The Vetiver Network International (TVNI)

Green Cycle Consulting Ltd.

Some thoughts on Contributions of Vetiver Systems in Mitigating Climate Change

Elise Pinners

Director, TVNI and GreenCycle Consulting Ltd.

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1. VS and its bonuses for CC mitigation

Climate change

- heavier storms, more erosion, landslides, flood damage to crops and infrastructure, and siltation of water bodies
- longer dry spells, crop failure, water shortage
- combine CC with human actions: degradation, reducing recharge of water bodies (ground and surface water) and reduced water quality (pollution)

Disregarding CC, Vetiver Systems already addresses these problems, in many applications:

- On-farm
- Infrastructure protection (bio-engineering)
- Treating polluted water & land (phyto-remediation)

Whatever VS would do to mitigate CC: its suite of benefits is already impressive, in terms of environment and economics!

Yet, there is potential, and this deserves further exploration:

- Bio-fuel
- Atmospheric carbon sequestration, soil carbon capture and storage
- Preventing GHG emission from waste water.

2. Characteristics of Vetiver grass

- **root mass exceeding all other species; capacity to produce biomass unequalled among grasses**
- deep, penetrating, extensive, soil-binding root system, reinforcing soil structure
- forming a dense hedge: very effectively retarding water flow, reducing erosive power of strong current
- Vetiver grows in the widest range of climate conditions, tolerating salinity, heavy metals, pesticides, herbicides, surviving submergence; can be grown hydroponically on floating rafts
- and more…

Strong root reinforcement holding up this wall of soil against water erosion


Vetiver's capacity to reduce erosion and improve soil texture – trapped top soil 40cm in 30 months

Growing vigorously in water.

When completely submerged Vetiver can survive more than 50 days.

Chemical characteristics

- its fast growth allow high intake of nutrients (N, P, sulphates) and toxins
- it breaks down nitrate, sulphate, toxins e.g. diuron, lindane, atrazin, …

Young Vetiver roots thrive in high N and P sewage effluent, using on average 1.1 litre of water a day

These characteristics can be used to:

- absorb contaminated water e.g. from:
  - city sewage
  - abattoirs, food processing plants, piggeries
  - solid waste dump leachate
- trap toxic sediment (e.g. in mines)
- break down toxins

3. Bio-fuel

The arguments are:

- Spatial - huge marginal lands of northern India, Pakistan (irrigation, poor drainage → saline soils & ground water) Vetiver can be grown on large scale and at high yield and at the same time rehabilitate the soil.
- Reducing GHG emission -

  a. bio-fuel replacing fossil fuel reduces CO_2 emission*

  b. biomass has much lower Sulfur content than even low Sulfur coal (which is costlier than regular coal) → reducing SO_2

  c. Likewise for emission of CFC's, nitrous oxides…

*: when medium-sized power plant adds biomass to its mix, its global warming emission reductions are equivalent to taking 17,000 cars off the road (source: Natural Resources Defence Council, http://www.nrdc.org/air/energy/renewables/biomass.asp)

Taylor Moore: replace 1 mega-Watt coal-fired power by biomass power → ±6000 t (6 million kg) CO_2/year (source: http://www.nau.edu/~soc-p/ecrc/biomass.html

- Costs - CO_2 reduction from coal power plants can be expensive ($100 -200/ton for some methods), but co-firing biomass with coal (in quantities as small as 15% biomass) gives 95% cost reduction

See Boucard’s calculations

Burning

- Good combustion required, to make that most N goes into the air as N2 → check NOxious compounds emission

Factors:

1. N content of foliage: in Vetiver not particularly high
2. How the grass is "cured", how it is burned

3. Silica in foliage: in Vetiver levels are higher than in many other grasses, and increasing with age (consolidated in leaf as mineralized "phytolith") – that is a downside (compared to Miscanthus low ash hybrid):

a. Ash disposal burden, fly ash deposition

b. Flux (in combi with other elements) damaging furnaces*

But how serious is that?

4. Possibly complex silicate salts capture, precipitate some of heavy metals, sulphur compound, nitrous oxides in mixed combustion reaction, preventing escape through the stack. Another plus for Vetiver?

* Boucard confirms: the mineral / silicate oxides & salts tend to flux firebrick, lowering their melting point → more expensive bricks required (70% instead of 50% alumina content (but 1 high alumina brick costs > $7; thousands of bricks needed in a large furnace).

