Title	**Impacts of heavy metals and medicinal crops on ecological systems, environmental pollution, cultivation, and production processes in China**
Author Name	Yi-Gong Chen, Xing-Li-Shang He, Jia-Hui Huang, Rong Luo, Hong-Zhang Ge, Anna Wołowicz, Monika Wawrzkiewicz, Agnieszka Gładysz-Płaska, BoLia Qiao-Xian Yu, Dorota Kołodyńska, Gui-Yuan Lv, Su-Hong Chen
Journal Name	Ecotoxicology and Environmental Safety
Year	2021
Volume and Issue	219
Pages	112336
Abstracts	Heavy metals are widely distributed in the environment due to the natural processes and anthropogenic human activities. Their migration into no contaminated areas contributing towards pollution of the ecosystems e.g. soils, plants, water and air. It is recognized that heavy metals due to their toxicity, long persistence in nature can accumulate in the trophic chain and cause organism dysfunction. Although the popularity of herbal medicine is rapidly increasing all over the world heavy metal toxicity has a great impact and importance on herbal plants and consequently affects the quality of herbal raw materials, herbal extracts, the safety and marketability of drugs. Effective control of heavy metal content in herbal plants using in pharmaceutical and food industries has become indispensable. Therefore, this review describes various important factors such as ecological and environmental pollution, cultivation and harvest of herbal plants and manufacturing processes which effects on the quality of herbal plants and then on Chinese herbal medicines which influence human health. This review also proposes possible management strategies to recover environmental sustainability and medication safety. About 276 published studies (1988–2021) are reviewed in this paper.
Keywords	Heavy metals; Medicinal crops; Ecological effects; Environmental pollution; Manufacturing process

Title	**Ecological indicators and bioindicator plant species for biomonitoring industrial pollution: Eco-based environmental assessment**
Author Name	InesTerwayet Bayouli, Houssem Terwayet Bayouli, Aronne Dell'Oca, Erik Meers, Jian Sun
Journal Name	Ecological Indicators
Year	2021
Volume and Issue	125
Pages	107508
Abstracts	Industrial pollution remains a driving force to ecosystem alteration. Pollutants are released in the atmosphere interacting in turn with other components of earth system such as plant species. Despite the long-term exposition of vegetation cover to pollution is drastically devastating, less is known about the contribution of ecological indicators for its monitoring. The aims of this study are (i) to introduce the ecological indicators in assessing the cement dust impact on plant species and its biomonitoring and (ii) to screen new indicator species for phytoremediation studies. Floristic surveys were conducted in the cement plant closeness following quadrat method. Vegetation indicators such as total plant cover, perennial and annual species densities and diversity were assessed. Bioindicator species were identified using the bioaccumulation factor (BF) and translocation factor (TF). A decrease of perennial species richness and a decline of total vegetation cover by 7 times as well as a diversity decrease ranging from 2.99 to 2.31 were found pertinent indicators of land degradation in the industrial area. Annual species densities were significantly affected by cement pollution. Species like *Lygeum spartum*, *Atractylis serratuloides* and *Gymnocarpos decander* arise as indicators of heavy metals pollution. Pollution in the cement plant vicinity excluded sensitive species like *Helianthemum kahiricum*, *Stipa tenassissima*, *Plantago coronopus*. This study allowed the identification of indicator species of potential use in phytoremediation applications and emphasized the possibility of relaying on the vegetation indicators to assess the impact of cement pollution.
Keywords	Vegetation cover; Tolerant species; Floristic diversity; Industrial pollution; Cement plants; Ecological indicators

Title	**Understanding the holistic approach to plant-microbe remediation technologies for removing heavy metals and radionuclides from soil**
Author Name	Mayur Thakare, Hemen Sarma, Shraddha Datar, Arpita Roy, Prajakta Pawar, Kanupriya Gupta, Soumya Pandit, Ram Prasad
Journal Name	Current Research in Biotechnology
Year	2021
Volume and Issue	3
Pages	84-98
Abstracts	Heavy metals (HMs) and radionuclides are released through geological and anthropogenic activities and enter the environment through wastewater, soil and sediment. Large amounts of Pb (>1000 ppm), Zn (>4000 ppm) and Cd (40–400 ppm) have recently been reported in soils near Picher, USA. These inorganic pollutants cannot be degraded and cause damage to the vital human organs. Different industrial and municipal solid waste was a major source of HMs in soil, including airborne aerosols. In the same manner, nuclear waste and radioactive materials used (e.g., medical facilities) or released in different processes contribute to the environmental pollution of radionuclides. The release of such HMs ions from different sources leads to mutagenesis, carcinogenesis and poses serious risks to the living organisms. As a result, proper management of waste from these sources, as well as environmentally friendly remediation methods, is imperative. However, recent studies have shown that it is more difficult to remove HMs and radionuclides from the soil, but they can be effectively neutralized or converted into a less toxic metabolites. The combination of a unique plant-microbe system plays a key role in the remediation process. However, new bioremediation methods are now being used to eliminate HMs and radionuclides. Microbes are capable of bio-transforming, bio-sorbing and biomineralizing HMs and radionuclides through their inherent catabolic process. Enhancing phytoremediation using different strategies for the remediation of HMs and radionuclides is necessary to ensure that the land resource is safe, fertile and productive for sustainable use.
Keywords	Heavy-metals; Radionuclides; Microbes enhanced phytoremediation; Plant growth-promoting rhizobacteria (PGPR); Sustainability; Toxicity

