polluting water sources by mixing wastewater, using it for irrigation
	Adding sewage sludge to the soil

Kabata-Pendias and Pendias (1984) determined 0.01-2 ppm Cd as normal value for soils and 3-8 ppm as critical value.

Signs of cadmium (Cd) harming plants include:

- Inhibited root growth
- Difficulty in absorbing, transporting, and using water and essential nutrients
- Slow plant growth and low biomass
- Lowered chlorophyll production, leading to reduced photosynthesis
- Impaired respiration, nitrogen, and carbohydrate processes
- Decreased plant yield and quality

Smoke solutions

Recently, as an important "biostimulant", plant-derived smoke solutions, an alternative environmentally friendly application that can contribute to agricultural production, have come to the fore.

Smoke solutions contain organic compounds:

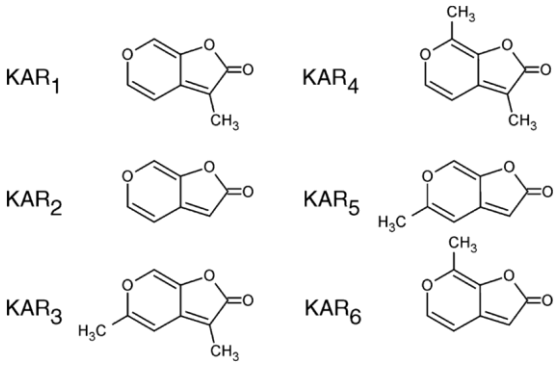
- Alcohol, aldehydes, ketones and furfural

- Formaldehyde, phenols and quinols, which act as preservatives

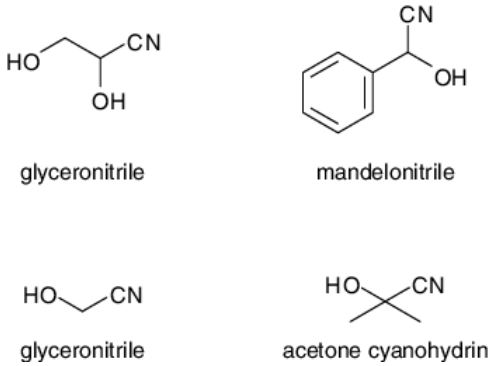
- Pyrogallol, which acts as an antioxidant, antiseptic and anti-bacterial

The active compounds in smoke

Karrikin and cyanohydrins, cannot be synthesized naturally by plants, but can be produced as water-soluble volatile compounds by thermochemical decomposition of carbohydrates such as cellulose in organic matter by pyrolysis at high temperature and in the absence of oxygen.