Boucard's 50Mw power plant, 4563 ha in Barahona, Dominican Republic

1. Main product – essential oil
2. By-product – power plant daily need of 1000 tons/day of Vetiver bales (from 12.5 ha), or: > 500 tons coal

- In tropics, under irrigation or good annual rainfall: up to 80 t/ha/y dry vetiver grass
- Easy & safe farming operations; no diseases, no weather damage
- Unlike sugarcane, Vetiver plantation needs no re-planting; annual harvesting, any time of year, for >20 years, just adding fertilizer
- Baling with standard hay baler after 3-4 days of sun drying
- Once established: production cost US$15/ton (1 ton=2000 lbs)

- **Dry grass calorific value: 7,000 btu /pound** (± ½ of coal)

Cost of fuel per Million btu (MMbtu)

7000 btu/lbs dry leaf → 142.9 lbs /Mmbtu

- **Vetiver**: $15/2000 lbs x142.9 lbs/Mmbtu → **$1.07 /MMbtu**
- **Coal**: $45/2000 lbs (ton, in the US) x14,000 btu/lbs as cheapest fuel costs → **$1.60 /MMbtu**
- **Crude petroleum**: only $595/2000 lbs (or 100$/barrel=336 lbs) x55.5 lbs/Mmbtu (or 18,000 btu/lbs) → **$16.5 /MMbtu**

A most lucrative use for tropical farmland, if electricity at US$0.12 per Kw/h is the final product

If somebody in the third world ever figures this out, the challenge is to ensure that food crops are not displaced for fuel production; only second rate farmland be used for vetiver fuel production..

4. Carbon sequestration and storage

Tropical grasses:

- CIAT, Fisher et al, Nature 2002 & other sources: 3 -14 T /ha/year of Carbon stored
- CIAT '95: *Andropogon guyanus* (Vetiver close relative) stores 53 T /ha CO_2 o.m.

But Vetiver:

- Huge root mass attaining 2-4 m depth after two years; much more massive than *Andropogon guyanus*
  → how much for larger root mass ensuring larger C storage?
  (how much is root sequestration for tropical grass land?)
- Also huge biomass above ground; one reason for high Vetiver plant vigour is ***Mycorrhiza*** association → how much for this positive factor?
- Let's take 70 T /ha for Vetiver *(very speculative!)*

Carbon capture conclusion:

- currently there's no handy way to measure carbon uptake or conversion under Vetiver
- any measure for Vetiver will be highly variable, quite unlike forest on depleted soils

- lack of site uniformity: hard to come up with rule-of-thumb for hedges strewn across a landscape (unlike measuring from space vegetative changes in a 10K ha monoculture on laterite)
- even in well-documented cases "hard numbers" can be specious (which is why all kinds of "fudge factors" are built into these kinds of calculations, to come up with some sort of reasonable, conservative estimate

Future: technologies, methodologies, algorithms are rapidly improving: this should allow measurement of Carbon capture by Vetiver.

Since Vetiver can have such a positive impact on <u>overall biomass production in a system</u>, it has one more advantage over other candidates for carbon emission reduction

- Roots sink carbon in the soil
- Hedges keep trapped sediments buried so they don't otherwise oxidize (enormous problem in muck soils, example: sugarcane in Florida Everglades)
- Secondary growth: enhanced carbon capture by increasing organic productivity in areas Vetiver protects
- **Possibility for <u>mulch and/or bio-fuel</u>**

Only counting aerial biomass gives ‘unfair’ outcome:

- figures unfavourable: Vetiver has a regular foliar turn-over (harvested or not);
- not trimming plants is (in most applications) also poor management

Such dilemmas have been overcome in other carbon schemes, and we can too!

