RESEARCH AND DEVELOPMENT OF THE VETIVER SYSTEM FOR TREATMENT OF POLLUTED WATER AND CONTAMINATED LAND

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SPECIAL CHARACTERISTICS SUITABLE FOR PHYTO REMEDIATION

MORPHOLOGICAL CHARACTERISTICS

- **Stiff and erect stems**
- **Deep and extensive root system**
- **It has no above or underground stems**

PHYSIOLOGICAL CHARACTERISTICS

- **Tolerant to drought, water logging, acidic, alkaline, sodic and saline conditions**
- **Tolerant to highly polluted environment such as heavy metal and nutrient contamination**
- **Tolerant high level of herbicides and pesticide in the soil**
- **Growing on all soil types: heavy clay to sand dune**

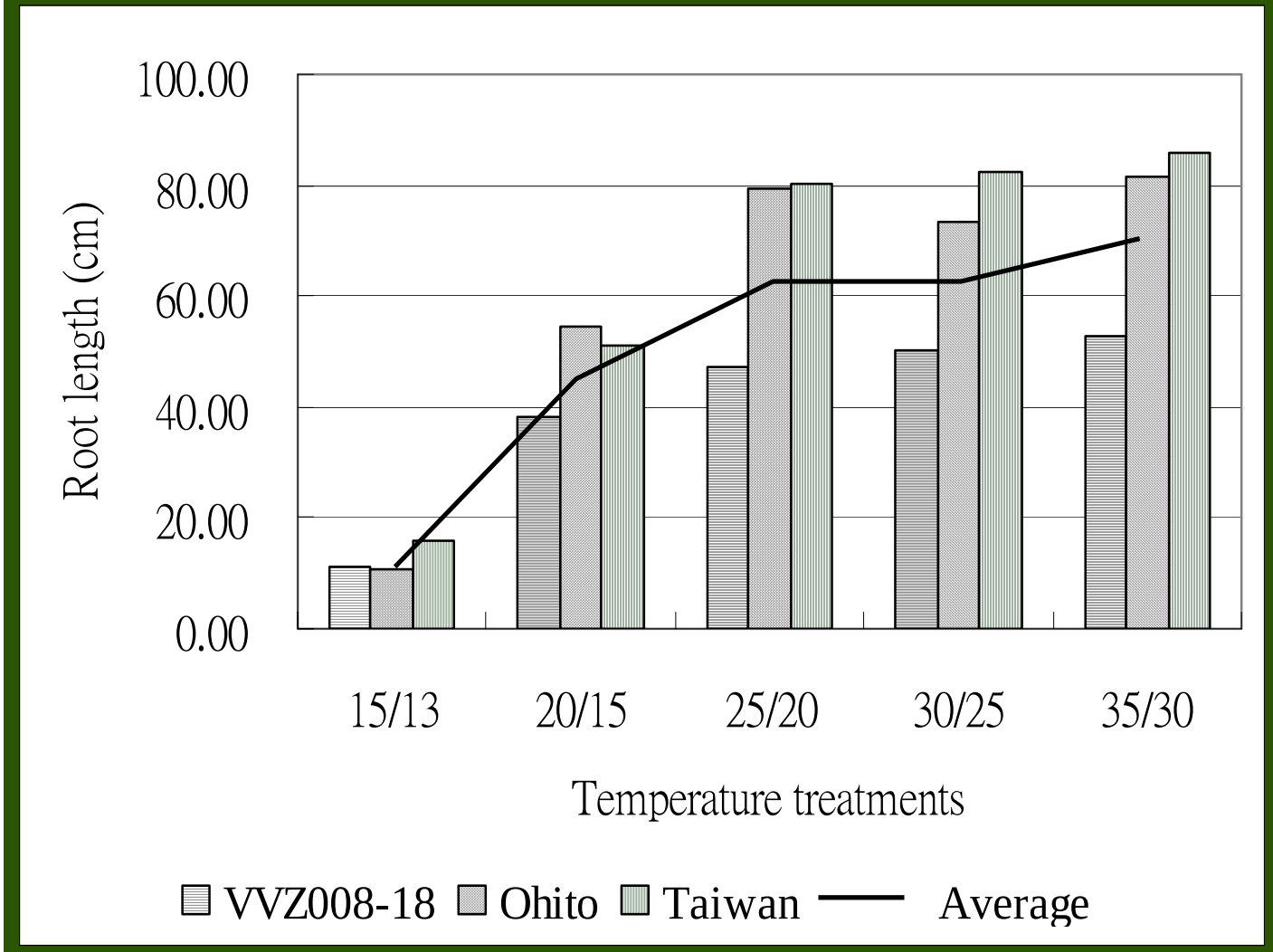
GENETIC CHARACTERISTICS

- **It is sterile, it flowers but sets no seeds**
- **Therefore it is non invasive and no weed potential**
- **It can be eliminated easily by Glyphosate spray or uprooting**