Title	**Effects of heavy metals and organic matter fractions on the fungal communities in mangrove sediments from Techeng Isle, South China**
Author Name	Yunzhu Xiao, Maoyu He, Jiefen Xie, Li Liu, Xiaoyong Zhang
Journal Name	Ecotoxicology and Environmental Safety
Year	2021
Volume and Issue	222
Pages	112545
Abstracts	Heavy metal pollution has become a serious environmental problem in mangrove ecosystems and has attracted more attention. Most of previous studies have mainly focused on the effects of heavy metals on bacterial communities in mangrove sediments. This study was the first to investigate the effects of heavy metals (e.g., As, Co, Cr, Cu, Mn, Ni, Pb, V and Zn) and organic matter fractions (including total organic carbon (TOC), total nitrogen (TN), and total sulfur (TS)) on the fungal communities in mangrove sediments from Techeng Isle, South China. The results of this study indicated that the average contents of Mn, Pb and V of 8.30–161.80 μg/g presented relatively higher pollution levels, while the concentrations of Zn, Cr, Cu and Ni of 0.80–21.93 μg/g were lower than those recorded in other mangrove ecosystems. Furthermore, the sediment fungal community structures responded differently to the nine heavy metals and three organic matter fractions. Heavy metals Cr, Pb and V displayed significant positive correlations with Eutypella ($P < 0.05$), whereas significant negative correlations with *Cystobasidium, Lulworthia, Cladosporium, Lulwoana* and *Cephalotheca* ($P < 0.05$). In addition, the effects of heavy metals and TS on many fungal genera were opposite to those of TOC and TN. Fungal genera that decreased with high TOC and TN contents may be increased with high heavy metal contents and TS, and vice versa, and the genera that increased with high TOC and TN contents may be decreased with high heavy metals and TS. Our results suggested that many heavy metals, such as Cr, Pb and V, were sensitive to several fungal genera in mangrove sediments, and heavy metals together with organic matter fractions may participate and shape the fungal communities in mangrove sediments.
Keywords	Heavy metals; Fungal communities; Mangrove sediments; South China

Title	Morpho-physiological retardations due to iron toxicity involve redox imbalance rather than photosynthetic damages in tomato
Author Name	UrmiDas, Md MotiurRahman, Zuthika Rani Roy, Md MominurRahman, Ahmad Humayan Kabir
Journal Name	Plant Physiology and Biochemistry
Year	2020
Volume and Issue	156
Pages	55-63
Abstracts	Iron (Fe) toxicity is a major nutritional disorder that affects growth and yield in plants. Understanding the responses or damages due to Fe-toxicity may provide useful knowledge to improve tomato varieties. This study investigates the physiological and molecular responses in Fe-toxic tomato plants. The tomato plants were grown in separate hydroponic containers with two concentrations of Fe-EDTA (25 μM and 5 mM) in addition to the other nutrient elements. Fe-toxicity showed a severe reduction in growth parameters, which was accompanied by the increased electrolyte leakage and cell death in tomato. However, the SPAD score, quantum efficiency of PSII, and photosynthesis performance index did not show any changes in leaves, suggesting that damages due to Fe-toxicity are not related to the photosynthetic disturbance in tomato. The FCR (ferric chelate reductase) activity in root along with the Fe concentration in root and shoot significantly increased, being consistent with the upregulation of Fe-related genes (*SlNramp1* and *SlFRO1*) in roots. It suggests that inefficiency to cope with elevated Fe is closely linked to Fe mobilization and uptake in roots of tomato. Consequently, this sensitive genotype was more prone to oxidative damages because of the inefficient antioxidant defense linked to antioxidant enzymes and metabolites. In conclusion, the growth retardation in Fe-toxic tomato is not related to photosynthetic inefficiency but highly associated with oxidative injuries in cells. These findings could be targeted in breeding or transgenic program to improve tomato plants sensitive to Fe toxicity.
Keywords	Iron toxicity; Tomato; Fe-reductase activity; Redox imbalance; PSII

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Keywords	Iron toxicity; Tomato; Fe-reductase activity; Redox imbalance; PSII

Title	**Enhancing Iron uptake and Alleviating Iron Toxicity in Wheat by Plant Growth-Promoting Bacteria: Theories and Practices**
Author Name	Le He, Zonghao Yue, Can Chen, Chunyan Li, Juan Li and Zhongke Sun
Journal Name	International Journal of Agriculture & Biology
Year	2020
Volume and Issue	23(1)
Pages	190-196
Abstracts	Though iron is a rich mineral in soil, its bioavailability for many crops is low. Considering the vital role of iron in all organisms, iron deficiency (ID) is one of the most widespread and common nutritional problem in the world. The hidden hunger caused by ID seriously affects the quality of human life and economic development. As one of the major staple foods, wheat grain is in short of iron as well. Iron absorbing in wheat is mainly through its root by the strategy II which gets iron from the rhizosphere through the release and uptake of Fe-chelating mugineic acid phytosiderophores. Meanwhile, there are versatile bacteria lived in both the rhizosphere and indigenous region of wheat root. Many of them are communistic or termed plant growth-promoting bacteria (PGPB), needing iron for growth and work as well. Contrasting to wheat, bacteria uptakes both dissociative inorganic and associative organic iron combined with siderophores more efficiently, mainly through different ATP binding cassette transporters. Laboratory and field experiments showed many PGPB improve wheat iron uptake when iron is deficient by producing different metabolites and regulating transporters, which provided basis for a microbiological strategy to iron biofortification. On the other side, many PGPB reduced iron toxicity to wheat as their strong bioleaching capacity and negative regulation of iron uptake or transport when iron is plenty © 2020 Friends Science Publishers.
Keywords	Iron uptake; Iron deficiency; Iron toxicity; Wheat; PGPB

