

Inhibition of rice seedling growth in Ga- and In-contaminated acidic soils is respectively caused by Al and Al + In toxicity

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Abstract

Limited information exists on the effects of emerging contaminants gallium (Ga) and indium (In) on rice plant growth. This study investigated the effects on growth and uptake of Ga and In by rice plants grown in soils with different properties. Pot experiment was conducted and the rice seedlings were grown in two soils of different pH (Pc and Cf) spiked with various Ga and In concentrations. The results showed concentrations of Ga, In, and Al in soil pore water increased with Ga- or In-spiking in acidic Pc soils, significantly decreasing growth indices. According to the dose-response curve, we observed that the EC₅₀ (effective concentration resulting in 50 % growth inhibition) values for Ga and In treatments were 271 and 390 mg kg⁻¹ in Pc soils, respectively. The context of previous hydroponic studies suggests that growth inhibition of rice seedlings in Ga-spiked Pc soils is mainly due to Al toxicity resulting from enhanced Al release through competitive adsorption of Ga, rather than from Ga toxicity. In In-spiked Pc soils, both In and Al toxicity resulted in growth inhibition, while no such effect was found in Cf soils due to the low availability of Ga, In and Al under neutral pH conditions.

Deriving solar irradiance and pan evaporation from satellite data

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Abstract:

Knowledge about spatial and temporal variations of surface global solar radiation (GSR) and evaporative loss of water from ground (ET) are important to many researches and applications. In this study, empirical relationships have been established for GSR retrieval from geostationary satellite images by Heliosat-3 method. The derived GSR data have also been used to generate consecutive maps of 10-day averaged pan evaporation (Epan) as the basis to produce regional ET estimation by a strategy that does not require remote sensed land surface temperatures (LST). The retrieved daily GSR and the derived 10-day averaged Epan were validated against measurements of pyranometer and class-A pan at selected Central Weather Bureau (CWB) stations spread at various climatic regions in Taiwan. Comparing with CWB observed data, the overall relative mean bias deviations (MDB%) and root mean square differences (RMSD%) in daily solar irradiance retrieval were about 5% and 15%, respectively. Seasonally, the largest MDB% and RMSD% of retrieved daily solar irradiance both occurred in spring (9.5% and 21.3% on average), while the least MDB% (-0.3% on average) and RMSD% (9.7% on average) occurred in autumn and winter, respectively. For 10-day averaged Epan estimation, mean MBD% and RMSD% for stations located at coastal plain areas were 0.1% and 16.9%, respectively. However, in mountainous areas, the mean MBD% and RMSD% increased to 30.2% and 34.5%, respectively. The overestimation was mainly due to the large differences in surrounding microenvironments between the mountainous and plain areas.

Fractionation of chromium and nickel in serpentine soils from temperate to tropical regions

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Abstract

Serpentine soils contain high levels of geogenic Cr and Ni, which may pose potential risk to the environment due to the increase of bioavailability of the metals during soil weathering. This study determined the lability of Cr and Ni by sequential selective extraction (SSE) and illustrated its relationships to mineral composition and physicochemical properties of serpentine soils for eight pedons along a pedoclimate gradient including temperate, subtropical, and tropical regions in Austria, Japan, Taiwan, and Indonesia. Although the mineral origin of Cr was different from that of Ni, Cr significantly accompanied Ni in various pedoclimates. Geochemical Cr and Ni fractions (by SSE) followed the order: residual (F4) > Fe/Mn oxide (F2) > organic matter (F3) > acid soluble (F1). Soil properties associated with changes in climate/weathering state, including pH, organic carbon, exchangeable Ca/Mg, and dithionite-citrate-bicarbonate extractable Fe, correlated with all fractions of Cr and Ni. Individual and the sum of all labile pools ($\Sigma F1-F3$) of Ni were much higher than those of Cr in all pedons. Cr and Ni bound to Fe/Mn oxides (F2) was higher in the tropical soils than in the temperate soils, while Cr and Ni bound to organic matter (F3) was higher in the temperate soils than in the tropical soils along this pedoclimate gradient. Our results demonstrate that Cr and Ni are gradually transformed into labile pools in the soils as chemical weathering progresses from temperate to tropical climate.