R & D ON ADVERSE GROWING CONDITIONS

THRIVE ON TEMPERATURE RANGE BETWEEN -14 AND 55^0c

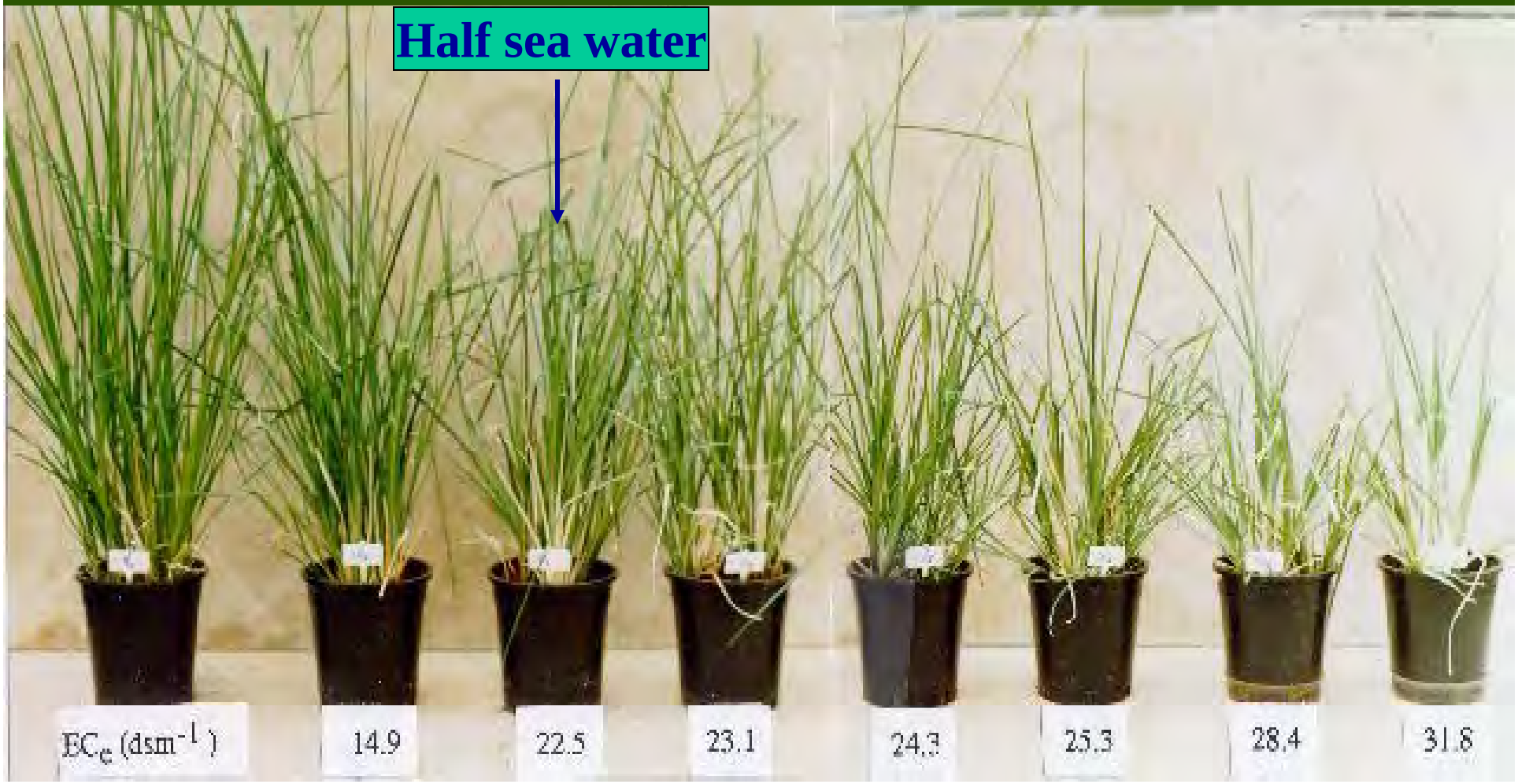
The effect of soil temperature on the root growth of vetiver.