Title	Phenotypic Assessment of Natural Diversity in Low-Land Rice Germplasm as Affected by Iron Toxicity
Author Name	Saha, D., Mohanty, I. C., Panda, S., Bastia, D., & Pradhan, S.
Journal Name	Current Journal of Applied Science and Technology
Year	2020
Volume and Issue	39(15)
Pages	43-51
Abstracts	Iron toxicity that seriously affect rice yield is a critical concern for the crop improvement programs in rice. Morphological analysis of germplasm is essential for the success of varietal crop improvement programs. The objective of this investigation is to estimate the phenotypic diversification of one hundred and fifty germplasm to identify the tolerant genotypes under iron toxic situation for exploitation of inherited variability from the accessible germplasm. Experiment has been carried out under lowland field condition to determine the reaction of rice germplasm under hotspots for iron toxicity. Significant differences among the genotypes have been observed. A significant difference is present among all the traits like days to 50% flowering, Plant height, panicle length, grain/panicle, grain weight, yield, leaf bronzing index (LBI) and tillers number. The phylogenetic analysis was also carried out to find out a core population for further study like association mapping with trait of interest. The genotypes like Mahsuri, Kusuma, Ganjamgedi, Pratikhya, Swarna, Dhusura have been found to be tolerant genotypes under iron toxic condition.
Keywords	Iron toxicity, genetic diversity, tolerant, morphological

Title	Preliminary study on the electrocatalytic performance of an iron biochar catalyst prepared from iron-enriched plants
Author Name	XinqiangCao YingpingHuang, ChangcunTang, JianzhuWang, DavidJonson, YanfenFang
Journal Name	Journal of Environmental Sciences
Year	2020
Volume and Issue	88
Pages	81-89
Abstracts	*Eichhornia crassipes* is a hyperaccumulator of metals and has been widely used to remove metal pollutants from water, but disposal of contaminated plants is problematic. Biochar prepared from plants is commonly used to remediate soils and sequester carbon. Here, the catalytic activity of biochar prepared from plants enriched with iron was investigated as a potentially beneficial use of metal-contaminated plants. In a 30-day hydroponic experiment, *E. crassipes* was exposed to different concentrations of Fe(III) (0, 4, 8, 16, 32 and 64 mg/L), and Fe-biochar (Fe-BC) was prepared by pyrolysis of the plant roots. The biochar was characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray spectrometry (EDS), Brunauer–Emmett–Teller (BET) analysis, X-ray photoelectron spectroscopy (XPS) and atomic absorption spectrometry (AAS). The original root morphology was visible and iron was present as γ-Fe2O3 and Fe3O4. The biochar enriched with Fe(III) at 8 mg/L (8-Fe-BC) had the smallest specific surface area (SSA, 13.54 m^2/g) and the highest Fe content (27.9 mg/g). Fe-BC catalytic activity was tested in the electrocatalytic reduction of H_2O_2 using cyclic voltammetry (CV). The largest reduction current (1.82 mA/cm^2) was displayed by 8-Fe-BC, indicating the highest potential catalytic activity. We report here, for the first time, on the catalytic activity of biochar made from iron-enriched plants and demonstrate the potential for reusing metal-contaminated plants to produce a biochar catalyst.
Keywords	Hyperaccumulator; Eichhornia crassipes; Fe-doped biochar; H_2O_2 electrocatalysis

Title	**Mechanistic understanding of iron toxicity tolerance in contrasting rice varieties from Africa: 2. Root oxidation ability and oxidative stress control**
Author Name	Dorothy A. Onyango, Fredrickson Entila, James Egdane, Myrish Pacleb, Meggy Lou Katimbang, Mathew M. Dida, Abdelbagi M. Ismail and Khady N. Drame
Journal Name	Functional Plant Biology
Year	2020
Volume and Issue	47(2)
Pages	145-155
Abstracts	To enhance breeding efficiency for iron (Fe) toxicity tolerance and boost lowland rice production in sub-Saharan Africa, we have characterised the morphological, physiological and biochemical responses of contrasting rice varieties to excess iron. Here, we report the capacity of four varieties (CK801 and Suakoko8 (tolerant), Supa and IR64 (sensitive)) to oxidise iron in the rhizosphere and control iron-induced oxidative stress. The experiments were conducted in hydroponic conditions using modified Magnavaca nutrient solution and 300 ppm of ferrous iron (Fe^{2+}) supplied in the form of $FeSO_4$. Severe oxidative stress was observed in sensitive varieties as revealed by their high levels of lipid peroxidation. Histochemical and biochemical analyses showed that tolerant varieties exhibited a better development of the aerenchyma and greater oxygen release than the sensitive varieties in response to excess Fe. Both suberin and lignin deposits were observed in the root, stem and leaf tissues but with varying intensities depending on the variety. Under iron toxic conditions, tolerant varieties displayed increased superoxide dismutase (SOD), glutathione reductase (GR), peroxidase (POX) and ascorbate peroxidase (APX) activities in both the roots and shoots, whereas sensitive varieties showed increased APX and catalase (CAT) activities in the roots. This study had revealed also that Suakoko8 mainly uses root oxidation to exclude Fe^{2+} from its rhizosphere, and CK801 possesses a strong reactive oxygen species scavenging system, in addition to root oxidation ability. Key traits associated with these tolerance mechanisms such as a well-developed aerenchyma, radial oxygen loss restricted to the root cap as well as strong activation of antioxidative enzymes (SOD, GR, POX and APX) could be useful selection criteria in rice varietal improvement programs for enhanced Fe toxicity tolerance.
Keywords	abiotic stress, aerenchyma, antioxidants, iron oxidation control, radial oxygen loss, rice.