Key words: bioavailability; heavy metal; sequential extraction; soil geochemistry; ultramafics

Vanadium background levels in different types of soils from Taiwan

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Abstract

The global vanadium (V) demand in industry increased 8% from 2006 to 2014, and it is predictable that the global V demand will become 3.45% higher in next decade. This increase of global V demand may lead to more potential risk to the environment than before. According to the International Agency for Research on Cancer, vanadium pentoxide is a possible carcinogenic to humans. However, only 5 countries currently regulate the guideline of soil vanadium except for Taiwan. Therefore, this study attempted to set up a baseline of soil vanadium from nine pedons with 45 horizon samples. These pedons were selected from different parent materials for the monitoring of soil and environmental quality. Additionally, total V was analyzed by using portable x-ray fluorescence (PXRF) in situ and ICP followed with HF-digestion in lab. From the experimental results by ICP, total vanadium concentration in the soils from Taiwan ranged from 35.4 mg/kg to 392 mg/kg and the average level was 144 mg/kg. Moreover, total vanadium concentrations in the mafic (basalt) soils were higher than in the felsic (slate, sandstone and shale, and andesite) soils. However, the degree of soil weathering did not clearly affect the V concentration between pedons. Additionally, V concentration obtained from PXRF positively correlated well with that by ICP, demonstrating PXRF was an feasible alternative to determine V in the field for rapid screening of V.

Keywords: vanadium; PXRF; ICP-AES; soil contamination

Characterization of geochemical elements in serpentine soils by portable X-ray fluorescence

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Abstract

Serpentine soils are characterized with higher concentrations of Mg, Cr, and Ni than the soils from other parent materials. The balance between Ca and Mg is crucial to soil fertility. Additionally, excessive Cr and Ni in soils may contribute to ecological and environmental risk. Therefore, rapid quantification of these elements in serpentine soils is important in the field for soil and environmental quality. Portable X-ray fluorescence (pXRF) has the potential to provide rapid, cost-effective, non-destructive alternatives to traditional expensive and time-consuming wet chemistry analysis, which has been recommended to field screening of elements in soils. Accordingly, this study used pXRF with matrix matched calibration performed every 10 cm in three times for a pedon, collected from a serpentine area in eastern Taiwan. The horizon soil samples were further divided into three parts of subsamples. They were fresh, sieved less than 10 mesh and sieved less than 100 mesh ones for quantifying Mg, Ca, Cr and Ni. The experimental results indicated that concentrations of all elements from the 10 mesh samples were highest and those from the fresh ones were lowest. These differences illustrated that the methodology of pXRF was dependent on water content and particle size. Moreover, the variation of vertical distribution of Cr was clearer than Ni due to the difference of elements sources in the soils. Cr was mainly from chromite which was always locally distributed in the serpentine soils, but the other elements were from homogeneous silicates. The value of Ca/Mg ratio ranged from 0.09-0.32 and decreased with the increase of soil depth, demonstrating that study soil can be verified as soils by pXRF.

Key words: Serpentine soil; pXRF; chromite; chromium; nickel.

Carbon storage along a chronosequence of basaltic soils in Penghu Island, Taiwan

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Abstract

Global and regional soil organic carbon (SOC) has attracted the attention from publics due to climate change. Numerous factors would contribute to the accumulation of soil organic carbon. However, soil chronosequence is the best case to study SOC stock for understanding the shift of SOC accumulation with different soil ages. In this study, four soil pedons were sampled to determine the content of organic carbon and calculate the SOC stocks to the depth of 100 cm. All pedons were situated along a chronosequence in Penghu Island of Taiwan to investigate in the correlation between soil relative age and SOC stock. From the experimental results, the pedons from the stratigraphic age of 12.2 Ma contained 8.8-9.5 kg/m² of SOC stock in the depth of 0-100 cm; however, the stock ranged in 7.0-7.3 kg/m² in the pedons at the stratigraphic age of 8.2-8.5 Ma. The SOC stocks in the top 30 cm or 50 cm depth did not show clear difference between pedons, which indicates that over a wide range of time scales the SOC stock in the 0-100 cm depth is more likely to reflect the chronological age.

Key words: Carbon sequestration, Basaltic soil, Chronosequence, Soil organic carbon (SOC).

