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Winter SOS: E4E
W4 Upper Division Lit Review

I left off last week wondering about phytoaccumulation of toxins and how serious of a problem that would prove to be in my business. This week, week 4, I narrowed my focus down a little too much. I need to start my review by looking at the plants which do accumulate toxins, determine what those are used for, determine which part of the plant is edible, determine which soil conditions the plant phytoaccumulates under, and go from there. While I'm divulging what I should have done now, this last week I have read some less than helpful articles and will continue my review anyways.

Heavy metals phyto-assessment in commonly grown vegetables: Water spinach (I. aquatica) and okra (A. esculentus) by Ng, C. C., et al. (2016) looks at the growth response and inventories the heavy metal accumulation in different tissues of water spinach and okra. They highlight the crux of my concern on page 1 paragraph 2,

"Most people assume that all vegetables are nutritious as well as safe to consume, unaware that some parts of the vegetable may be contaminated with heavy metals and other sources of contaminants. Heavy metals are non-biodegradable and can be very persistence in the environment; [heavy metals] have the potential to accumulate in different body organs (Radwan and Salama 2006; Chailapakul et al. 2008; Qishlaqi et al. 2008.) By consuming contaminated vegetables, excessive accumulation of dietary heavy metals such as cadmium, lead and chromium can lead to severe health problems in humans."

Basically all this study did was compare control plants of okra and water spinach growing in a medium that was not spiked with pollutants against three separate versions of those plants which were spiked individually with either copper (Cu), lead (Pb), or zinc (Zn). While their results shows that the plants did accumulate each of those metals (which resulted in different growth patterns), only the high levels of Pb found in the shoots of both okra and water spinach exceeded safety limits. However this does not answer the question of repeated ingestion and its effects on the eater over time. Additionally these plants were grown in a lower soil pH (4.63-5.01) which affects both plant growth and metal availability in the plant extractable water in the soil profile. Furthermore, as they say on page 7 paragraph 6:

"Even though both water spinach and okra cultivated in Zn and Cu treatments did not exceed the allowable levels; the presence of high amounts of Zn and Cu in food is enough to pose health problems, as it has been reported that the major source of these metals are available in almost all urban environmental soils (Thornton 1991; Li et al. 2001). As a general rule of thumb, any high concentration f heavy metal accumulation in edible parts...of vegetables renders it as not recommended for food consumption."

Hence my concern. In short, it doesn't really matter if the levels of heavy metals in the food being grown exceeds standards because bioaccumulation literally means that the toxins accumulate over time.

Anyways, moving on to *Zinc, Lead, and Cadmium tolerance, Uptake and Accumulation by Typha latifolia* by Ye, Z. H., et al 1997. T. *latifolia* is a cattail and not exactly my primary concern, but I read the paper anyways. The authors say that wetlands have been used recently to treat metal contaminated effluent and thus the cattails found there are prime examples of phytoaccumulators. However most of what they said did not stick, so I'll just highlight what I gleaned from the study.

Page 476 paragraph 2: "Tolerance appears to be metal- specific, as evolution of tolerance to one metal does not automatically confer tolerance to another. When multiple metal tolerance occurs, this generally reflects toxic levels of several metals in the sub- stratum (Antonovics et al., 1971; Foy, Chaney & White, 1978). Moreover, the level of tolerance developed can often be related to the amount of metal in the soil (Antonovics et al., 1971; Foy et al., 1978)."

They also go into some general plant mechanisms of metal tolerance which I thought could be applied to multiple plants, edible or not, so I took note of them. They can be found on page 478 paragraph 6:

" Baker (1981) suggested two basic strategies of metal uptake related to tolerance: (1) the 'excluder' strategy, in which shoot concentrations of heavy metals are maintained at a constant low level until a critical soil concentration is reached when toxicity ensues and unrestricted metal transport results; (2) the 'accumulator' strategy, in which metals are actively concentrated within plant tissues over the full range of soil concentrations, implying a highly specialized physiology. Berry (1986) also suggests three basic strategies of response: avoidance, detoxi- fication, and biochemical tolerance, each of which affects tissue metal concentrations in different ways. The present study shows that T. latifolia can colonize both uncontaminated and metal-polluted areas and that the concentrations of Zn, Pb and Cd in the leaves are maintained at low levels in the populations investigated although concentrations of these metals in the associated soil-sediments and in the roots can vary widely. Similar results have been reported in this species by other authors (Table 11). Collectively these observations might indicate that T. latifolia can tolerate heavy metals and that this might depend mainly upon metal exclusion ability. The exclusion of metals from above-ground tissues has also been suggested in T. latifolia by Taylor & Crowder (1983a) and Fernandes & Henriques (1990). Metal tolerance and metal exclusion in this species may be related to its oxygen transport capability, radial oxygen loss from the roots and the capability of modifying its rhizosphere."

These tolerance mechanisms are definitely something I should look into in future readings.

From the above I moved forward into an article I thought was highly appropriate for what I'm trying to do in my business: *Soil health as a predictor of lettuce productivity and quality: A case study of urban vacant lots* by Knight, A. et al 2013. Essentially they inventoried the soil of twelve city owned plots in Cleveland, Ohio and then graded the plant health of lettuce grown therein. I won't go into each number specifically because that's not what I care about. What I do care about is how they graded the soil and plant health. This week in my Enterprise for Equity class Joanne was talking about pricing. She showed us a pricing matrix that we, the students, will place our business within to be graded against other existing similar businesses. We see what our business offers compared to our competitors and judge what our pricing should be. If I offer soil test analysis done within the business I might be able to hitch my price up due to the extra service offered.