Title	**Genetic diversity of African's rice (Oryza glaberrima Steud.) accessions cultivated under iron toxicity**
Author Name	Tawelsi Mayaba, Nerbéwendé Sawadogo, Mahamadi Hamed Ouédraogo , Boureima Sawadogo , Mawulé Aziadekey , Moussa Sié , Mahamadou Sawadogo
Journal Name	Australian journal of Crop Science
Year	2020
Volume and Issue	14(03)
Pages	415-421
Abstracts	Iron toxicity stress is one of the most important constraints to rice production in Togo. Although several methods were explored to control this stress, the best one is still the genetic control through the use of tolerant or resistant varieties. Our hypothesis is that African's rice, *Oryza glaberrima*, accessions contain sources of tolerance or resistance to the iron toxicity stress. Thus, the aim of this study was to determine the level and the structure of the African's rice, *Oryza glaberrima*, genetic diversity and to identify tolerant genotypes. Two hundred and four (204) accessions obtain from Africa Rice genebank and eight control varieties were evaluated under iron toxicity conditions using alpha lattice design with three replications. There was significant variability among accessions for height of mature plants and weight of 1000 seeds. The coefficient of variation values ranged from 10.56% for the 50% flowering to 77.47% for the sterility rate. The principal component analysis (PCA) with all the measured characteristics revealed that the first four axes accounted for 59.93% of the total variability. The coordinates of the variables showed that, six (6) accessions (T30, T60, H60, Tf, yield and Tox60) are associated to the factor F1 with an eigenvalue of 2,81. A high correlation between 50% flowering and plant height, fertile tillers and number of tillers, sterility rate and total number of seeds and yield were also observed. The accessions were divided into three (3) distinct groups. Sixty (60) accessions and four (4) controls (CG14, IR64, Azucena Whyte and NERICA L-20) identified as tolerant genotypes were clustered together in Group 3. These tolerant accessions could be exploited in the rice breeding program for the tolerance to iron toxicity stress.
Keywords	Agromorpological variability, Genotypes, Oryza glaberrima, Iron toxicity stress.

Title	**Bridging old and new: diversity and evaluation of high iron-associated stress response of rice cultivated in West Africa**
Author Name	Bathe Diop, Diane R Wang, Khady N Drame, Vernon Gracen, Pangirayi Tongoona, Daniel Dzidzienyo, Eric Nartey, Anthony J Greenberg, Saliou Djiba, Eric Y Danquah, Susan R McCouch
Journal Name	Journal of Experimental Botany
Year	2020
Volume and Issue	71(14)
Pages	4188-4200
Abstracts	Adoption of rice varieties that perform well under high iron-associated (HIA) stress environments can enhance rice production in West Africa. This study reports the genetic characterization of 323 rice accessions and breeding lines cultivated in West Africa using genotyping-by-sequencing and their phenotypic response to HIA treatments in hydroponic solution (1500 mg l^{-1} $FeSO_4 \bullet 7H_2O$) and hot-spot fields. The germplasm consisted of four genetic subpopulations: *Oryza glaberrima* (14%), *O. sativa-japonica* (7%), *O. sativa-indica* Group 1 (45%), and *O. sativa-indica* Group 2 (25%). Severe versus mild stress in the field was associated with a reduced SPAD value (12%), biomass (56%), and grain yield (57%), with leaf bronzing explaining 30% and 21% of the variation for biomass and grain yield, respectively. Association mapping using 175 indica genotypes identified 23 significant single nucleotide polymorphism (SNP) markers that mapped to 14 genomic regions. Genome-wide association study (GWAS) signals associated with leaf bronzing, a routinely used indicator of HIA stresses, differed in hydroponic compared with field conditions. Contrastingly, six significant SNPs on chromosomes 8 and 9 were associated with the SPAD value under HIA stress in both field and hydroponic experiments, and a candidate potassium transporter gene mapped under the peak on chromosome 8. This study helps define criteria for assessing rice performance under HIA environments.
Keywords	Abiotic stress; genetic diversity; GWAS; population structure; rice; West Africa

Title	Iron toxicity resistance strategies in tropical grasses: The role of apoplastic radicular barriers
Author Name	Advanio Inácio Siqueira-Silva, Camilla Oliveira Rios, Eduardo Gusmão Pereira
Journal Name	Journal of Environmental Sciences
Year	2019
Volume and Issue	78
Pages	257-266
Abstracts	The revegetation of mined areas poses a great challenge to the iron ore mining industry. The initial recovery process in degraded areas might rely on the use of Fe-resistant grasses. Tropical grasses, such as *Paspalum densum* and *Echinochloa crus-galli*, show different resistance strategies to iron toxicity; however, these mechanisms are poorly understood. The Fe-resistance mechanisms and direct iron toxicity as a function of root apex removal were investigated. To achieve this purpose, both grass species were grown for up to 480 hr in a nutrient solution containing 0.019 or 7 mmol/L Fe-EDTA after the root apices had been removed or maintained. Cultivation in the presence of excess iron-induced leaf bronzing and the formation of iron plaque on the root surfaces of both grass species, but was more significant on those plants whose root apex had been removed. Iron accumulation was higher in the roots, but reached phytotoxic levels in the aerial parts as well. It did not hinder the biosynthesis of chloroplastidic pigments. No significant changes in gas exchange and chlorophyll a fluorescence occurred in either grass when their roots were kept intact; the contrary was true for plants with excised root apices. In both studied grasses, the root apoplastic barriers had an important function in the restriction of iron translocation from the root to the aerial plant parts, especially in *E. crus-galli*. Root apex removal negatively influenced the iron toxicity resistance mechanisms (tolerance in *P. densum* and avoidance in *E. crus-galli*).
Keywords	Paspalum densum; Echinochloa crus-galli; Apoplastic barrier; Iron toxicity