Feasibility of Using Reservoir Sediments Amended with Organic Matter as the Tray Nursery Substrate for Rice Seedlings

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Abstract

The nursery substrate soil for growing rice seedlings mostly come from the mountain areas in Taiwan. This practice has caused serious concern due to its negative effects on soil conservation. In this study, the feasibility of using reservoir sediments as alternative nursery substrate for rice seedlings was investigated. Two sediments with the textures of clay and sandy loam were amended with 0%, 5%, 10% and 20% rice husk (RH) and rice husk biochar (RHB) (pyrolysis at 500 °C) and added with mixed fertilizers (Urea 0.08 g, Na₂HPO₄ 0.06 g, KCl 0.08 g per 100 g treatment soil). Eight grams of the pretreated rice seeds were then grown in each treatment under a submerged condition for 15 days. The chemical composition of the soil solutions, including the N and P concentrations, DOC, pH and Eh, were analyzed at a time interval of 5 days during the growing period. The seedling height and biomass were measured at the day 4, 9, and 14. The results showed that the fine sediment was a better alternative substrate for rice seedlings than the coarse sediment that exhibited a lower seedling quality. The results also showed that both sediments amended with 5%~10% RH and RHB have better performances in rice seedling heights. On the other hand, RHB amendment can better increase seedling growth than RH amendment. To sum up, it is technically feasible to use reservoir sediments as nursery substrate for growing rice seedlings. Furthermore, this application can benefit the recycling and the reuse of reservoir sediments as well as agricultural by-products, such as rice husk.

Key words: rice seedling; nursery substrate; reservoir sediment; rice husk; biochar; organic matter

Effects of low molecular organic acids on Cr(III) photo-oxidation in the presence of Fe(III)

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Abstract

Chromium is a commonly found pollutant in the soils/sediments and water bodies because it can be discharged intentionally or unintentionally from various industrial activities. Chromium exists in two major forms of Cr(III) and Cr(VI). The physicochemical properties and toxicities of Cr(VI) and Cr(III) are quite different. Cr(III) is a cation, exhibiting a lower mobility and toxicity than that of Cr(VI), and thus, the possible oxidation of Cr(III) to harmful Cr(VI) in a natural system had received much scientific concerns in the past decades.

Photolysis of FeOH^{2+} is a well-known pathway occurred naturally which are capable of generating hydroxyl radicals ($\cdot\text{OH}$) for Cr(III) oxidation in an acidic solution. These reactions may be modified by the low molecular weight organic acid (LMWOA), because LMWOA distributes widely in the environment which may participate in the redox reactions. However, the role of LMWOA in regulating Fe species and subsequent Cr(III) photo-oxidation as influenced by pH remains unexplored. To evaluate precisely Cr transformation and fate, it is necessary to investigate the reactions of Fe(III) photolysis and Cr(III) photo-oxidation in detail when various LMWOAs are presented. Therefore, the objectives of this study are to evaluate systematically the effects of irradiation, pH and LMWOAs, including citric acid, oxalic acid and acetic acid, on the photo-oxidation of Cr(III) in the presence of Fe(III). Benzene was used as OH radical scavenger to investigate the reaction mechanisms of photo-oxidation of Cr(III) in the Fe(III)/organic system through the kinetic studies.

Result showed that Cr(III) could be oxidized in the presence of Fe(III) at pH 2-4 under UV irradiation. At pH 3, Cr(III) photo-oxidation exhibited the highest efficiency because the proportion of FeOH^{2+} , a major Fe species of generating OH radicals upon its photolysis, was greatest according to the calculations by a chemical equilibrium model of Visual MINTEQ. Phenol, formed by interacting benzene with OH radicals, it was confirmed that OH radicals were the major oxidants for Cr(III) in the acidic solution containing Fe(III). Although both phenol and Cr(VI) formations were attributed to the OH radical productions, the ratio of phenol/Cr(VI) did not maintain a constant value. The results demonstrated that some side reactions, such as Cr(VI) reduction by Fe(II), were involved in the Cr(III) photo-oxidation reactions.

With the addition of 50-400 μM citrate and oxalate into a system with 400 μM Fe(III) at pH 3, 300 μM Cr(III) photo-oxidation was greatly inhibited, and thus, no discernible Cr(VI) were

produced within 4 h reactions. Even if the OH radicals could still be produced through the photolysis of $\text{Fe}(\text{OH})^{2+}$ or Fe-organic complexes in the organic-containing systems, the rapid reduction of Cr(VI) by these two organic compounds may overwhelm Cr(III) photo-oxidation. Besides, a significant increase in Fe(II) productions, derived from the photolysis of Fe-organic complexes, were observed with the addition of the organic compounds. Rapid reduction of Cr(VI) by Fe(II) in an acidic solution may be the alternative reason inhibiting Cr(VI) productions. Dissolved oxygen (DO) was involved in photolysis of Fe-organic complexes, and thus, a decrease in DO concentrations was observed at the initial reaction time. However, with an accumulation of Fe(II), the interactions of $\text{O}_2^{\bullet-}$, a photolytic product, with Fe(II) may release the O_2 molecules and lead to an elevation of DO.

