Effect of adding wood vinegar on cucumber (Cucumis sativus L) seed germination

To cite this article: Ming Lei et al 2018 IOP Conf. Ser.: Earth Environ. Sci. 128 012186

View the article online for updates and enhancements.
Effect of adding wood vinegar on cucumber (Cucumis sativus L) seed germination

Ming Lei, Bingjie Liu, Xiao Wang*

Institute of Coastal Environmental Pollution Control, Key Laboratory of Marine Environmental Science and Ecology, Ministry of Education, College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100, China

E-mail address: wangxiao_ouc@163.com

Abstract. Wood vinegar, a liquid by-product that was obtained from the condensed vapor generated during the biomass pyrolysis, had been reported as plant growth promotor, but the impact on the plant seeds was still not clear. Thus, we investigated the effects of wood vinegar on the germination and seedling growth of cucumber seeds through the germination experiments. The results showed that the different diluted wood vinegar addition showed no significant difference in the germination rates of cucumber seeds compared to those of the CK treatment (P > 0.05). However, the added wood vinegar at the 10000-time dilution significantly increased the root length and dry biomass of cucumber by 20.9 % and 5.92 %, respectively (P < 0.05). Therefore, the wood vinegar at an optimal time of dilution could be used a promising soaking agent for the seeds germination, and further enhance crop yields.

1. Introduction
Wood vinegar, a liquid by-product of biochar production that was obtained from the condensed vapors generated during the biomass pyrolysis (450 – 600 °C) [1]. It consisted mainly of 80 – 90% water and 10 – 20% organic compounds including more than 200 chemical components. And the main components were organic acids based mainly on acetic acid, phenolic, alkane, alcohol and ester compounds [2]. Wood vinegar had been reported to support multiple benefits for agricultural production, comprehensive utilization of waste, environmental protection and sustainable development industries [3]. Previous studies showed that the wood vinegar application into soil could stimulate plant growth through improving soil acidity, elevating soil cation exchange capacity (CEC), and consequently benefiting the N and P translocation from soil to plant [4]. Additionally, the increased chlorophyll content and enhanced photosynthetic rate and root vigor were also found followed by the wood vinegar addition [5]. However, little attention has been paid to the influence of wood vinegar on the seed germination and the seedling growth of plant. Therefore, the objectives of this study were to investigate the effect of different concentrated wood vinegar as soaking agent on the seeds germination and seedling development of cucumber.

2. Materials and methods

2.1 The preparation of samples
The seeds of cucumber (Cucumis sativus L) in this study was purchased from Fuxinnong Agricultural Products Store, which were cultivated by the Qingdao Institute of Agricultural Sciences. The discarded
wood was pyrolyzed at 450 °C for 5 h to produce the wood vinegar (the liquid by-product collected from the cooling systems after pyrolysis process). Afterwards, the wood vinegar was stood for 6 months under darkness and the middle component was collected for further analyses and seeds germination experiment. The pH and density of wood vinegar was 2.85 and 1.05 kg m⁻³, respectively.

2.2 Experimental design
The cucumber seeds were soaked in 10 % H₂O₂ solution for 30 minutes, then were soaked with CaSO₄ solution overnight in the darkness, afterwards, the soaked seeds were washed with distilled water for 4 – 5 times. The clean petri dishes (diameter 9 cm, depth 1.5 cm) and filter paper (8.5 cm in diameter) used in this study were sterilized by high temperature (121 °C) and each petri dish was put on two pieces of filter paper. Twenty cucumber seeds were randomly spaced on top of the filter paper in each petri dish with 10 mL different diluted wood vinegar (i.e., 500, 1000, 5000, 10000, 50000, 100,000 and 500,000 times with distilled water) and without wood vinegar (distilled water). All the treatments were performed in four replicates, the 7-day germination experiment was cultivated in a greenhouse at 20 °C and 60% humidity and the rates of germination in each petri dish was recorded daily. After the 7 days of incubation, the root and stem length of cucumber seedling were measured using vernier caliper (500-173, Mitutoyo, Japan), and the fresh and dry biomass were weighed by electronic balance (TP-214, Denver Instrument, USA).

2.3 Statistical analysis
All the data in this study were expressed as mean values. Error bars in the results represented the standard deviation. Significant differences among the treatments were analyzed using one-way analysis of variance (ANOVA) with Duncan’s multiple range test (P = 0.05) using Statistical Product and Service Solutions Software 20.0 (SPSS 20.0).