Title	**Assessment of photo-modulation, nutrient-use efficiency and toxicity of iron nanoparticles in *Vigna radiata***
Author Name	Saheli Pradhan, Samarendra Barik & Arunava Goswami
Journal Name	Environmental Science: Nano
Year	2019
Volume and Issue	---
Pages	1 -11
Abstracts	Sustainable agricultural practices are in high demand taking into account the environmental pollution and toxicity generated by commercial fertilizers. In order to address such a specific issue, herein, we propose iron nanoparticles (FeNPs) as a suitable alternative to commercially available iron-salt based fertilizers. Being a micronutrient, an excess or deficiency of iron creates toxic response within plant systems. Taking this great challenge in hand, we deliberately applied FeNPs within the mung bean plant taken as a model plant system. FeNPs showed great promise in enhancement of morphological attributes and pigment contents; meanwhile, FeNPs improved the photochemical as well as carbon assimilatory pathway. FeNPs overcome the harmful effect of commercially available iron-fertilizers; even the cellular machinery was well protected and was devoid of any kind of toxic or stress response. Biophysical analysis revealed that FeNPs modulated the activity of FeS proteins for such an overwhelming response. Meanwhile, a brief biosafety study confirmed their biocompatibility for practical applications. We envisioned the promising potential of FeNPs in sustainable agricultural practices.
Keywords	Sustainable agricultural; fertilizers; iron nanoparticles (FeNPs); micronutrient; photochemical; biosafety

Title	**Iron oxide nanoparticle phytotoxicity to the aquatic plant Lemna minor: effect on reactive oxygen species (ROS) production and chlorophyll a/chlorophyll b ratio**
Author Name	Lilian Rodrigues Rosa Souza, Luís Eduardo Bernardes, Maike Felipe Santos Barbetta & Márcia Andreia Mesquita Silva da Veiga
Journal Name	Environmental Science and Pollution Research
Year	2019
Volume and Issue	---
Pages	1-11
Abstracts	Although iron oxide occurs naturally in the environment, iron oxide nanoparticles have distinct mobility, reactivity, and toxicity, which can harm the human health and nature. This scenario has motivated the investigation of the toxic effects of iron oxide nanoparticles (akaganeite predominance + hematite) on the aquatic plant *Lemna Minor*. First, nanoparticles were synthesized and characterized; then, different iron oxide NP concentrations were added to *Lemna Minor* culture. After 7 days, all the *Lemna Minor* leaves died, irrespective of the added NP concentration. The iron oxide NP impact on the plant was evaluated based on *malondialdehyde* (MDA) production from *thiobarbituric* acid reactive substances (TBARS), which was dose-dependent; i.e., lipid peroxidation in the plant increased with rising iron oxide NP concentration. The chlorophyll content decreased at high iron oxide NP concentrations, which disrupted the light absorption mechanism. Fe accumulation in *Lemna Minor* roots also occurred, which can harm nutrient uptake. Therefore, the iron oxide NP toxic impact on plants and related ecosystems requires further studies in order to prevent environmental damage.
Keywords	Iron oxide; nanoparticles; Lemna minor; Phytotoxicity

Title	**Antioxidant efficiency and mechanisms of green tea, rosemary or mate extracts in porcine Longissimus dorsi subjected to iron-induced oxidative stress**
Author Name	Zhou F, Jongberg S, Zhao M, Sun W, Skibsted LH
Journal Name	Food Chemistry
Year	2019
Volume and Issue	298
Pages	----
Abstracts	Plant extracts from rosemary (RE), green tea (GTE), and maté (ME) were compared for the protection against iron-induced oxidation in porcine homogenates at total phenolic concentrations from 25 to 250 ppm. Lipid oxidation as indicated by TBARS was in all cases sufficiently suppressed, especially for RE. Hydrophobic RE retarded overall oxidation in the homogenates with an inverted dose-dependent response. Optimum delay of oxygen consumption was found at the lowest concentration applied, similar to protection against thiols and formation of protein radicals as measured by ESR, whereas the high concentration increased oxygen consumption and caused additionally thiol loss possibly due to thiol-quinone interactions, generating protein-phenol complexes. Hydrophilic ME or GTE increased the initial oxygen consumption rate as an indication of prooxidant activities at elevated concentrations. However, they were found to protect myoglobin and protein at those high concentrations with GTE being more efficient, possibly due to better chelation effect.
Keywords	Oxidation; Myoglobin; Lipid; Myofibrillar protein; Phenolic extracts; Chelation