Temperature treatments: day **15** °C /night 13 °C.

HIGHLY TOLERANT TO SOIL SALINITY

Saline threshold level is at EC_e=8 dsm^{-1}, and vetiver can survive at 47.5 dsm^{-1} under dryland salinity conditions



Vetiver growing among mangrove seedlings in Australia

Salt tolerance level of Vetiver grass as compared with some crop and pasture species grown in Australia.

Plant Species	Soil EC_{se} (dSm^{-1})	
	Saline Threshold	50% Yield Reduction
Bermuda Grass *(Cynodon dactylon)*	6.9	14.7
Rhodes Grass (C.V. Pioneer) *(Chloris guyana)*	7.0	22.5
Tall Wheat Grass *(Thynopyron elongatum)*	7.5	19.4
Cotton *(Gossypium hirsutum)*	7.7	17.3
Barley *(Hordeum vulgare)*	8.0	18.0
Vetiver *(Vetiveria zizanioides)*	8.0	18.0

HIGHLY TOLERANT TO SOIL ACIDITY, ALUMINIUM AND MANGANESE TOXICITIES

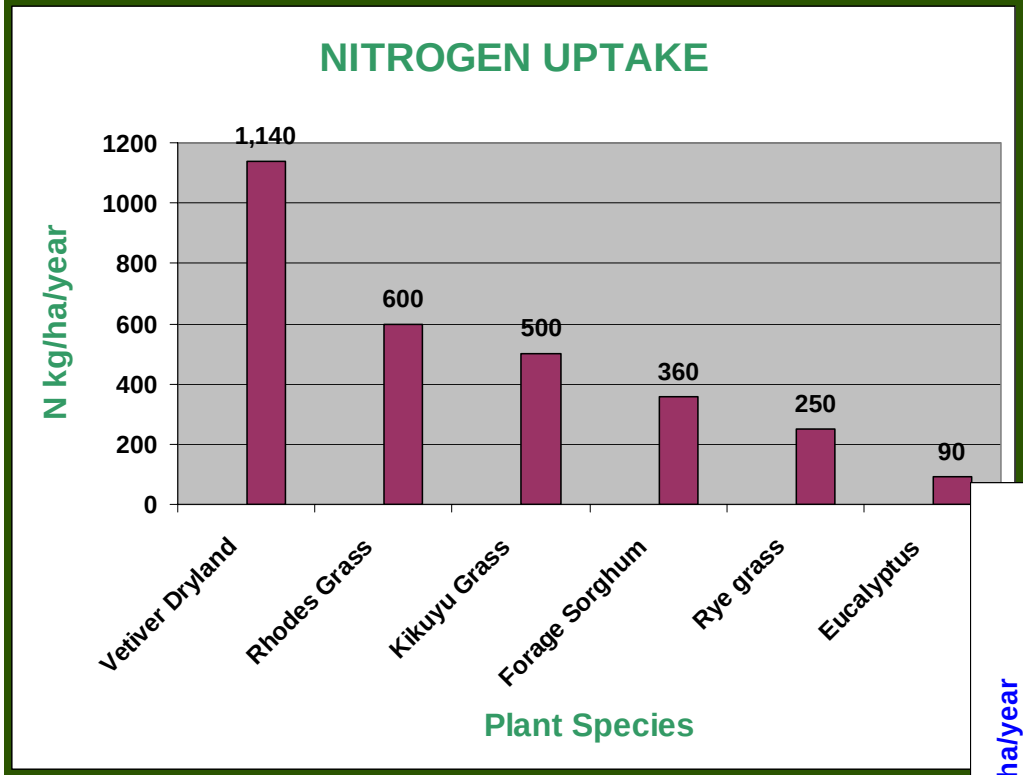
pH	2.0	2.2	3.8	4.4	4.8	5.5	7.3	7.6
Al%	90	90	68	36	11	2	trace	trace