3. Result and discussion

3.1 Effects of adding wood vinegar on the germination rates of cucumber
As presented in Figure 1, the wood vinegar addition at different dilution times (500 –100000) showed no significant difference in the germination rates of cucumber seeds compared to those of the CK treatment (P > 0.05). The cucumber germination rates in the higher times (> 5000) diluted wood vinegar treatments were close to that of the CK treatment. However, the diluted wood vinegar at 1000 times caused a slight decrease (5.3% relative to the CK treatment) in the cucumber germination rates, showing that the application of wood vinegar in enhancing crop production should be at an optimal level.

![Figure 1](image-url)

**Figure 1.** Effects of wood vinegar on the germination rate of cucumber seeds. The different letters among different treatments indicate the significant differences, which were analysed by Duncan’s test (P = 0.05) using SPSS 20.0. Error bars represent standard errors of the mean (n = 4).
Figure 2. The effect of different concentrations of wood vinegar on root length (a), stem diameter (b), fresh biomass (c) and dry biomass (d) of cucumber seedlings. The different letters among different treatments indicate the significant differences, which were analysed by Duncan’s test ($P = 0.05$) using SPSS 20.0. Error bars represent standard errors of the mean ($n = 4$).

3.2 Effects of adding wood vinegar on the cucumber growth

As Figure 2a showed that the added wood vinegar at the diluted time of 10000 significantly increased the root length of cucumber by 20.9% compared to that of the CK ($P < 0.05$). Similarly, the highest diluted time (i.e., 100000) of wood vinegar addition promoted the cucumber root development, but no significant difference was observed between the highest diluted wood vinegar treatment and the CK treatment ($P > 0.05$), which could be related to the enhanced photosynthetic rate and root vigour followed by the wood vinegar addition, ultimately contributing to the stimulation of the plants growth [5]. For the stem length of cucumber (Figure 2b), the low diluted times (< 5000) of wood vinegar addition didn’t significantly enhance the cucumber stem growth. However, the high-times (e.g., 10000 and 50000) diluted wood vinegar caused notably decreases in the cucumber stem length ($P < 0.05$), which needed further explanations. The additions of different-times diluted wood vinegar showed no obvious promotion effect in the fresh biomass of cucumber seedlings compared to the CK treatment, but the added wood vinegar at the diluted time of 10000 significantly decreased the fresh biomass by 11.5% relative to the CK treatment (Figure 2c). The results indicated that wood vinegar addition has no effect on enhancing the fresh biomass of cucumber seedlings. For the dry biomass of cucumber (Figure 2d), the low diluted times (< 10000) of wood vinegar addition significantly decreased by 18.4% – 20.0%, implying that the harmful chemicals contained in high concentrated wood vinegar could inhibit
the biomass production through hampering photosynthetic activity [6]. When the added wood vinegar at the dilution times of 5000, 10000 and 50000, the dry biomass of cucumber seedlings slightly increased, suggesting that a certain concentration of wood vinegar could be conducive to cucumber [7].

4. Conclusion
The results from the pot experiments revealed that the wood vinegar application at suitable dilution times (i.e., 5000 –10000) could enhance the germination rates of cucumber seeds and promote the seedlings growth. The mechanisms for that may be attributed to the elevated root vigor and photosynthetic rate following the input of certain substances (e.g., phenolic substances) contained in the wood vinegar, which could consequently stimulate the growth of cucumber. Therefore, the addition of wood vinegar may provide a suitable condition for the plant growth, and the specific mechanisms still also deserve further research.

Acknowledgements
This work was financially supported by the National Science Fund for Distinguished Young Scholars of China (41325013).

References
[1] Czernik S, Bridgwater A V 2004 Energy Fuels 18 590-598
[2] Jun M, Tohru U, Takeshi F 2004 J Wood Sci 49 262-270
[3] Lehmann J 2007 Nature 447 143-144
[4] Vaccari F P, Maienza A, Miglietta F, Baronti S, Di Lonnardo S, Giagnoni L and Valboa G 2015 Agr. Ecosyst. Environ. 207 163-170
[5] Zheng H, Wang Z Y, Deng X, Herbert S and Xing B S 2013 Geoderma 260 32-39
[6] Bass A M, Bird M I, Kat G and Muirhwad B 2016 Sci. Total Environ. 550 459-470
[7] Shen F S, Lu J L, Tan J Z 2002 Journal of Agricultural Science Yanbian University 24 26-29