Unlike the system with citrate and oxalate, Cr(III) photo-oxidation reactions was not inhibited completely in the acetate system. Because acetate would not complex with Fe(III), photolysis of Fe-organic complexes did not occur. Therefore, the OH radical productions were mainly from the photolysis of $\text{Fe}(\text{OH})^{2+}$, and thus, acetate may serve as a reductant when it was added into the irradiated Fe(III)/Cr(III) system. However, with the addition of higher concentrations of acetate (i.e., $> 50 \mu\text{M}$), the oxidative product of acetate, i.e., $\bullet\text{CH}_2\text{CO}_2\text{H}$, may react with Fe(II) and promote $\text{Fe}(\text{OH})^{2+}$ productions. Thus, the inhibition of Cr(VI) production was comparable lower when higher concentrations of acetate were added.

Indigenous Removal of Selenite and selenate Using Al/Si and Fe/Si coprecipitates

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Abstract

Selenium (Se) is a critical micronutrient to the health of living organisms, but it has a narrow range between dietary deficiency and toxic level. The predominant species of Se in aqueous environments are selenate (SeVI) and selenite (SeIV), which possess high mobility and bioavailability due to their high solubility. Anthropogenic activities, such as mining, agriculture, power generation, and oil and gas industry sectors can bring excess Se into ecosystems. Once being released into the environment, Se will be rapidly distributed and may reach to a levels that is toxic to fish and wildlife. Selenium (Se) is extensively used in electrical rectifiers, photocells, photoexponometers, and other semiconductor devices. Inappropriate handling the effluents of semiconductor plants have led to the releases and wide distributions of Se in the ecosystems. To prevent further deteriorations of environments, decreasing Se discharges and the development of low cost and reliable technologies, including precipitation, adsorption, and oxidation/reduction, for Se removal from the waste streams of industries are of major priority. Elucidating the removal efficiency of Se in the environments is important to eliminate the potential risks derived from Se toxicity. In this study, Al/Si and Fe/Si coprecipitates were selected as model adsorbents, and the removal efficiency of selenite and selenate, two major Se species in environments, onto the coprecipitates were systematically examined. The surface properties of Al/Si and Fe/Si coprecipitates affected strongly on selenite and selenate removal. The Si core with Al shell structure of the Al/Si system shielded more efficiently the negative charges from SiO₂, resulting in a higher zero points of surface charges than that of Fe/Si system. Thus, adsorption of selenite/selenate was favorable in the Al/Si system. Both selenite and selenate adsorption on Al/Si coprecipitates exhibited exothermic reactions, which was also observed while selenite was adsorbed on Fe/Si coprecipitates. However, selenate adsorption on the Fe/Si coprecipitates increased with increasing reaction temperature, suggesting the occurrence of endothermic reaction. The kinetic adsorption data of selenite/selenate on Al/Si and Fe/Si systems were described well by the pseudo-second-order kinetic model. Selenate and selenite adsorption on Fe/Si or Al/Si were greatly inhibited by the presence of strong phosphate ligand, whereas weak ligand, such

as, sulfate, affected only selenite adsorption, indicating the lower affinity of selenate than that of selenite on the surfaces of Fe/Si and Al/Si coprecipitates. The results were further confirmed by the lower desorption percentage of selenate (< 40%) from Fe/Si systems than that of selenite (over 70%) from both Fe/Si and Al/Si systems while phosphate was presented. Selenium adsorption on Al/Si and Fe/Si coprecipitates relied on the surface properties of the adsorbents, reaction temperatures, and the presence of competitive anions. Because Al polymers were formed and bonded with the SiO₂ cores during the precipitation processes, the negative charges from the SiO₂ were shielded well by the Al polymers. Thus, compared to the Fe/Si coprecipitates, the Al/Si coprecipitates exhibited a higher PZC, which facilitated the developments of more positive charges at a given pH for adsorbing anionic forms of selenium. Because the geometric structure and chemical properties of selenite was similar to that of phosphate, the high affinity of selenite on both Fe/Si and Al/Si coprecipitates led to an enhancement of its adsorption capacity as compared to that of selenate.