Now the scientists in this study did a lot of tests on the soil: pH; moisture content; soil texture; SOM; active carbon; ammonium; nitrate; microbial biomass N; nematode community parameters; bacteria feeding nematodes; fungal feeding nematodes; plant parasitic nematodes; number of nematode genera; nematode food web enrichment index and structure index. Then they tested the plants for: dry biomass; numbers of leaves/plant; and subjective appearance scores. So now the question for me becomes which of these tests are the most feasible, the most useful, and the least time consuming, and how can I do that for my clients? I already plan to do pH test using test kits, a soil moisture test with a tensiometer, a soil texture test with the soil triangle, and I've considered doing the SOM test using sieves and ovens as well as the biomass test using a Berlese funnel and my microscope. Are the rest of the tests worth my time at that point?

Moving on I read *Lettuce plants as bioaccumulators of trace elements in a community of central Italy* by Nali, C., et al 2008 which basically surveyed the airborne trace elements found on lettuce leaves grown within Central Italy. This study gave me a broad sense of what urban grown lettuce might have on it, though it should be noted that Italy's pollutant level laws are a bit different from the U.S's. While some pollutants, as they say, were able to be washed off the leaves, others were not. Of importance the enriched elements within the lettuce leaves were cadmium (Cd) and Zn. This seems to round the concensus I've been reading where Cd, Zn, Cu, Pb, and As are among the most common and enriching metals found within urban soils. It is on these toxins that I'll focus my future readings.

Speaking of arsenic (As), I read this article *Genetic effect on phytoaccumulation of arsenic in Brassica juncea L* by Rahman, M., et al (2012) which asked the question: can certain morphological differences serve as genetic markers of an increased ability of a plant to accumulate the heavy metal As and can the trait be passed down to the F2 generation? What they found was stem diameter has a direct effect on shoot uptake of As and that that uptake behaviour is heritable and thus renders B. *juncea* and affective phytoaccumulation of As. Just something to think about as I consider the hardy brassicas for planting in our Asarco polluted soils.

Let's move on to the book I've been reading, The Bio-Integrated Farm by Shawn Jadrnicek (2016). This was a comprehensive book demonstrating the techniques used by Shawn on his many permaculture farm ventures. He emphasizes stacking functions and turning one farm component's output into another's input. He also goes into detail on how to do what he does via his step by steps. I took notes on what Shawn has to say and I won't go into them all here, but here are a few tidbits I did glean and would like to share.

Shawn says that while it's great to stack functions, the golden number for those functions is seven. Once seven functions have been attained the environment takes on its own life. To stack functions is to have multiple uses for one component. For example the herb spiral explained on pages 4-5 and which can also be seen at the Organic Farm at Evergreen. The herb spiral can perform 11 different functions if properly planned including proper hydrology from the top to the bottom with the appropriate edible plants planted accordingly, the increase of crops grown on a single space, and the relocation of recently excavated soil just to name a few. However the functions of the herb spiral interacts with the functions of a pond place just north of it, hence the name of the book and ecological principle of *bio-integration.*

Shawn also bought the ancient cultivation practice of *chinampas* which situates the growing land on top of dredged soil found at the bottom of a wetland which has been formed into raised beds leaches its nutrients back into the water. This system is the penultimate of stacking functions. He says that he bases all of his farming practices off of the chinampa model. This includes putting ponds inside the greenhouse, outside of the greenhouse, uphill of the growing spaces, and uphill of the chicken coop.

Which brings me to the last thing I want to talk about- the chicken coop. The chicken coop has a built in black soldier fly nursery. This nursery makes compost, serves as chicken feed, and eats chicken manure all which occupying the same space as the chickens because it is under the chicken tractor. I am very excited to try this system on someone's land.

There were many other practices and principles I learned, all of which were nuanced and site specific. This book should be a staple in any permaculture enthusiast's library. Now that i'm finished with it I think I'll move on to <u>Pesticides in the Soil</u>...or maybe something a little less dry.

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Being that I've solidly deduced that I need a list of phytoaccumulating edible plants, that's where I think I'll start next week. Wish me luck.

References

Jadrnicek, S. (2016). *The bio-integrated farm: A revolutionary permaculture-based system using greenhouses, ponds, compost piles, aquaponics, chickens, and more*. White River Junction, VT: Chelsea Green Publishing.

Knight, A., Cheng, Z., Grewal, S. S., Islam, K. R., Kleinhenz, M. D., & Grewal, P. S. (2013, 01). Soil health as a predictor of lettuce productivity and quality: A case study of urban vacant lots. *Urban Ecosystems, 16*(3), 637-656. doi:10.1007/s11252-013-0288-1

Nali, C., Balducci, E., Frati, L., Paoli, L., Loppi, S., & Lorenzini, G. (2008, 02). Lettuce plants as bioaccumulators of trace elements in a community of central Italy. *Environmental Monitoring and Assessment, 149*(1-4), 143-149. doi:10.1007/s10661-008-0189-6

Ng, C. C., Rahman, M. M., Boyce, A. N., & Abas, M. R. (2016, 04). Heavy metals phyto-assessment in commonly grown vegetables: Water spinach (I. aquatica) and okra (A. esculentus). *SpringerPlus, 5*(1). doi:10.1186/s40064-016-2125-5

Rahman, M., Haq, N., & Williams, I. D. (2012, 02). Genetic effect on phytoaccumulation of arsenic in Brassica juncea L. *Euphytica, 186*(2), 409-417. doi:10.1007/s10681-012-0632-1

Ye, Z. H., Baker, A. J., Wong, M. H., & Willis, A. J. (1997, 07). Zinc, lead and cadmium tolerance, uptake and accumulation by Typha latifolia. *New Phytologist, 136*(3), 469-480. doi:10.1046/j.1469-8137.1997.00759.x