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Zinc Sulfate as an Inhibitor on the Mycelial Growth of the Fungus: A Short Review and Some Insights

Chee Kong Yap[1] and Shih Hao Tony Peng[2]*

[1]*Department of Biology, Faculty of Science, Universiti Putra Malaysia, Malaysia*

[2]*All Cosmos Bio-Tech Holding Corporation, Malaysia*

Introduction

Zinc is an essential metal and micronutrient needed by the animals and humans, and as plant nutrition to support their normal functions and growth. It is a catalytic component of over 300 enzymes including transferases, hydrolases, lyases, oxidoreductases, isomerases and ligases [1].

Zinc can be found in natural in the environment, foods, soils and water [2] besides man-induced inputs [3]. However, elevated level of zinc can negatively affect the growth of plants such as the medicinal plant *Centella asiatica* [4]. Once bioaccumulated inside the living organisms, it may distribute throughout the body and binds to metallothioneins. In gastropods, zinc distributes into different organs such as digestive tract, cephalic tentacles, muscles and remainder of mudflat snail *Telescopium telescopium* [5,6]. Besides, zinc can be a stress on the changes of allozymes of *Perna viridis* [7]. Furthermore, Yazdani, et al. [8], reported the *Trichoderma atroviride* has the uptake capacity of Zn by acting as a bioremediator.

Zinc sulfate is an inorganic compound and its molecular formula is $ZnSO_4$ [9]. Specifically, it is an herbicide to the control the growth of the moss. Nonetheless, the zinc toxicity of zinc sulfate is dependent on the amount of zinc in the product [2].

Zinc Sulfate as Inhibitor of Fungal Growth

Zinc has shown various antagonistic effects on plant susceptibility to disease of the host pathogen interaction based on many citations [10,11]. The study on zinc sulfate for the toxicity study in plants has been reported in the literature [12]. Al-Maali, et al. [13], conducted a comparative study on the impact of zinc citrate and zinc sulfate on the growth and biomass composition of mycelium of medicinal fungus *G. lucidum* cultivated in liquid media.

There have been a number of literatures that zinc sulfate to act as an inhibitor of mycelial growth of fungus. For example, Li, et al. [11], studied the peach gummosis that was caused by *Lasiodiplodia theobromae*. The gummosis is a prevalent disease that disturbed the peach production. Interestingly, Li, et al. [11], showed significant inhibition of mycelial growth of *L. theobromae* by zinc sulfate in comparison to the control.

According to Malachova, et al. [14], zinc has been shown antifungal activity against *Pleurotus ostreatus* and *Pycnoporus cinnabarinus*. Similarly, Lanfranco, et al. [15], reported zinc significantly diminished the fungal biomass of *Fusarium oxysporum*. According to Grewal, et al. [10], zinc that was applied to the soil could lessen the infections of *F. graminearum*. Rakib, et al. [16], reported that copper and zinc in the foliar samples of mature oil palm were significantly lower Miri than those in Betong. In contrast, higher *Ganoderma* occurrence was found at Miri with lower copper and zinc in the foliar samples than those in Betong with higher Cu and Zn. At the same time, the oil palms infected by *Ganoderma* in Miri suffered deficiencies of copper and zinc. This indicated that copper and zinc were chemical inhibitor of *Ganoderma* growth in the oil palm plantation area. Zinc deficiency in oil palm *Elaeis guineensis* could promote the prevalent of the *Ganoderma* disease after severe infection [16].

Zinc sulfate could reduce the development of the fungus *Ganoderma*. This could be due to zinc is vital in upholding the integrity of biological membranes [17]. Malachova, et al. [14], found that zinc has antifungal activity against *Pycnoporus cinnabarinus* and *Pleurotus ostreatus.* They explained that Zn blocked the making of the phytotoxin fusaric acid (a *Fusarium oxysporum* virulence factor) [18]. In the case of *Botrytis cinerea*, Zn stress caused a reduction in the production of plentiful cell wall degrading enzymes [19]. Therefore, the effects of zinc sulfate on hyphal morphology, development, and phytotoxin production of *Elaeis guineensis* may contribute in lessening the symptoms of the oil palm *Ganoderma*'s disease.

***Corresponding author:** Chee Kong Yap, Department of Biology, Faculty of Science, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

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Our hypothesis also supported by Duffy and Defago [18], that Zn significantly decreased the fungal biomass of the fungus *F. oxysporum*. According to Lanfranco, et al. [15], the abnormal hyphal morphology in the presence of zinc could have triggered chitin (main cell wall polysaccharide) deposition. Lew [20], reported that zinc ions at 50 mM could damage the internal hydrostatic pressure of the cell and inhibiting the elongation of the hyphal tip of *L. theobromae*. The same mechanism can be provided when zinc sulfate could potentially inhibit the mycelial growth of *G. boninense*. This could be due to zinc sulfate may have comparable function and protection against *G. boninense*. Li, et al.'s [11] finding indicated that zinc sulfate can serve to inhibit the pathogen and to enhance the peach resistance against the pathogen. The application of Zn to the soil has been reported to reduce the infections of *Fusarium graminearum* [10]. Similarly, zinc sulfate can be used to control the oil palm disease caused by *G. boninense*. The application of zinc sulphate in the fertilizers to infected *Ganoderma* diseased oil palm may serve to balance zinc loss and to control the oil palm disease.

Therefore, the above reviewed literatures points to the potential of zinc sulfate in the inhibition of the growth of *G. boninense* and thus to enhance the defence of oil palm against *G. boninense*. This also can provide a new insight into host oil palm's responses mediated by zinc. In view of that, the effect of zinc sulfate on inhibition of the oil palm disease *G. boninense* in the field is a very interesting study in the future.

Nonetheless, from ecotoxicological point of view, excessive application of zinc in the crop plantation can cause soil pollution by zinc toxicity symptoms including reduced yields and stunted growth [3]. This is due to the formation of zinc ions from zinc sulfate that dissolves in the water system that can be termed as zinc bioavailability. Thus, the bioavailability of zinc to the animals and plants are dependent on the water pH and other abiotic factors [2]. In most crops, the Zn toxicity symptoms usually become noticeable at a range of 100 to 300 mg Zn/kg of leaf dry weight [1]. However, zinc toxicity in crops is far less common than Zn deficiency especially in the oil palm plantation [16]. Therefore, zinc toxicity is usually not an ecotoxicological concern in the crops such as oil palm plantation.

Concluding Remarks

Based on the above literature, zinc sulfate can be used as an inhibitor to control the growth of the fungus. It is proposed that zinc sulfate can be used as a potential anti-fungal agent especially the well-known fungal disease in the oil palm plantation namely *Ganoderma boninense* that disturbed the normal growth of oil palm *Elaeis guineensis* in the field ecosystem [21]. However, further studies are needed to know the effective dosage of zinc sulfate for application under the field ecosystem. The use of zinc sulfate could be an agricultural technology but it not economical, considering the high cost of using zinc sulfate to control the oil palm disease. Its use can be challenged from industry point of view when the huge plantation area of oil palm is taken into account.

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