Growth was not affected at pH=3.3 and extremely high Mn level of 578 mg/kg

Highly tolerant to acid sulfate soil conditions with pH = 3.0

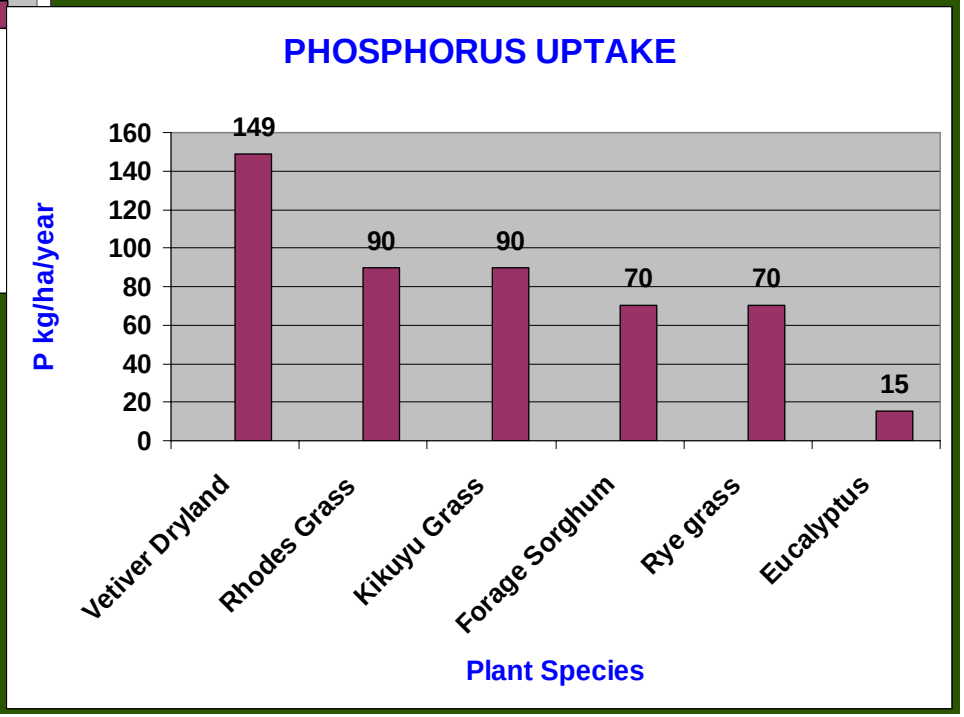
One year after planting