Title	Acquisition and Homeostasis of Iron in Higher Plants and Their Probable Role in Abiotic Stress Tolerance
Author Name	Durgesh K. Tripathi1, Shweta Singh, Shweta Gaur, Swati Singh, Vaishali Yadav, Shiliang Liu, Vijay P. Singh, Shivesh Sharma, Prateek Srivastava, Sheo M. Prasad, Nawal K. Dubey, Devendra K. Chauhan & Shivendra Sahi
Journal Name	Frontiers of Environmental Science
Year	2018
Volume and Issue	Volume 05
Pages	----
Abstracts	Iron (Fe) is a micronutrient that plays an important role in agriculture worldwide because plants require a small amount of iron for its growth and development. All major functions in a plant's life from chlorophyll biosynthesis to energy transfer are performed by Fe (*Brumbarova* et al., 2008; *Gill* and *Tuteja*, 2011). Iron also acts as a major constituent of many plant proteins and enzymes. The acquisition of Fe in plants occurs through two strategies, i.e., strategy I and strategy II (*Marschner* and *Römheld*, 1994). Under various stress conditions, Nramp and the YSL gene families help in translocation of Fe, which further acts as a mineral regulatory element and defends plants against stresses. Iron plays an irreplaceable role in alleviating stress imposed by salinity, drought, and heavy metal stress. This is because it activates plant enzymatic antioxidants like catalase (CAT), peroxidase, and an isoform of superoxide dismutase (SOD) that act as a scavenger of reactive oxygen species (ROS) (Hellin et al., 1995). In addition to this, their deficiency as well as their excess amount can disturb the homeostasis of a plant's cell and result in declining of photosynthetic rate, respiration, and increased accumulation of Na+ and Ca− ions which culminate in an excessive formation of ROS. The short-range order hydrated Fe oxides and organic functional groups show affinities for metal ions. Iron plaque biofilm matrices could sequester a large amount of metals at the soil–root interface. Hence, it has attracted the attention of plant physiologists and agricultural scientists who are discovering more exciting and hidden applications of Fe and its potential in the development of bio-factories. This review looks into the recent progress made in putting forward the role of Fe in plant growth, development, and acclimation under major abiotic stresses, i.e., salinity, drought, and heavy metals.
Keywords	Trace elements; iron (Fe); abiotic stress; plants; reactive oxygen species (ROS); enzymatic antioxidants; proteins; gene families

Title	**Physiological and transcriptomic analysis of responses to different levels of iron excess stress in various rice tissues**
Author Name	May Sann Aung, Hiroshi Masuda, Takanori Kobayashi & Naoko K. Nishizawa
Journal Name	Soil Science and Plant Nutrition
Year	2018
Volume and Issue	64, 3
Pages	370 – 385
Abstracts	Iron (Fe) toxicity is a major nutritional disorder of plants and affects rice yield and production in rainfed and irrigated lowland rice grown in acid soils. Rice plants are reported to have exclusion and inclusion adaptation strategies for preventing damage from excess Fe. However, the molecular mechanisms behind the Fe toxicity response and the identities of the genes involved remain largely unknown. To reveal these mechanisms, we exposed rice plants to different levels of ferrous (Fe2+) excess treatment for 14 days and analyzed their growth, bronzing score, and mineral concentrations. Then, gene expression patterns in various tissues (roots, discrimination center [DC], stems, old leaves [OLs], and newest leaves [NLs]) in response to different levels of Fe excess (×1, ×10, ×20, ×50, and ×70 Fe) were examined using microarray analysis. Our results showed that the higher levels of Fe excess led to more Fe being preferentially translocated to OLs, thus avoiding Fe excess damage in the NL. We proposed three zones of Fe excess levels: the non-affected, affected, and dead zones. As an exclusion strategy, Fe uptake- and transport-related genes were suppressed in roots since in the non-affected zone. Roots are important for preventing Fe uptake to the plant body under Fe excess stress. As inclusion strategies, first, some genes highly induced in various tissues under Fe excess, such as OsNAS3, OsVIT2, and rice ferritin genes (OsFers), may be important for detoxification or isolation of excess Fe within the plant body. OsZIPs may contribute to the maintenance of zinc homeostasis. Second, the plant induces the expression of oxygen and electron transfer genes, cytochrome P450 family proteins, or some NAC-type transcription factors to avoid reactive oxygen species and abiotic stress caused by Fe excess in the affected zone. The plant may use similar Fe homeostasis mechanisms in the non-affected and affected zones in the NL and roots but employ different mechanisms in the OL, DC, and stem tissues. Our results will contribute to current screening and breeding efforts, which aim to develop Fe excess tolerance in diverse rice cultivars, thus increasing rice production in lowland fields.
Keywords	Iron toxicity; rice; microarray; stress responses; transcriptome

Title	**Alleviation of iron toxicity in Schinus terebinthifolius Raddi (Anacardiaceae) by humic substances**
Author Name	Leonardo Barros Dobbss, Tamires Cruz dos Santos, Marco Pittarello, SávioBastos de Souza, Alessandro Coutinho Ramos&Jader Galba Busato
Journal Name	Environmental Science and Pollution Research
Year	2018
Volume and Issue	25
Pages	Pages 9416–9425
Abstracts	One of the industrial pillars of Espírito Santo state, South East of Brazil, is iron-mining products processing. This activity brings to a high level of coastal pollution due to deposition of iron particulate on fragile ecosystems as mangroves and restinga. *Schinustherebinthifolius (aroeira)* is a widespread restinga species. This work tested iron toxicity alleviation by *vermicompost humic substances* (HS) added to aroeira seedlings in hydroponic conditions. Catalase, peroxidase, and ascorbate peroxidase are antioxidant enzymes that work as reactive oxygen species (ROS) scavengers: they increase their activity as an answer to ROS concentration rise that is the consequence of metal accumulation or humic substance stimulation. *S. terebinthifolius* seedlings treated with HS and Fe augmented their antioxidant enzyme activities significantly less than seedlings treated separately with HS and Fe; their significantly lower Fe accumulation and the slight increase of root and leaf area confirm the biostimulating effect of HS and their role in blocking Fe excess outside the roots. The use of HS can be useful for the recovery of areas contaminated by heavy metals.
Keywords	Iron contamination ; Antioxidative enzymatic function ; Reactive oxygen species ; Catalase ; Peroxidase ; Aroeira