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**Rice genotypic variations in Cd toxicity and absorption and the root
histochemical examination**

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Abstract:

Paddy rice (*Oryza sativa* L.) is the staple food for East and South-East Asian countries. Cadmium accumulation in soil posing risk to the safety of rice consumption has been much concerned. The maximum permissible Cd concentration of polished rice (i.e. 0.4 mg kg⁻¹) has been indicated by the Codex Alimentarius Commission of FAO/WHO. Selecting the cultivars with low Cd-accumulation is a promising way to reduce the Cd contamination of rice grain. The objective of the present study was to investigate the rice genotypic variations in Cd toxicity and plant Cd distribution for selection of Taiwan's rice cultivars with low levels of Cd-accumulation in plant.

In this study, eight cultivars of paddy rice bred with the criteria of rice grain quality in Taiwan were used. The cultivars are stated in 3 different types: japonica rice (i.e. TY3, TK9, TNG71, and KH 145), glutinous rice (i.e. TKW 1 and TKW3), and indica rice (i.e. TCS10 and TCS17). Seedlings of each cultivar developed with three leaves completely emerged were transplanted into the solutions with 5, 10, 50, 100 and 250 µM CdCl₂, respectively; further a control was set at 0 µM CdCl₂. After 7-day cultivation, plant samples were harvested, washed thoroughly with deionized water, and then measured root length and plant height. Next, root and shoot tissues were separately sampled and oven-dried at 65°C for 72 h for dry weight measurement. Dried plant materials were digested with HNO₃/HClO₄ (v/v = 4/1) and Cd concentrations in the digests were determined with a flame atomic absorption spectrophotometer. In order to carry out histochemical analyses, extra root specimens from the rice seedlings after 0 and 50 µM Cd exposures were drawn before oven-drying for digestion. Free-hand sections of the root specimens were prepared, commencing at approximately 5 mm from the root tip. They were stained with safranin-O, mounted in water, and viewed under an optical microscope.

In results, the Cd treatments resulted in significant reductions in root elongation and shoot extension for each cultivar, compared with the control. The Cd spikes exceeding 5 µM significantly reduced the root elongations of the cultivars except TK9. A reduction exceeding 50% of control in root elongation especially of TNG71 was caused by Cd exposure of 5 µM.

The reductions in shoot extension by Cd exposure of 5 μ M were higher than 50% of control for the most of cultivars except TY3 and TK9. TK9 would be the superior genotype to tolerate Cd toxicity in root elongation and shoot extension. TY3 could tolerate Cd toxicity in shoot extension most. On the contrary, TNG71 did tolerate Cd toxicity neither in root elongation nor shoot extension.

In addition, the Cd concentrations in root and shoot were significantly increased with an increase of Cd spikes for each cultivar. The root Cd concentrations of TCS10 and TCS17 were higher than those of the other cultivars, except for Cd exposures of 100 and 250 μ M. The shoot Cd concentrations of TCS10 and TCS17 were higher than those of the other cultivars certainly. That is, there was a higher Cd-absorption rate per unit solution Cd increased in the root and shoot for TCS10 and TCS17. This revealed the seedlings of TCS10 and TCS17 would have a relatively high ability in Cd accumulation. On the contrary, the root Cd concentrations of TK9 and TKW3 were relatively low; the shoot Cd concentrations of TNG71 and KH145 were relatively low. Because TNG71 and KH145 were classified in the high lignification group, their relatively low Cd concentrations in shoot would be related to their highly lignified root cell walls. Nevertheless, the Cd absorbed by rice plant would predominantly accumulate in root but rather transferred to shoot.

In summary, TNG71 and KH145 would not tolerate the Cd toxicity (i.e. exceeding 5 μ M Cd) in root elongation and shoot extension growth; however they showed the relatively low Cd concentrations in shoot. There would be a low translocation of Cd in the plant of TNG71 and KH145. The findings about the genotypic variations in Cd tolerance and accumulation in rice plant will be used in the further studies for selection of Taiwan's cultivars with low Cd in rice grain.

Viability of Biochar on Reducing C Mineralization and Improving Nutrients Status in a Compost-treated Oxisols

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Abstract:

In this study, we evaluated the in vitro C mineralization kinetics of a swine manure compost-treated Oxisols' topsoil following the addition of various amounts of biochar. We hypothesized that biochar stabilizes compost organic matter and reduces C mineralization, and further improves the nutrient status of the studied Oxisols. Top soil of Oxisols was incubated at 25 °C with 0%, 0.5%, 1.0%, and 2.0% (w/w) biochar, and each treatment has added 5% swine manure compost. Carbon mineralization was then analyzed by measuring the alkali absorption of CO₂ released at regular intervals over a 434-d observation period. Our study results confirm that biochar added to compost-treated Oxisols stabilizes compost organic matter and reduces C mineralization, and improve the nutrients status. In studied Oxisols, biochar significantly reduced C mineralization. When adding compost to soils, applying high amounts of biochar can stabilize and prevent the rapid mineralization of swine manure compost. It is important in an area with high-temperature and high-precipitation climatic condition for reducing organic fertilizer needs. The soil pH, exchangeable bases and CEC only showed minor increase with biochar addition increased. The net soil fertility change of our study revealed a positive effect of biochar on total soil C, N, P, Mehlich 3-extractable P, K, Mg, Fe, Pb and Zn, but a slightly positive and negative effect on extractable Ca, Mn and Cu. The combined effects of fertilization, leaching and adsorption of nutrients by the soil and added biochar resulted in observed variations in nutrient availability. In our studied soils, the addition of 1% biochar was the most appropriate treatment amount for compost stabilization in Oxisols. In this study, we suggested that biochar produced at high temperature could be the optimum treatment for long-term soil C sequestration and improve Oxisols nutrient status in Taiwan.

Key words: Biochar, C mineralization, Oxisols, Nutrient availability.

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Growth and Cadmium Uptake of Soybeans Cultivated in Contaminated Soils

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Abstract:

This study aimed to evaluate the feasibility of growing soybean (*Glycine max* (L.) Merr. cv. Leichhardt) as an energy crop in a cadmium-contaminated paddy field. The effects of cadmium (Cd) on the growth of soybean plants, including uptake and distribution of Cd within the different soybean tissues of mature plants, were examined. Soybean seeds were planted in the contaminated soil with < 7 mg Cd kg⁻¹ on September, 2006 and were harvested on January, 2007, at the Hemei Township of Changhua County in central Taiwan. For the control group, low Cd concentrations of uncontaminated soil were used as a comparison. As a result, the growth and the yield of soybeans are not significantly affected by the Cd contaminated soil from the field observations. In addition, the total percentages of metal decreased with increasing distance from the irrigation water inlet. However, there was no significant correlation of Cd concentration from soybean tissues to root zone soil with < 7 mg Cd kg⁻¹. The root of soybean tissues contains the highest amount of Cd and followed by leaves, stem, pod, and seed. The average amounts of Cd concentrations in seeds were 0.47 and 0.4 mg kg⁻¹ in the farmlands contaminated with means of Cd at 3.4 and 3.3 mg kg⁻¹ soil, respectively. The Cd concentrations in crude oil after press or extraction were less than 0.1 mg L⁻¹. We can conclude that although the benefit to farmers will be reduced if rice is replaced by soybean, the risk of harvesting contaminated rice grain can be avoided. Therefore, Soybeans (cv. Leichhardt) can be recommended as an alternative crop for producing bio-diesel fuel in Cd contaminated farmlands.

Key Words: Cadmium (Cd), Energy crop, *Glycine max*, Soybean

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**Influence of copper on reactive oxygen species, antioxidants, and
cations accumulation in grapevines**

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Abstract:

The intensive and long-term application of copper (Cu)-based fungicides in vineyards has led to the accumulation of Cu on the surface of some vineyard soils around the world, thus posing the problems of Cu toxicity to the organisms therein. In the present study, a hydroponic experiment was conducted to investigate the oxidative stress in leaves of grapevine exposed to elevated Cu. The nitroblue tetrazolium (NBT) and 3', 3'-diaminobenzidine (DAB) was employed as chromogenic substrate to observe the formation of superoxide and hydrogen peroxide in leaves treated with different Cu levels. Results showed that increase in Cu levels and duration of treatment led to the increase of Cu concentration in grapevine leaf. However, cations (K, Mg, and Ca) concentration was not influenced by Cu level. For antioxidants, Cu-induced increase in superoxide dismutase (SOD) activities was observed for grapevine leaves exposed to 100 μ M after 2 days. For reactive oxygen species, Cu stress increased production of H₂O₂ and malondialdehyde (MDA) after 24 and 48-hour treatment. However, a decline of SOD activity as well as H₂O₂ and MDA contents was observed after long-term exposure to higher levels of Cu. From microscopic viewpoint, Cu-induced accumulation of O₂⁻ and H₂O₂ in grapevine leaves is detected by histochemical staining of NBT and DAB. The present results indicated that Cu exposure causes severe oxidative stress to grapevine leaves.