R & D ON NUTRIENT UPTAKE AND TOLERANCE

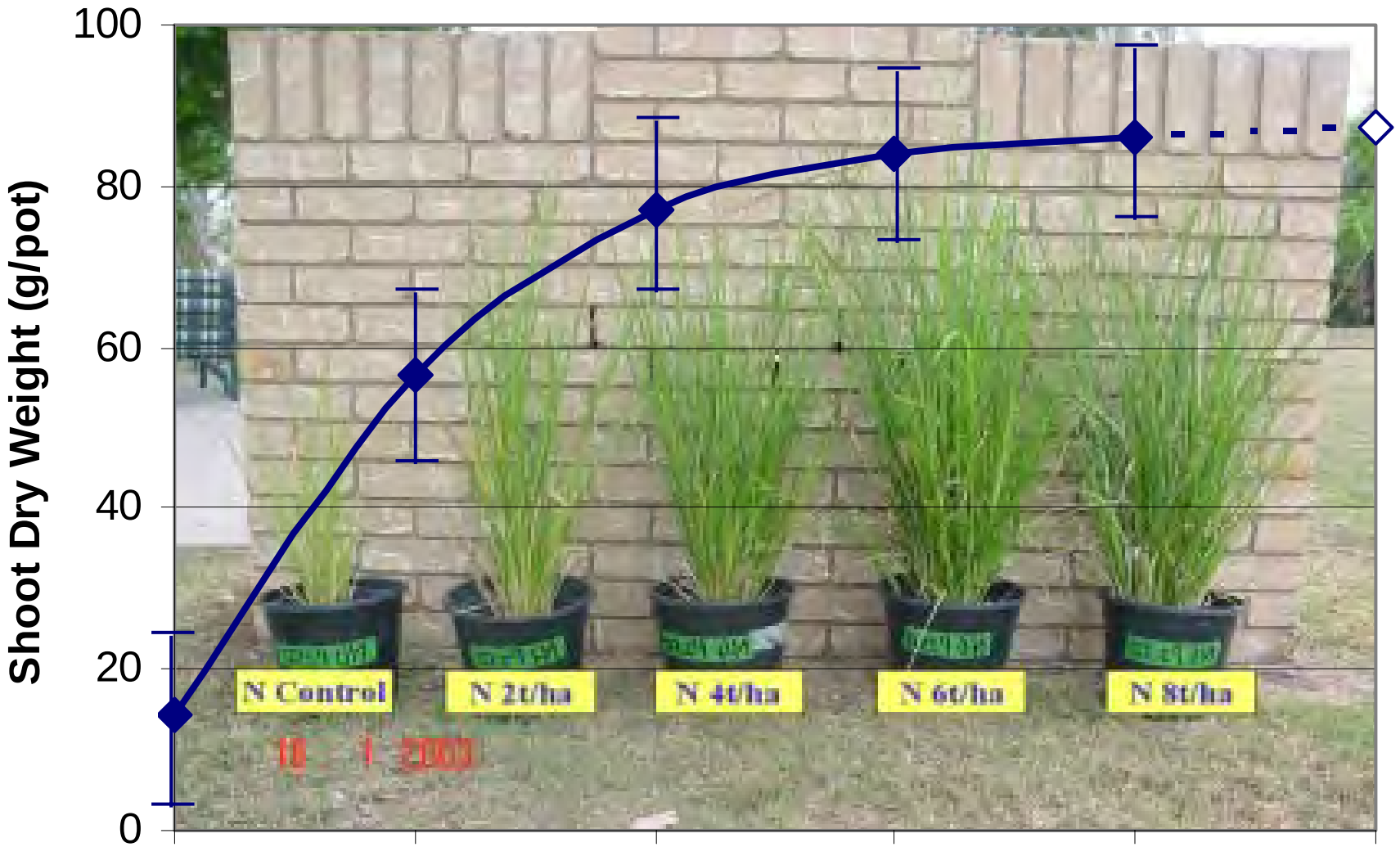


Potential N uptakes as compared with others plants

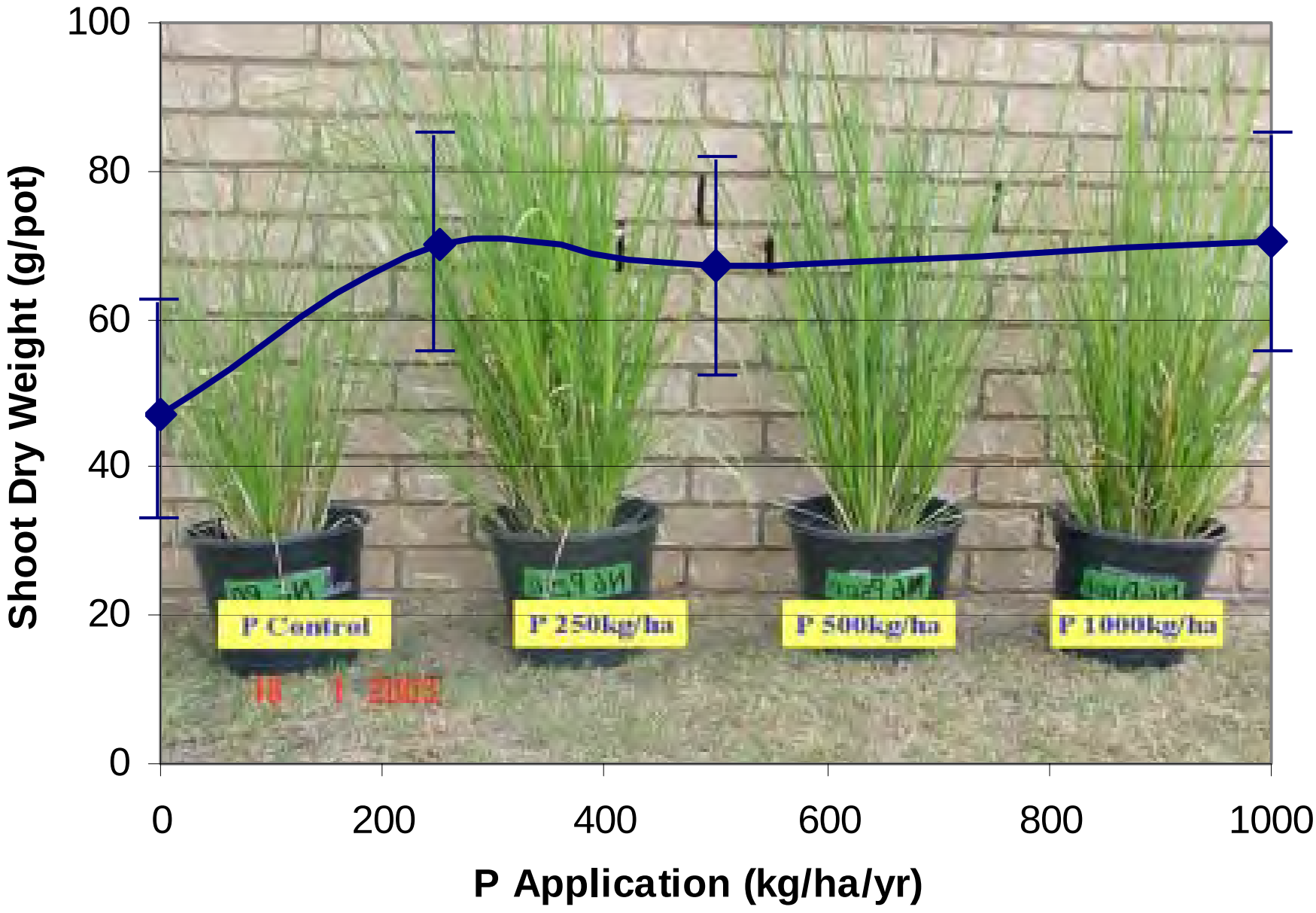
Potential P uptakes as compared with others plants