Title	**Shoot tolerance mechanisms to iron toxicity in rice (*Oryzasativa L.)***
Author Name	Lin-Bo Wu, Yoshiaki Ueda, Shang-Kun Lai & Michael Frei
Journal Name	Plant, Cell and Environment
Year	2017
Volume and Issue	Volume 40
Pages	570–584
Abstracts	Iron toxicity frequently affects lowland rice and leads to oxidative stress via the Fenton reaction. Tolerance mechanisms were investigated in contrasting genotypes: the intolerant IR29 and the tolerant recombinant inbred line FL483. Seedlings were exposed to 1000 mg L^{-1} ferrous iron, and the regulation of genes involved in three hypothetical tolerance mechanisms was investigated (I) Iron uptake, partitioning and storage. The iron concentration and speciation in different plant tissues did not differ significantly between genotypes. Sub-cellular iron partitioning genes such as vacuolar iron transporters or ferritin showed no genotypic difference s. (II) Antioxidant biosynthesis. Only one gene involved in carotenoid biosynthesis showed genotypic differences, but carotenoids are unlikely to scavenge the reactive oxygen species (ROS) involved in Fe toxicity, i.e. H2O2 and hydroxyl radicals. (III) Enzymatic activities for ROS scavenging and antioxidants turnover. In shoots, *glutathione-S-transferase* and *ascorbate oxidase* genes showed genotypic differences, and consistently, the tolerant FL483 had lower *dehydroascorbatereductase* and higher *ascorbate oxidase* activity, suggesting that high rates ascorbate reduction confer sensitivity. This hypothesis was confirmed by application of exogenous reduced ascorbate or L-galactono-1,4-lactone, which increased lipid peroxidation under iron toxic conditions. Our results demonstrate in *planta pro-oxidant* activity of reduced *ascorbate* in the presence of iron.
Keywords	Iron contamination ; Antioxidative enzymatic function ; Reactive oxygen species ; Catalase ; Peroxidase ; Aroeira

Title	**Role of Iron in Alleviating Heavy Metal Stress**
Author Name	Zaid ul Hassan, Shafaqat Ali, Muhammad Rizwan, Qasim Ali, Muhammad Zulqarnain Haider, Muhammad Adrees & Afzal Hussain
Journal Name	Essential Plant Nutrients
Year	2017
Volume and Issue	Volume-54 Issue-4
Pages	356-366
Abstracts	Heavy metals naturally present in soils usually result from human activities such as agricultural practices, mining, automobile, sewage processing, and metal industries. Higher concentrations of these metals in surrounding environment showed toxic effects on plants and animals. Heavy metals entered in soil-plant environment through various anthropogenic activities are taken up and accumulated in various plant parts. Higher concentrations of these metals showed toxic symptoms in plants. Heavy metals at higher dosage negatively affect plants physiological, morphological, and biochemical traits. On the other hand, plants used different strategies to cope with damaging effects induced by metal toxicity. There are some metals such as macro and micro nutrients, which are essentially required by plants for their growth and development processes. Micronutrient such as iron plays a key role in minimizing toxic effects of heavy metals and limits their entry in food chain. It has been thoroughly documented by many researchers that Fe has potential to alleviate metal toxicity by limiting metals uptake in different plants. Reports suggested that Fe improves plant physiological, morphological, and biochemical parameters by neutralizing metals toxicity. However, Fe deficiency resulted in malnutrition that affects human population worldwide. Various strategies have been used to enhance food quality, improve Fe uptake from soil and increased Fe shortage through a process known as *biofortification*. Fe uptake can be enhanced by *overexpressing* genes. Micronutrients level in plants could also be enhanced through agricultural practices, plant breeding, and biotechnology techniques.
Keywords	Heavy metals; Fe; Anthropogenic activities; Physiological; Morphological; Biochemical; Micronutrient; Biofortication

Title	Responses of rice to chronic and acute iron toxicity: genotypic differences and biofortification aspects
Author Name	Michael Frei, Richmond Narh Tetteh, Ando Lalaina Razafindrazaka, Michael Apolonius Fuh, Lin-Bo Wu & Mathias Becker
Journal Name	Plant Soil
Year	2016
Volume and Issue	408, 1–2
Pages	149–161
Abstracts	Iron (Fe) toxicity is a wide spread stress in low land rice production. The aim of this study was to differentiate between responses to acute Fe stress during the vegetative stage and chronic Fe stress throughout the growing period. Methods Six rice genotypes were tested in a semi artificial greenhouse setup, in which acute (almost 1500 mg L^{-1} Fe in soil solution during the vegetative stage) and chronic (200to300mgL^{-1} Fe throughout the season) Fe toxicity were simulated. Results Acute Fe stress induced early development of heavy leaf bronzing, whereas moderate symptoms occurred in the chronic treatment throughout the season. Grain yields were only reduced in the chronic stress treatment (−23 %) due to reductions in spikelet fertility, grain number and grain weight. Symptom formation during the early growth stages did not reflect yield responses in all genotypes. Only one genotype showed increases in grain Fe concentrations (24 % in the acute stress and 44 % in the chronic stress) compared to the control. Conclusions contrasting genotypes responded differently to acute and chronic Fe toxicity, and one genotype showed consistent tolerance and the ability to translocate excess Fe into grains. These traits can be useful in the adaptive breeding of rice for Fe toxic environments.
Keywords	Breeding; Cereals; Food security; Iron deficiency anemia; Metal homeostasis; Flooded soils