Title: Repeated fire effects on net primary production, soil respiration, and net ecosystem production in Datu tableland, central Taiwan

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Repeated fires might have different effect on ecosystem carbon storage than a single fire event, but information on repeated fires and their effects on forest ecosystems and carbon storage is scarce. In general, the increasing fire frequency would promote the grass encroachment. The invaded grasses sprout quickly after fire and become fuel at the next fire event. This grass-fire positive feedback cycle usually results in repeated fire. In this study, we used the protection forest at Dadu tableland in central Taiwan as an example, and aimed to know how the high frequently repeated fire influences net primary production (NPP), soil respiration, and net ecosystem production (NEP). The original dominate vegetation in Datu tableland was *Acacia confuse*, and the repeated fire led to tree mortality and induced the grass (*Panicum maximum*) to invade and replace the original forest. The vegetation type in Dadu tableland includes: (1) unburned forest (*Acacia confuse*, denoted as AC), (2) grass invaded forest (IV), (3) standing dead with grass (SD) (4) grassland (GR). The NPP were higher at AC ($11.7 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$) and IV ($11.2 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$), and decreased by repeated fires. The SD and GR sites only remained 90% ($10.1 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$) and 60% ($7.0 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$) NPP of original forest. Heterotrophic soil respiration had a more constant value among vegetation type ranging between 7.0 and $8.6 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$. Therefore, the NEP decreased from 4.5 and $2.6 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$ at AC and IV, respectively, to $2.1 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$ at SD and $-0.1 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$ at GR. The resulted indicated that repeated fire is a quiet negative impact on carbon cycle.

Effects of breeding conditions on the growth and cadmium distribution of a hydroponically grown impatiens

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Abstract

Impatiens could be bred using its cutting and was evidenced to accumulate high concentration of cadmium in the shoots. To assess its best breeding conditions, a hydroponic experiment with five cadmium concentrations (0, 5, 10, 20, 40 μM), two lighting periods (12h and 20 h), and two solution intensities (50% and 100%) was conducted. The objective was to assess the suitable hydroponic situations for breeding the seedlings could be further used in the cadmium-contaminated soils. Experimental results show that various treatments did not significantly affect the root length, leaf area, chlorophyll content, and fresh weight of impatiens grown for 50 days. Impatiens grown in 50% solution intensity accumulated significantly higher cadmium concentrations compared with 100% treatment. The maximum cadmium concentration in the root and shoot was more than 2600 and 1400 mg/kg, respectively. Treatments of lighting period and solution intensity affected the subcellular distribution of cadmium but not the chemical forms. Cadmium was primarily association with pectate/protein for most of these treatments regardless of organ, lighting period, solution intensity, and solution cadmium concentration. When considering the growth exhibitions and cadmium fraction in the impatiens, 100%-12H-20 μM was the best hydroponic condition for breeding rooted cuttings with high tolerance of cadmium.

Key words: cadmium; chemical form; impatiens; phytoextraction; subcellular distribution

Effects of *in-situ* biochar incorporation on microbial community in a highly weathered soil

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Abstract:

Biochar has been considered as a potential amendment to increase soil microbial activities, but it is still vague on its effects of microbial community in the amended soils. This study aims to incorporate a wood biochar (WB), pyrolyzed at 400 °C, into a highly weathered soil to evaluate the changes of microbial community after 1 year *in-situ* incubation. Field trials were conducted in 7 treatments including control (O), biochar (2% and 4%, w/w) (WB2; WB4), compost (1%) (C), compost (1%) + biochar (2% and 4%) (CWB2; CWB4) and polyacrylamide in 50 ppm (PAM) in this study. Soil microbial communities were measured using next generation sequencing (NGS) technique in this study. The NGS analytical results indicated that the majority of sequences from CWB treatments were assigned to species *Anaerolinea thermolimosa*, *Caldithrix palaeochoryensis*, *Chthoniobacter flavus*, and *Cohnella soli*. In addition, canonical-correlation analysis (CCA) shown that the microbial community structure was obviously determined by the order of soil factors as follows: inorganic N (IN), available P (AP), pH, soil organic C (SOC), porosity and bulk density (Bd) and aggregate stability. The treatments with co-application of compost and biochar (CWB2 and CWB4) facilitate the domination of *Caldithrix palaeochoryensis*, *Chthoniobacter flavus*, and *Cohnella soli* which help decomposition of organic matter and oxidation of ammonia in the soil. Apparent increase of IN, AP, porosity and SOC resulted from biochar and compost might be the critical reason to induce the change of soil microbial community. Additional, co-application of compost and biochar are also considered as a suitable strategy for biochar incorporation in the rural soil.

Keywords: Biochar, highly weathered soil, microbial community, next generation sequencing.