Vetiver growth increased with N application up to 6t/ha/year, higher rates did not affect yield



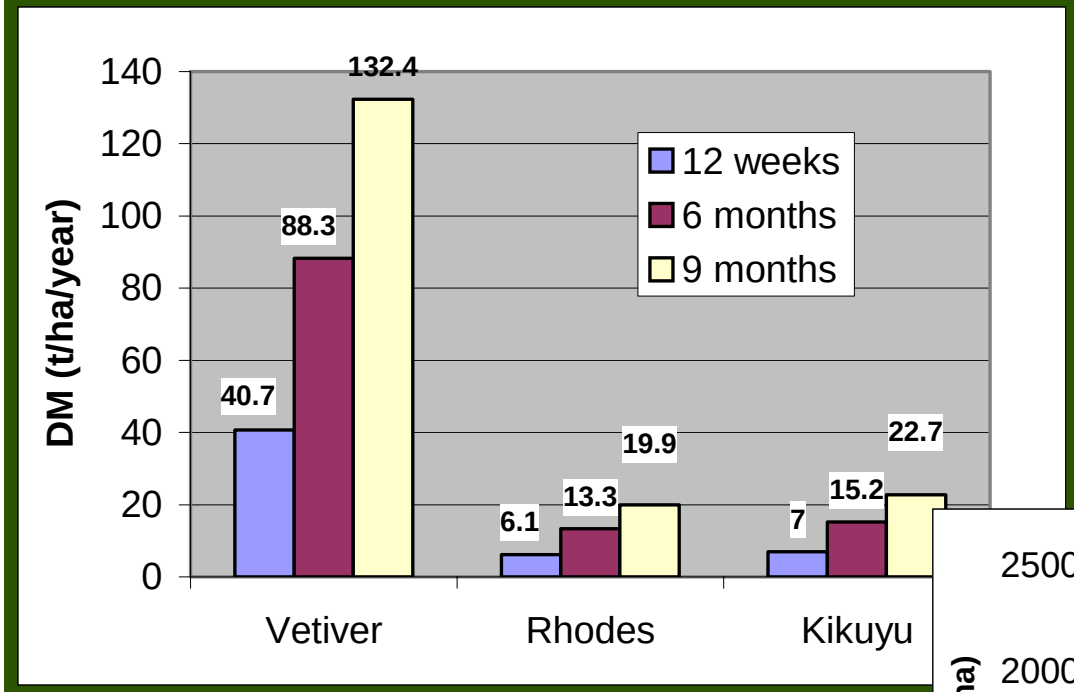
Vetiver growth increased with P application up to 250/ha/year, higher rates did not affect yield



The highest yield treatment (N= 6000 kg/ha/year and P= 250 kg/ha/year) and the lowest yield treatment (N nil and P nil).