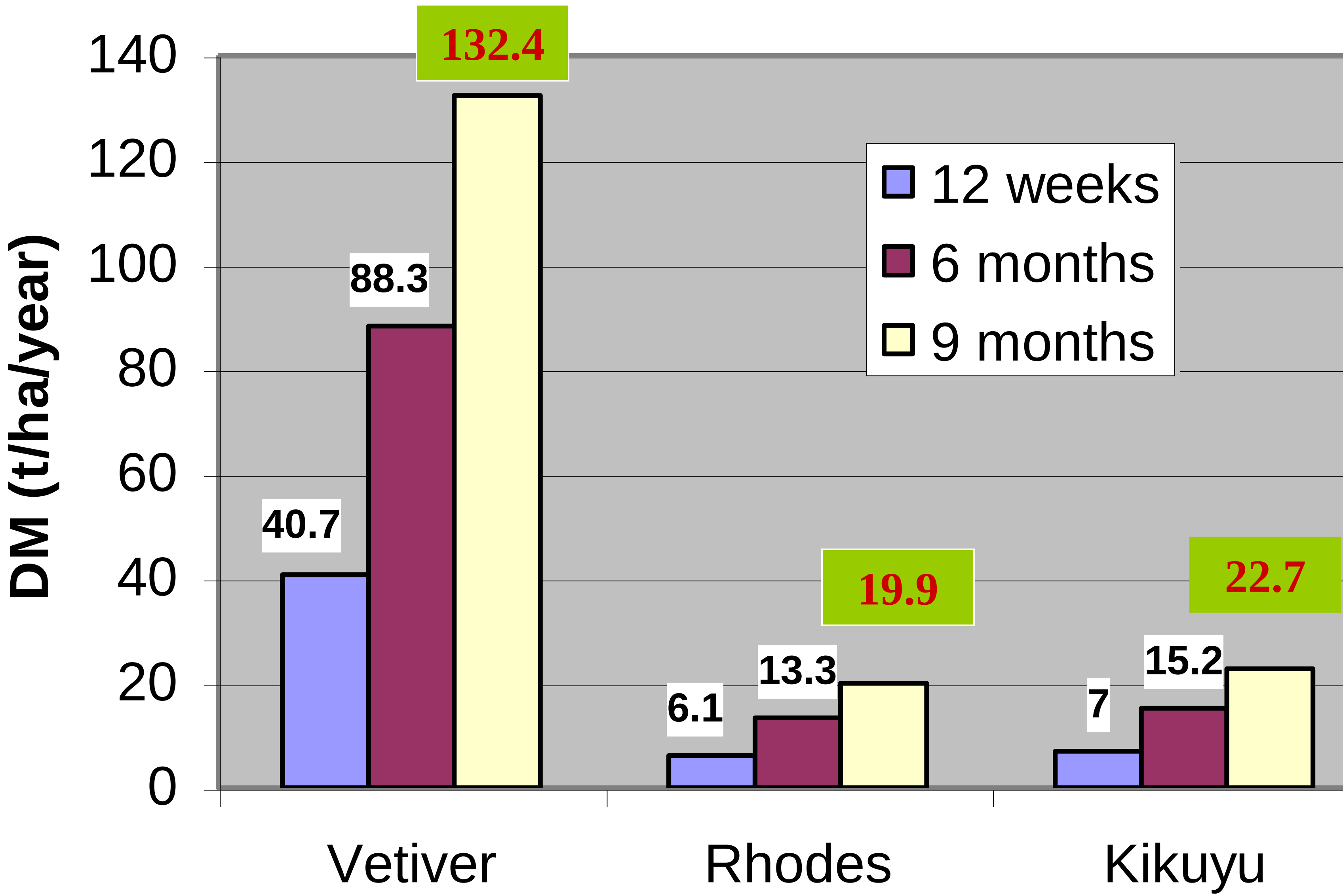
5. Reducing GHG emission from waste water

Mulch:

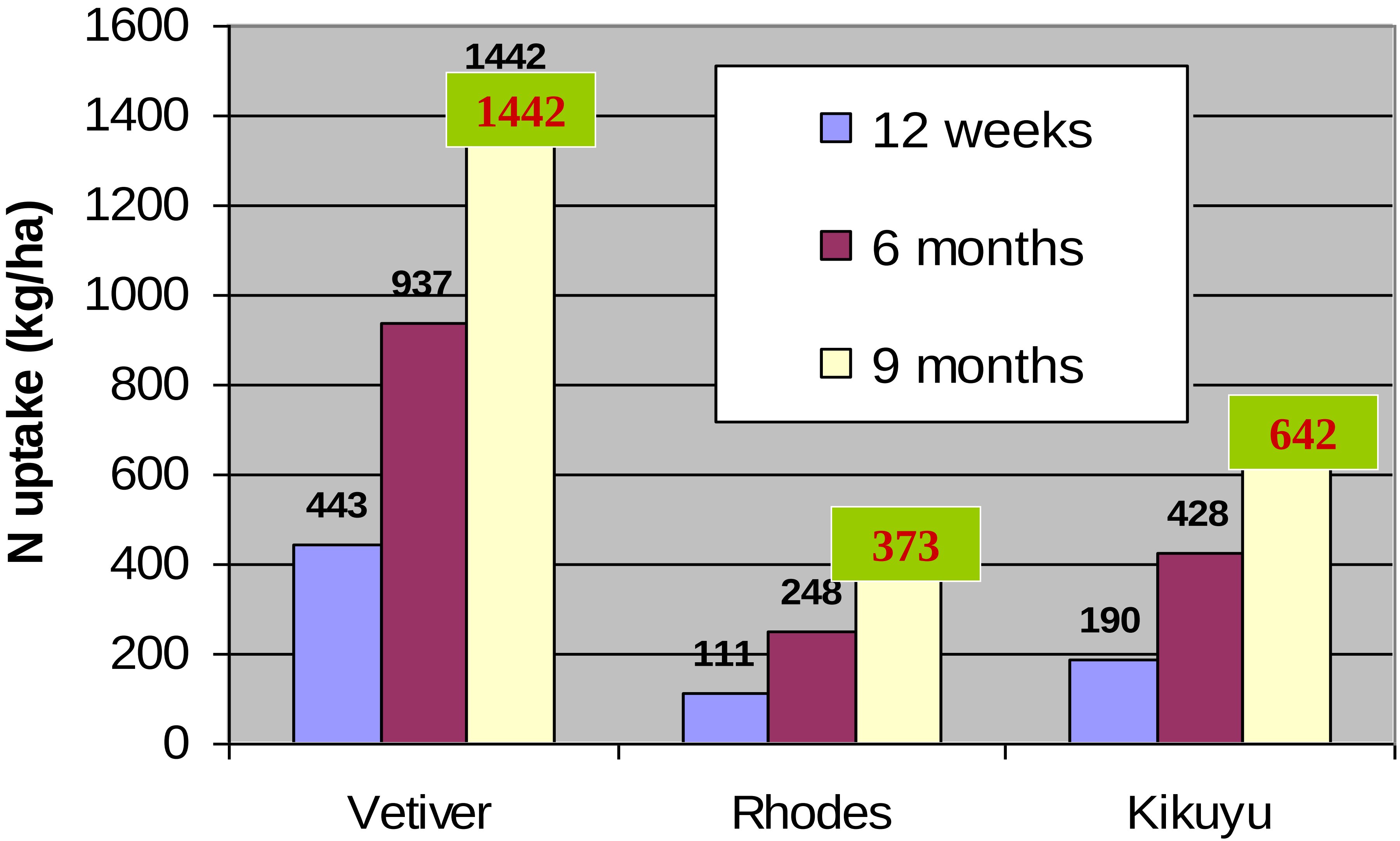
- Decomposition produces CH_4 (methane gas), NH_3 (ammonia), CO_2 and a host of other gases
- Absorbing nitrate into biomass reduces overall return of N to the atmosphere no matter what form
- Not absorbing nitrate: → underground aquifers, to be either locked there or → oceans → de-nitrification

Vetiver mulch is what is abundantly produced in the application of VS for water quality improvement, especially when treating sewerage, with high levels of N which – without treatment – would partly emit CH_4 end up as NH_3 (ammonia)