Rice Hull Immobilized Indigenous Bacteria as a Novel Biofungicide against Rice Blast Disease

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Abstract:

Plant root rhizospheric microbe natural interactions are essential for plant health, plant growth and disease suppression. Exploring the abilities of naturally occurring rice soil bacteria to reduce rice blast disease, caused by the fungal pathogen *Magnaporthe oryzae*, could provide a sustainable solution to minimize the yield loss due to rice blast disease. In the Philippines alone, yield losses ranging from 50-85% have been reported. Rhizobacteria were isolated from the rice field soil in University of the Philippines Los Banos and were tested for their effectiveness to inhibit the growth of *M. oryzae*. The bacteria were identified as *Bacillus subtilis* 5, *Bacillus cereus* 3S5, and *Pseudomonas fluorescens* 10S2. The biofungicide was formulated with both rice hull mixture and liquid media which contained bacterial suspension of *Bacillus subtilis* 5, *Bacillus cereus* 3S5, and *Pseudomonas fluorescens* 10S2. The biofungicide was tested on rice cultivar UPLRi-5 under controlled conditions and the results showed decrease in rice blast disease intensity, which is 33% higher compared to the control.

Keywords: rhizobacteria, rice blast disease, biocontrol, biofungicide.

Assessing the effects of soil washing with ferric chloride on cadmium removal, soil properties and rice growth in Cd-contaminated paddy fields

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Abstract:

Cadmium (Cd) polluted in paddy field is the serious problem, and rice consumption is the major exposure pathway for Cd in many countries of Asia area, thus reducing Cd uptake by rice from soils is very important for lowering the human exposure risk to Cd. Soil washing is regarded as a high efficiency remedial technology for Cd removal. However, limited information is available on evaluating the Cd removal efficiency and crop growth after on-site soil washing. Therefore, the aim of this study is to assess the effects of soil washing with ferric chloride (FeCl_3) on the Cd removal, soil properties and rice growth in paddy fields. Four Cd-contaminated paddy fields were conducted in this study, which located in central region of Taiwan. The Cd concentrations and soil properties were measured before and after soil washing, and the soil samples were collected by grid sampling method. In addition, it also measured the growth indices and Cd concentrations in brown rice of paddy rice (*Oryza sativa* L.) grown in paddy field after soil washing. The results showed that the average Cd concentrations in soils of four tested fields were significant decreased after soil washing with FeCl_3 , and the extents of decrease in Cd concentrations of four tested fields were 46.5%, 17.0%, 61.7% and 36.8%, respectively. It observed that the pH, EC and available P of soils were changed after soil washing, but there were no significant differences in available N, total N, organic carbon and cation exchange capacity (CEC) of soils between before and after soil washing. From the results of rice growth, it indicated that there was no significant decrease in shoot height, shoot biomass and grain yield of paddy rice grown in soils after soil washing, it also found that the concentration of Cd accumulated in brown rice were reduced. In conclusion, the results of this study indicated that the on-site soil washing with FeCl_3 could reduce the Cd concentration in soils and brown rice effectively. In spite of the soil washing had slightly effect on the soil properties, it could be restored through lime and fertilizer supplied. Therefore, it suggested that the on-site soil washing may be a feasible remedial technology for Cd removal in Cd-contaminated paddy soils.

Humic Acid Coprecipitation with Ferrihydrite: Microscopic Mechanisms and the Impact on Phosphate Adsorption

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Abstract:

Ferric hydroxides critically influence the preservation of organic matter (OM) and the bioavailability of oxyanions like arsenate and phosphate. While adsorption and coprecipitation of water-extractable OM on Fe hydroxides has been well documented, little is known regarding Fe coprecipitation with more complex humic acid (HA). We aimed to determine the C stabilization and phosphate adsorption capacity of HA/Fe coprecipitates in relation to surface and structural characteristics as affected by HA types and C/(C+Fe) molar ratios. With increasing C/(C+Fe) ratios, the decreasing proportion of near-surface C for coprecipitates containing HA enriched in polar functional groups implied a homogeneous distribution between C and Fe domains, yielding PO₄ sorption properties nearly equivalent to that of ferrihydrite. Structural disruptions of Fe hydroxides domains caused by their highly association with polar functional groups of HA enhanced the C solubilisation. While polar functional groups were limited, coprecipitates were composites consisting of core Fe hydroxide domains with surface outgrowth of HA domains. This surface-attached HA that was vulnerable to solubilisation blocked reactive sites on Fe hydroxides, leading to a significant decrease in PO₄ adsorption.