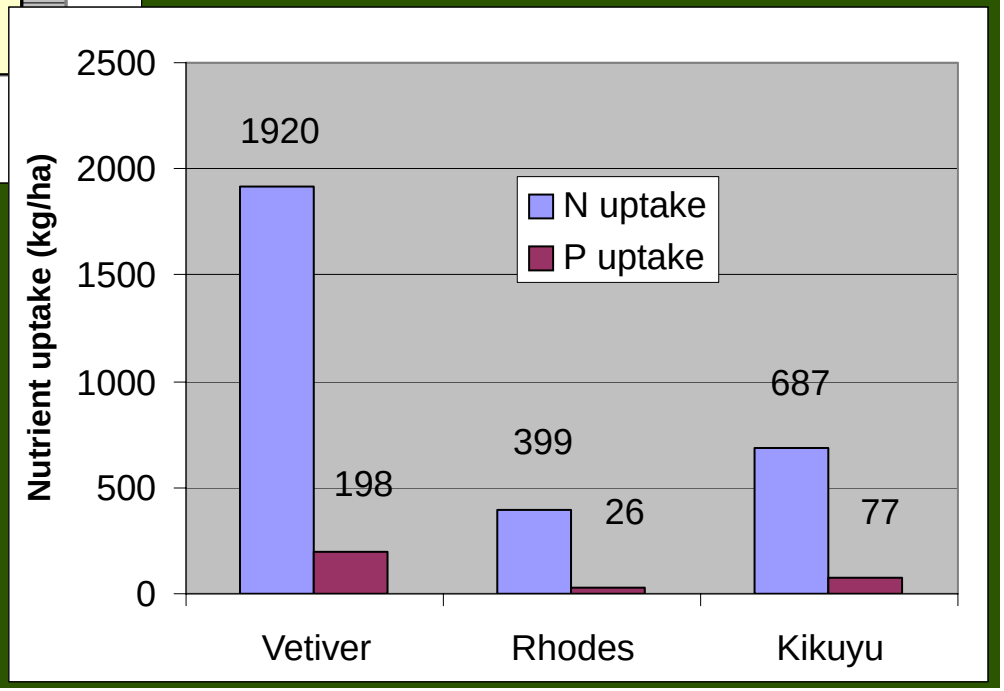
Left Vetiver growing vigorously, with no toxic effect at 10 000kgN/ha/year and 1000kgP/ha/year, as compared with the best treatment, 6 000kgN/ha/year and 250kgP/ha/year **Right.**

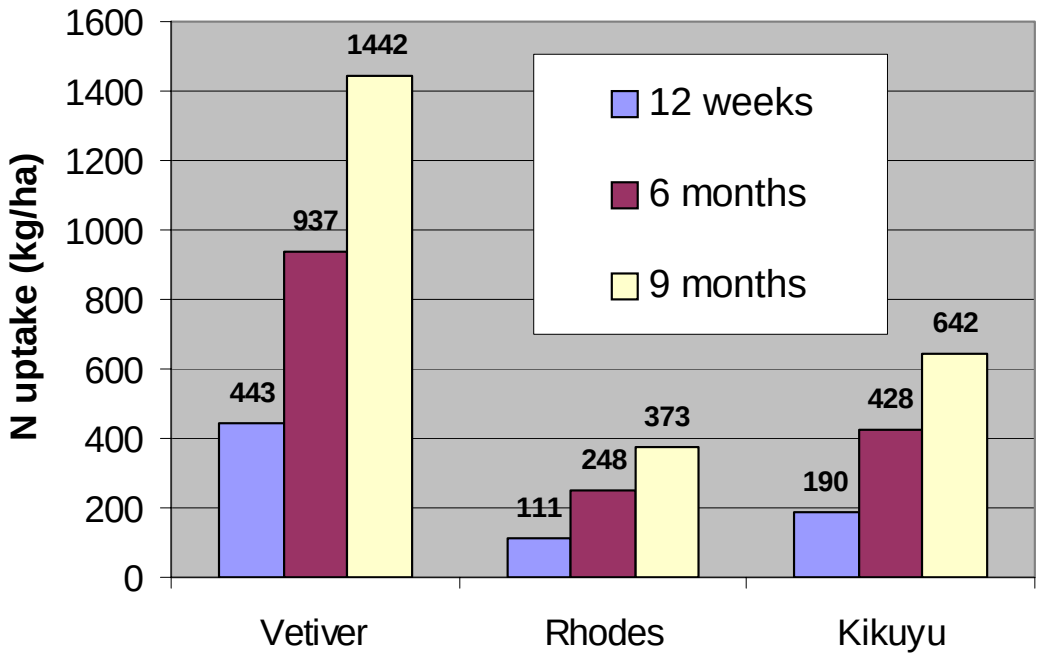
R & D ON BIOMASS PRODCTION AND NUTRIENT UPTAKE