Title	Mapping Seed Phytic Acid Concentration and Iron Bioavailability in a Pea Recombinant Inbred Line Population
Author Name	A. S. K. Shunmugam, X. Liu, R. Stonehouse, B. Tar'an, K. E. Betta,A. G. Sharpeb and T.D. Warkentin
Journal Name	Alliance of crop, soil and environmental science societies
Year	2015
Volume and Issue	Volume 55, Issue 2
Pages	828-836
Abstracts	Phytate, the storage form of P in seeds, is not well digested by monogastrics, thereby contributing to micronutrient deficiency, decreased feed efficiency, and environmental pollution. This research was aimed at developing a single nucleotide polymorphism (SNP) based genetic linkage map and mapping genomic regions associated with phytic acid- phosphorus (PA-P) concentration using a recombinant inbred line (RIL) population (PR-15) derived from a cross between a low phytate (low phytic acid [lpa]) mutant pea (*Pisum sativum L.*) genotype, 1-2347-144, and a normal phytate cultivar CDC Meadow. A total of 163 RILs were genotyped using a 1536-SNP Illumina GoldenGate array. Three hundred and sixty-seven polymorphic SNP markers ordered into seven linkage groups (LGs) were used to generate a linkage map with a total length of 437.2 cM. PR-15 lines were grown in replicated field trails in Saskatoon and Rosthern, SK, in 2012 and 2013. Chi-square statistics confirmed the single gene inheritance of PA-P concentration in these RILs. Phytic acid-phosphorus (PA-P) phenotype was mapped to LG5. Iron bioavailability (FEBIO) of PR-15 lines estimated using the Caco-2 cell culture bioassay was negatively correlated with PA-P concentration. A quantitative trait locus (QTL) for FEBIO was mapped on to the same location on LG5 as phytic acid concentration. The QTL with a maximum LOD score of 15.1 explained 60.5% of the phenotypic variation in FEBIO. The markers flanking this QTL region can be employed in marker-assisted selection to select pea lines with low phytate and greater Fe bioavailability.
Keywords	Seeds; micronutrient; environmental pollution; acid-phosphorus

Title	**Assessment of Iron Bioavailability and Iron Biofortification of Staple Food Crops: Guiding the Breeding Approach with in vitro and in vivo Screening Tools**
Author Name	Raymond Glahn and Elad Tako
Journal Name	European Journal of Nutrition & Food Safety
Year	2015
Volume and Issue	Volume-5, Issue-5
Pages	477-478
Abstracts	The objective of this presentation will be to demonstrate how the combination of invitro screening and an animal model can be extremely useful to develop and monitor Fe-biofortified crops, and evaluate meal plans in advance of human studies to determine if the crop is adequately *biofortified* with Fe prior to expensive human testing. Methods: In recent years much has been learned about how to properly screen varieties of staple food crops to improve the Fe content and bioavailability. Research has shown that simply measuring Fe content and levels of known inhibitors such as phytic acid and total polyphenols is not adequate to guide crop breeding efforts, as it leads to misdirection because of inability to assess all of the genetic, environmental, and environment by genotype interactions that play a role in Fe bioavailability from staple foods. Moreover, once *Fe-biofortified* crops are developed and released, there needs to be cost effective methodology in place to monitor and maintain the nutritional quality of successive harvests. Results: This presentation reports on a decade of applications of a high throughput bioassay (in vitro digestion/Caco-2 model) and a poultry feeding model that have been developed and applied to a variety of staple food crops (eg. beans, lentils, maize, sorghum and pearl millet). Recent comparisons to human efficacy trials involving black beans, pearl millet and red mottled beans.
Keywords	biofortified crops; bioavailability; staple foods

Title	**Pre-Roman Iron Age settlement continuity and cereal cultivation in coastal Finland as shown by multiproxy evidence at Bäljars 2 site in SW Finland**
Author Name	Santeri Vanhanen, Satu Koivisto
Journal Name	Journal of Archaeological Science: Reports
Year	2015
Volume and Issue	01
Pages	38–52
Abstracts	Pre-Roman Iron Age (ca. 500–1 BC) occupation was revealed at the site of Bäljars 2 in SW Finland. *Archaeobotany*, charcoal analysis, and geochemistry were applied to the samples gathered at the site. The results suggest habitation, storage, agriculture, fire- keeping, and plant gathering at the site during the Pre-Roman Iron Age. By that time, the *Lepinjärvi basin* was surrounded by rich local flora and served as an excellent node of communication with both overseas regions and the interior of Finland. Eight new sites were discovered around the lake, thus disproving the previously suggested hiatus of habitation around the lake. The light soils were suitable for early cultivation methods. The results point towards cultivation of ard-ploughed, fire-managed, and manured fields, where summer-annual barley, *speltoid wheats*, and possibly oat were grown. Other contemporary sites in Finland reveal that barley was the most *importantcereal* during the first millennium BC.
Keywords	Pre-Roman Iron Age; Coastal Finland, Settlement archaeology; Cereal cultivation; Geochemistry; Archaeobotany; Charcoal analysis