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Nanoparticle effect on degradation of vanillic acid, a germination inhibiting dormancy factor present in *Cyperus rotundus*

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ABSTRACT

Cyperus rotundus is one of the most invasive perennial sedge weed considered as the world's worst weed. The tubers of the weed remain viable for more than three years and pass over the harsh weather period by preventing the germination of buds present in the tubers. Due to dormancy, the tubers may sustain in the soil for longer and interfere with the crops raised in the following season. Phenols are considered as the major factor of dormancy in *Cyperus rotundus* tubers. Among different phenolic acids, vanillic acid is dominated, found under long and continuous stress. Nanoparticles are capable to degrade the phenols. In order to confirm whether the nanoparticles have effect on degradation of phenol present in *Cyperus rotundus*, the dominant phenol present in the tuber *i.e.*, vanillic acid was chosen. Experiment was conducted at the department of Nano Science and Technology, Tamil Nadu Agricultural University, Coimbatore to find the effect of different nanoparticles such as iron oxide, silver, titanium dioxide and zinc oxide on commercially available vanillic acid degradation during 2013-15. The maximum degradation of vanillic acid was observed with iron oxide nanoparticles at 25 mg *i.e.*, 60.6% degradation compared to control. Titanium dioxide, zinc oxide and silver nanoparticles at 25 mg recorded the 54.5, 49.3 and 24.8% degradation, respectively.

The purple nutsedge (*Cyperus rotundus*) causes serious problems in many crops all over the world than any other weed (Kadir *et al.* 2000). Often forms dense colonies and greatly reduces the crop yields. The sedge weed propagates mainly by producing a complex underground system of rhizomes, basal bulbs and tubers (Stoller 1975). The tubers remain viable for more than three years and pass over the harsh weather period by preventing the germination of buds present in the tubers. Jangaard *et al* (1971) reported that increasing phenolic compounds and abscissic acids in the tubers reduced the sprouting. *C. rotundus* tubers contain vanillic, coumaric, ferulic, hydroxybenzoic and protochatechuic acids (Komai *et al.* 1991). Among these, vanillic acid is dominant. Due to its highest free radical scavenging potential, vanillic acid is expected to protect plant roots from the adverse effects produced by free radicals (Swigonska *et al.* 2014). Due to dormancy, the tubers may sustain in the soil for longer time and interfere with the crops raised in the following season. Under this situation, new strategies have to be designed to break the dormancy of the tubers.

Synthesis and characterization of nanoparticles

The metal oxide nanoparticles (nps) such as iron oxide (Saha and Bhunia 2013), silver (Saware *et al.* 2014), titanium dioxide (Wang *et al.* 2007) and zinc oxide (Talam *et al.* 2012) were synthesized in wet lab. The synthesized nanoparticles were characterized by uv-vis spectrophotometer, Fourier Transform Infrared Spectroscopy (FTIR), X- Ray Diffraction (XRD), Scanning (SEM) and Transmission Electron Microscopes (TEM).

Vanillic acid degradation studies

In order to ascertain the effect of nanoparticles on phenol degradation, commercially available vanillic acid was treated with the synthesized nanoparticles such as iron oxide, silver, titanium dioxide and zinc oxide nanoparticles. 1, 2, 4, 6, 8 and 10 ppm of vanillic acid standard solutions were prepared using HPLC grade methanol. 10 ml of 10 ppm standard solution was treated with 5, 10, 15, 20 and 25 mg of iron oxide, silver, titanium dioxide and zinc oxide nanoparticles, separately. They were sonicated and kept undisturbed for 24 hours. Blank was run simultaneously. The absorbance was read at 230 nm in uv-vis spectrophotometer. By plotting graph of concentration of nanoparticles with concentration of vanillic acid, the degradation was determined.

Effect of iron oxide nanoparticles on vanillic acid degradation

Iron oxide nanoparticle on vanillic acid (commercially available) degradation was presented in **Table 1**. Iron oxide nanoparticles recorded higher per cent degradation of vanillic acid and it was concentration dependent. The maximum degradation of vanillic acid was observed with iron oxide nanoparticles at 25 mg *i.e.*, 60.6% degradation compared to control (3.94 ppm), which was observed to be on par with iron oxide nanoparticles at 20 mg (4.12 ppm). Metal oxide nanoparticle shows photocatalytic activities. Higher the surface area available, more will be the adsorption of the target molecules and higher will be the efficiency of the photocatalytic reactions. The iron oxide nanoparticles are act as nano-adsorbent and one of the potential elements for the degradation of phenol. It is used for oxidative degradation of phenols. This is in line with findings of Tavallali and Shiri (2012). Due to the biologically inert and non-toxic nature, iron oxide was chosen for the degradation of phenol present in the tubers of *C. rotundus* which is the main inhibitor of germination.