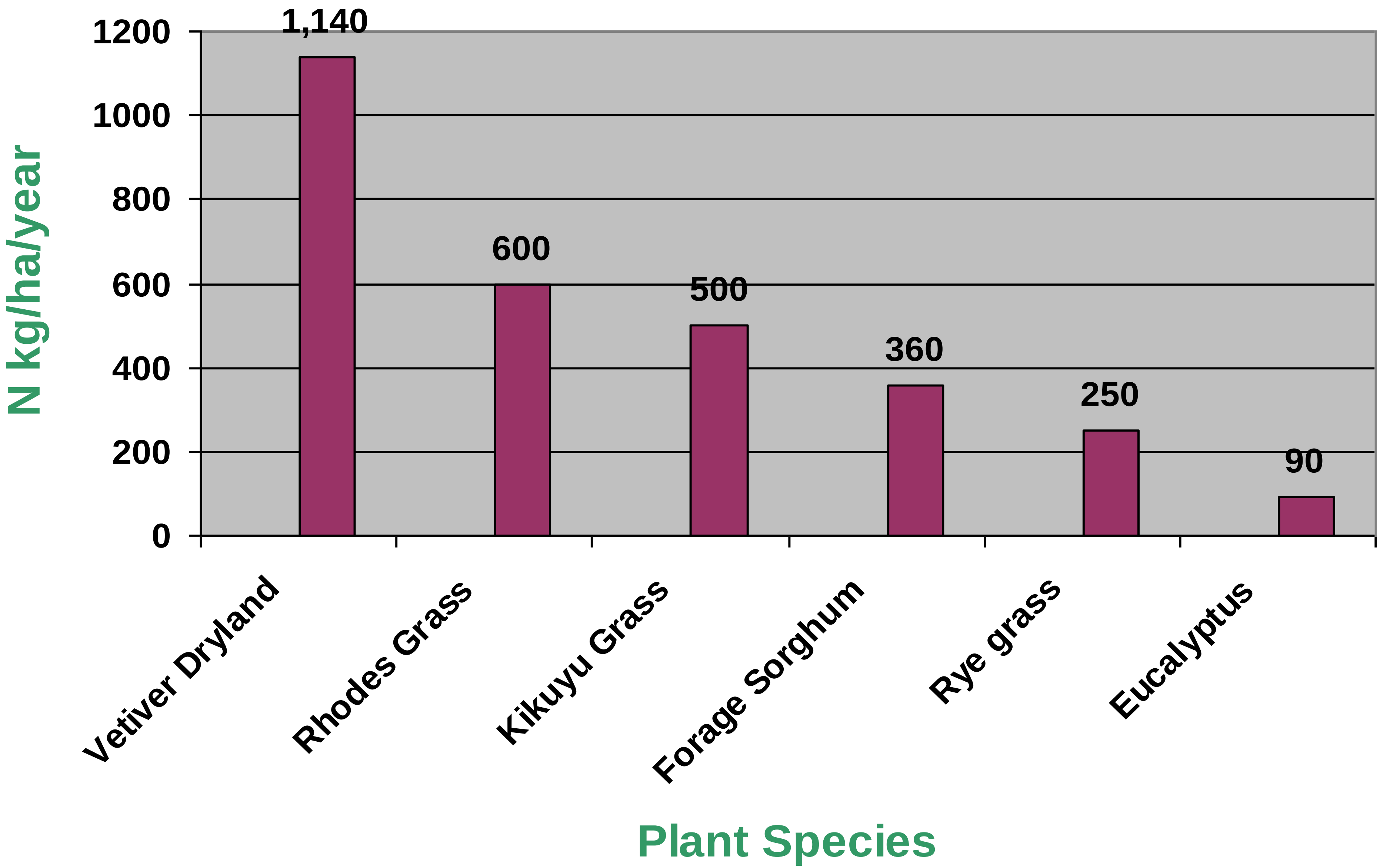
Comparative yield between Vetiver, Rhodes & Kikuyu grass



Comparative N removal over time



NITROGEN UPTAKE



High capacity of removing N and P in polluted water, Vetiver cleaned up blue green algae in 4 days

Sewage effluent infested with Blue-Green algae due to high Nitrate (100mg/L) and high Phosphate (10mg/L)

Same effluent after 4 days after treating with vetiver, reducing N level to 6mg/L (94%) and P to 1mg/L (90%)

08/12/00

VS for waste water treatment

- Nitrification: Ammonia oxidation → Nitrates NO3- (and Nitrite NO2-); nitrification reduces oxygen in the water, affecting aquatic life
- Nitrite can be reduced to nitrous oxide (N_2O) or ammonia (NH_3) by many species of bacteria

Treating waste water (sewerage) **nitrogen will be stored in biomass*** **→ MULCH**

We need to distinguish:

1. **Total treatment with Vetiver =?**
2. **Secondary treatment with Vetiver =?**

Or:

1. **Vetiver wetlands: how much methane can be recovered?**
2. **Vetiver ponds (along boundaries and on pontoons): idem?**

*: Mulch from high N conditions has no higher N concentration (unlike metallic elements); proportion N-compounds e.g. proteins remains constant (within certain range, decreasing over time when leaf is withering)

Back to the basics:

What happens with the leaves from the waste water treatment?