Karrikins

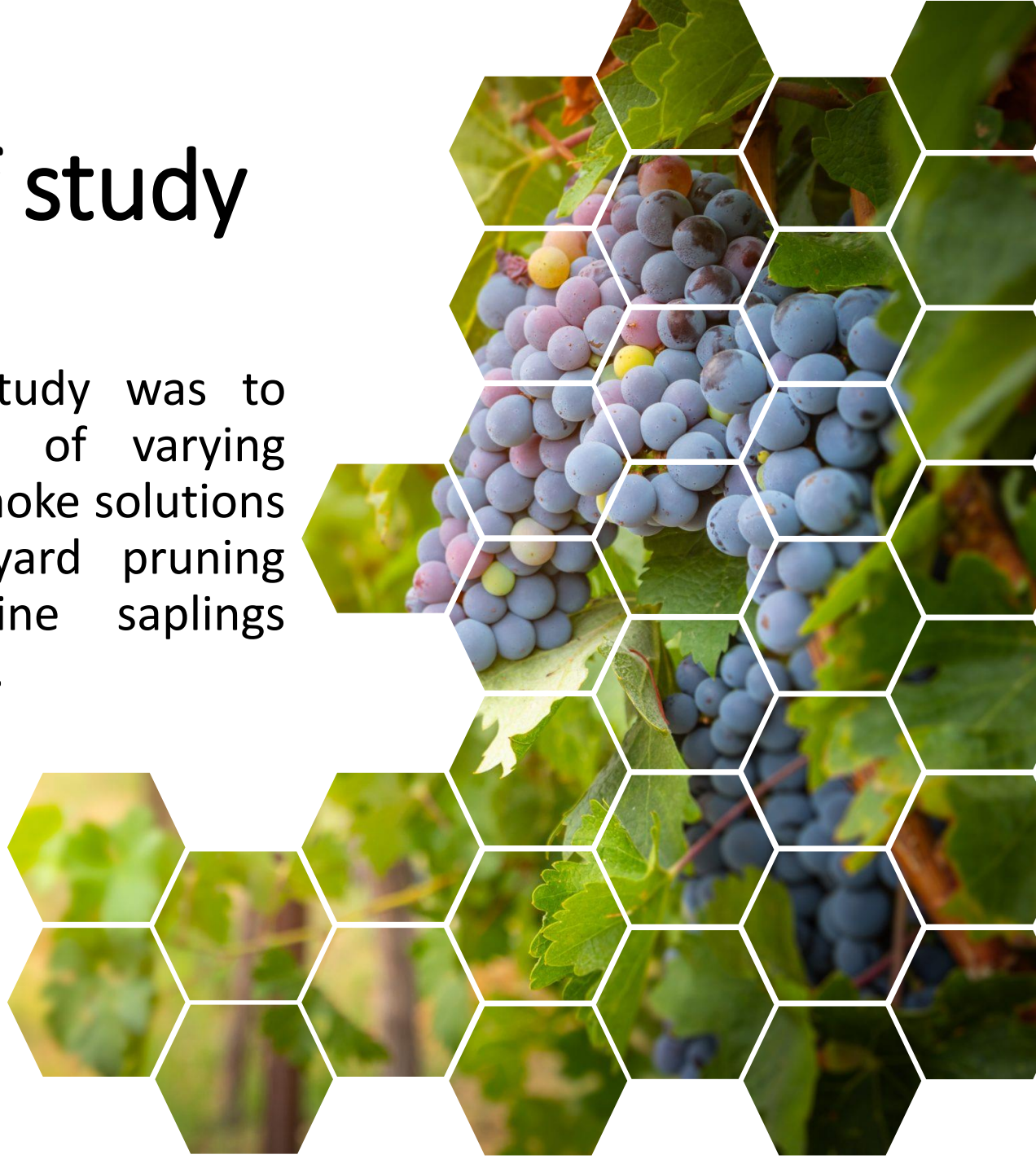


Cyanohydrins

These compounds have been reported to have stimulatory effects on growth and development-related events in plant species in various habitats and also protect plants against abiotic stress factors.

Purpose of study

The aim of this study was to assess the impact of varying concentrations of smoke solutions derived from vineyard pruning waste on grapevine saplings exposed to Cd stress.



Plant Material

Saplings of Narince grape variety grafted on 1103 Paulsen American grapevine rootstock, reported to be sensitive to Cd stress, were used as plant material in the study.

Narince

1103 P

Production of grafted grapevine saplings

Grafting was carried out according to the Omega (Ω) system. Paraffinization and acclimatization were then applied.

Preparation of vineyard pruning waste for burning

Vineyard pruning wastes were dried at 65°C for 120 hours until a constant weight was achieved.

Then, 1 kg of the dried wastes, divided into 3 sub-samples, was burned in the incinerator.

The apparatus used in the preparation of plant-derived smoke solution

A special system was used for the incineration process, comprising a 5 L metal incinerator (~165 °C), a silicone pipe, a 4 L bottle with pure water, a vacuum cleaner (suction power ~40 kPa), and an air supply hose. Two holes were drilled in the top of the water bottle. One hole was connected to the vacuum cleaner via an air supply hose, and the other was linked to the metal incinerator stove using a silicone pipe.

Dilution of smoke solutions to different concentrations

The concentrated solution obtained was termed the stock solution.

Subsequently, this stock solution underwent filtration using coarse filter paper and was then diluted to create concentrations of **0.5%**, **1%**, and **2%** in plant-derived smoke solutions.

The smoke produced during combustion was passed through distilled water.

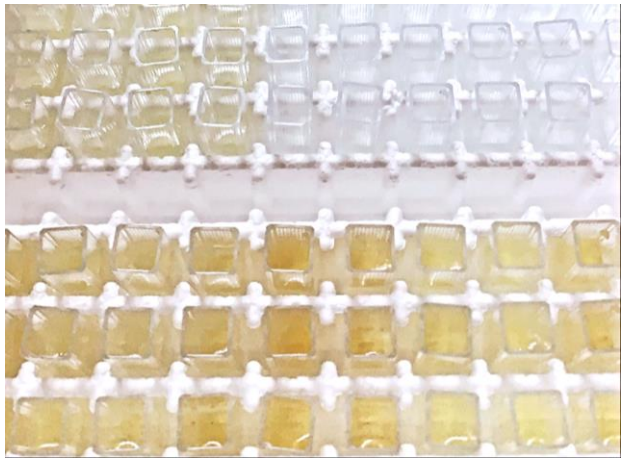
Cultivation of plants

Smoke solution treatments were started 4 weeks after planting. Leaves were sprayed with 25 mL of smoke solution per sapling.

Cd stress applications was applied 8 weeks after planting. 10 ppm $CdCl_2$ was applied to the root zone of plants together with fertilizers.

The experiment consisted of 5 treatments

- Control plants without treatment
- Cd stress + 0% smoke solution
- Cd stress + 0.5% smoke solution
- Cd stress + 1% smoke solution
- Cd stress + 2% smoke solution



Morphological, physiological, and biochemical analyses

- Plant Growth
- Leaf Chlorophyll Content
- Proline Content
- Relative Water Content
- Leaf Temperature
- Stomatal Conductance
- Membrane Damage Index
- Lipid Peroxidation
- Antioxidant enzyme activities

Statistical assessments

- Evaluation of Data

Summary of results

Application of Cd stress

Biomass
RWC
Stomatal Conductivity
Pigments

EL
MDA
Oxidative stress

Application of Cd stress + Smoke solution treatments

EL
MDA
Oxidative stress

Biomass
RWC
Stomatal Conductivity
Pigments
Total Phenolic Content
Antioxidant enzymes

Especially, the 0.5% smoke solution effectively alleviated Cd stress damage by improving growth characteristics and regulating physiological and biochemical responses compared to other concentrations.

In summary, this study found that plant-derived smoke solutions mitigate Cd stress in grapevines, enhancing antioxidant defenses.

The findings also support the idea that smoke solutions can serve as a cost-effective, quick, and eco-friendly biofertilizer, promoting vegetative growth for sustainable agriculture.


Thank you for your attention