Effect of silver nanoparticles on vanillic acid degradation

Silver nanoparticle on vanillic acid (commercially available) degradation was presented in **Table 1**. Silver nanoparticles exhibited well degradation of vanillic acid and the concentration was directly proportional to the degrading ability. Silver nanoparticles at 25 mg recorded the maximum degradation of vanillic acid content *i.e.*, 24.8% degradation compared to control (7.52 ppm). It was followed by silver nanoparticles of 20 mg (7.91 ppm). The photocatalytic property of the silver nanoparticles was applied in degradation of vanillic acid. Findings are in accordance with the studies of Vanaja *et al.* (2014), who had reported that, the degradation efficiency of silver nanoparticles was due to the photocatalytic behaviour and it is about 95.3% at 72 h of exposure.

Effect of titanium dioxide nanoparticles on vanillic acid degradation

Titanium dioxide nanoparticles on vanillic acid (commercially available) degradation was presented in **Table 2**. Titanium dioxide nanoparticles showed a good per cent degradation of vanillic acid in the experiment. Titanium dioxide nanoparticles at the rate of 25 mg recorded the maximum degradation of vanillic acid content *i.e.*, 54.5% degradation (4.55 ppm), which was observed to be at par with the titanium dioxide nanoparticles of 20 mg (4.87 ppm). Vanillic acid was degraded by the photocatalytic power of titanium dioxide nanoparticles. The removal efficiency of phenol was increased with the initial phenol concentration and rising of the contact time. It was confirmed by the findings of Nickheslat *et al.* (2013) who reported that the highest removal efficiency of phenol was 50% at initial phenol concentration and it was due to the photocatalytic power of titanium dioxide nanoparticles.

Table 1. Effect of iron oxide (Fe_2O_3) and silver (Ag) nps on vanillic acid (commercially available) degradation

Treatment (Concentration of nps)	Concentration of vanillic acid (ppm)	
	Fe_2O_3 nps	Ag nps
5 mg nps	9.19	9.84
10 mg nps	7.38	8.97
15 mg nps	5.94	8.40
20 mg nps	4.12	7.91
25 mg nps	3.94	7.52
LSD (p=0.05)	0.31	0.26

Effect of zinc oxide nanoparticles on vanillic acid degradation

Zinc oxide nanoparticle on vanillic acid (commercially available) degradation was presented in **Table 2**. The maximum degradation of vanillic acid was observed with zinc oxide nanoparticles at the rate of 25 mg *i.e.*, 49.3% degradation compared to control (5.07 ppm) which was observed to be on par with the zinc oxide nanoparticles of 20 mg (5.14 ppm). The photocatalytic behaviour of the zinc oxide nanoparticles was applied in vanillic acid degradation. Zinc oxide nanoparticles, with a high surface reactivity owing to large number of active sites, have emerged to be an efficient photocatalyst. Kruefu *et al.* (2012) reported that zinc oxide nanoparticles have better photocatalytic activity over phenol degradation.

Table 2. Effect of titanium dioxide (TiO_2) and zinc oxide (ZnO) nps on vanillic acid (commercially available) degradation

Treatment (Concentration of nps)	Concentration of vanillic acid (ppm)	
	TiO_2 nps	ZnO nps
5 mg nps	9.24	9.43
10 mg nps	7.49	8.01
15 mg nps	6.35	7.54
20 mg nps	4.87	5.14
25 mg nps	4.55	5.07
LSD (p=0.05)	0.61	0.18

Comparing all nanoparticles iron oxide nanoparticles recorded higher rate of vanillic acid degradation followed by titanium dioxide, zinc oxide and silver nanoparticles (**Figure 1**).