Can we use it to enhance soil carbon storage?

Or, feeding animals, reducing degradation, deforestation?

6. Combining CO_2 offset with other benefits

I. Compared with trees

In many cases:

- Easier planting and maintenance
- Speedier growth and biomass production

II. Compared with conventional engineering: adding vegetation

- conventional methods often cover with concrete, rocks, stones and/or artificial materials, or much slower (natural) re-vegetation, and with risks of slope collapse

III. Other environmental advantages that support vegetation

- VS supporting re-vegetation, reforestation where otherwise a vegetation or forest cover could not easily establish, e.g.:
  - shallow soils, steep slopes (ref. ICRAF research on tree roots)
  - rehab degraded (useless) farm land, alkaline, acid sulphate soils – faster than any other spp
  - shielding crops in dry, windy places
  - prevention of soil degradation

    1. on-farm SWC: **Soil erosion & oxidation is source of new atmospheric carbon; since Vetiver retains soil on site, it prevents "old" carbon from out-gassing (in addition to carbon in plant itself and biomass of companion plants)**
    2. mulch and/or compost (mixed)

7. Future perspectives

Combining CO2 offset with other benefits: fulfilling GEF mandate in a double way

1. EU: focus on *Miscanthus sinensis*

- Invasive* clump grass (stolons)
- Most of *Miscanthus* genus is tropical, producing a lot of biomass with low mineral content
- Miscanthus root structure is more like cane than Vetiver, M. stems tend to dehesce after senescence more quickly than Vetiver: that's a big drawback for *Miscanthus*
- Old *M. sinensis* clumps were seen dead in the centre - could be nutrient depletion, but: not a problem in Vetiver (architectural of Vetiver's curly little rhizomes); in terms of hedging ability & long life, Vetiver clumping excels
- Many believe *Miscanthus* has good future for biomass/carbon/energy production and conversion, but Vetiver has just as much promise in the tropics, plus the plethora of other benefits.

*: *Miscanthus* research is with hybrids, many touted as sterile. These go under the rubric "*M. giganteus*" (though hybrids can't have binomials) within this highly confused taxon. Interestingly, Veldkamp hopes to revise the genus along with its current congeneric *Saccharum* (he suspects there's only one genus, as in *Vetiveria* and *Chrysopogon*). Miscanthus crosses with cane species, and become weeds.

USA: focus on *Panicum virgatum*

(a less-robust clump grass somewhat useful as forage)

Brazil: focus on sugarcane

- Not interesting for smallholders
- Agro-chemicals → pollution
- For SWC only temporary (ratoon 3-19y)

Approved, relevant CDM technology for which VS can be relevant

Ref.	Methodologies Title	Options with VS, research
AMS-I.A.	Electricity generation by the user	Vetiver biomass for bio-fuel: small furnaces ?
AMS-I.D.	Grid connected renewable electricity generation	Idem – large scale (see Boucard example)
AMS-III.A.	Agriculture	SWC, mulching, reducing oxidation in soil
AMS-III.H.	Methane recovery in wastewater treatment	VS wetlands as secondary treatment of household waste water
AMS-III.I.	Avoidance of methane production in wastewater treatment through replacement of anaerobic lagoons by aerobic systems	Idem?

Research perspectives: win-win

Plug in Vetiver in overall data structure developing on grasses

- broader research on grasses v.à.v. trees

- observational & experimental trial comparisons among candidate species and Vetiver (make practical judgments on utility of Vetiver (using physiological & morphological indicators e.g. energy efficiency, nutrient partitioning, biomass production & turnover, water infiltration, etc.).

- Adding Vetiver to (comparative) research scenarios already underway with other grasses (fairly inexpensive, short time-frame, practical)

Policies

- Vetiver does not have to be better than anything else:
- if generally comparable, then adding other environmental & social benefits of Vetiver Systems to the policy stew…
- Q: Why "set-aside" marginal lands for biomass/fuel production & CO_2 offset when - by using Vetiver - those marginal lands can become productive environments while also producing biomass and lock up CO_2?
- Q: Why only trees would merit Carbon credits, why technology more suitable (in certain conditions) would not get the attention it deserves??
- Q: If VS is already so advantageous (economically) why would we seek Carbon Credits as well?