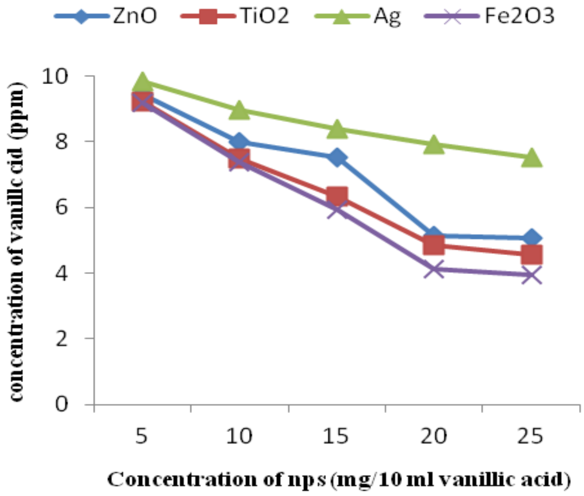

Figure 1. Effect of nanoparticles on vanillic acid degradation

Vanillic acid has been identified as one of the important phenolic compound present in the C. *rotundus* tuber. The metal oxide nanoparticle tested in this experiment effectively degraded the phytophenol at all concentrations. Maximum degradation of vanillic acid was observed with iron oxide nanoparticles at 25 mg *i.e.*, 60.6% degradation compared to control. Titanium dioxide, zinc oxide and silver nanoparticles at 25 mg recorded 54.5, 49.3 and 24.8% degradation, respectively. By degrading the germination inhibitor, the buds present in each tuber burst open and thus the entire network of tuber germinate at a time. Once the weed appear above ground can be managed effectively with the different means of control measures.

REFERENCES

Jangaard NO, Scker, MM and Schieferstein RH. 1971. The role of phenolics and abscisic acid in nutsedge tuber dormancy. *Weed Science* **19**: 17–20.

Kadir JB, Charudattan R, Stall WM and Brecke BJ. 2000. Field efficacy of *Dactylaria higginsii* as a bioherbicide for the control of purple nutsedge. *Weed Technology* **14**(1): 1–6.

Komai K, Tang CS and Nishimoto RK. 1991. Chemotypes of *Cyperus rotundus* in Pacific Rim and Basin: Distribution and inhibitory activities of their essential oils. *Journal of Chemical Ecology* **17**: 1–8.

Kruefu V, Ninsonti H, Wetchakun N, Inceesungvorn B, Pookmane P and Phanichphant S. 2012. Photocatalytic Degradation of Phenol Using Nb-loaded ZnO Nanoparticles. *Engineering Journal* **16**(3): 91–99.

Nickheslat A, Amin M, Izanloo H, Fatehizadeh A and Mousavi SM. 2013. Phenol photocatalytic degradation by advanced oxidation process under ultraviolet radiation using titanium dioxide. *Journal of Environmental and Public Health*. http://dx.doi.org/10.1155/2013/815310.

Saha S and Bhunia AK. 2013. Synthesis of Fe_2O_3 nanoparticles and study of its structural, optical properties. *Journal of Physical Science* **17**: 191–195.

Saware K, Aurade RM, Jayanthi PDK and Abbaraju V. 2014. Modulatory effect of citrate reduced gold and biosynthesized silver nanoparticles on 5ØüÞ-amylase activity. *Journal of Nanoparticles*. http://dx.doi.org/10.1155/2015/829718.

Stoller EW. 1975. Growth, development and physiology of yellow nutsedge. Proceedings of the North Central Weed Control Conference. **20**: 124–125.

Swigonska S, Amarowicz R, Krol1 A, Mostek A, Badowiec A and Weidner S. 2014. Influence of abiotic stress during soybean germination followed by recovery on the phenolic compounds of radicles and their antioxidant capacity. *Acta Societatis Botanicorum Poloniae* **83**(3): 209–218.

Talam S, Karumuri SR and Gunnam N. 2012. Synthesis, characterization, and spectroscopic properties of ZnO nanoparticles. *Nanotechnology.*, http://dx.doi.org/10.5402/2012/372505.

Tavallali H and Shiri M. 2012. Solid phase extraction of phenol from wastewater by magnetic iron oxide nanoparticles. *International Journal of ChemTech Research* **4**(1): 311–318.

Vanaja M, Paulkumar K, Baburaja M, Rajeshkumar S, Gnanajobitha G, Malarkodi C, Sivakavinesan M and Annadurai G. 2014. Degradation of methylene blue using biologically synthesized silver nanoparticles. *Bioinorganic Chemistry and Appl*ications **10**. http:/dx.doi.org/10.1155/2014/742346.

Wang P, Wang D, Li H, Xie T, Wang H and Du Z. 2007. Priority communication A facile solution-phase synthesis of high qualtity water-soluble anatase TiO_2 nanocrystals. *Journal of Colliod and Interface Sci*ence **314**: 337–340.