Potential DM yield of the three grasses

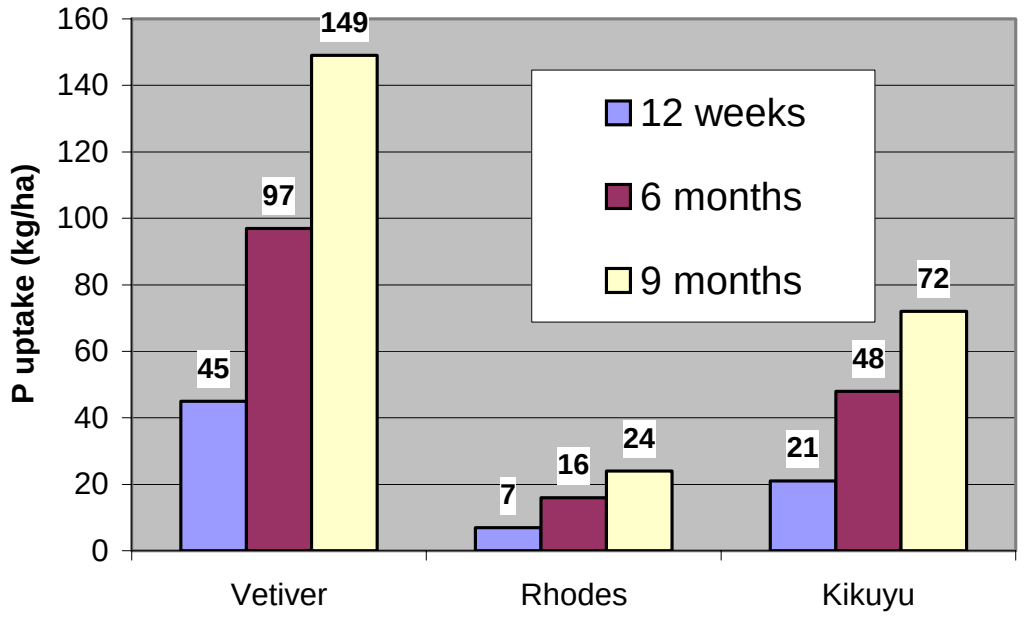
Potential N and P uptakes by the 3 grasses



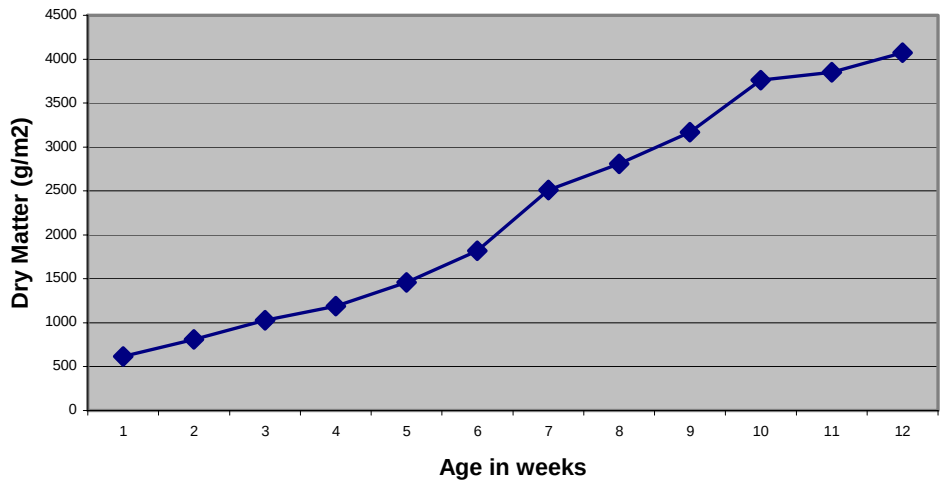


Potential P uptake by the 3 grasses

Potential N uptake by the 3 grasses

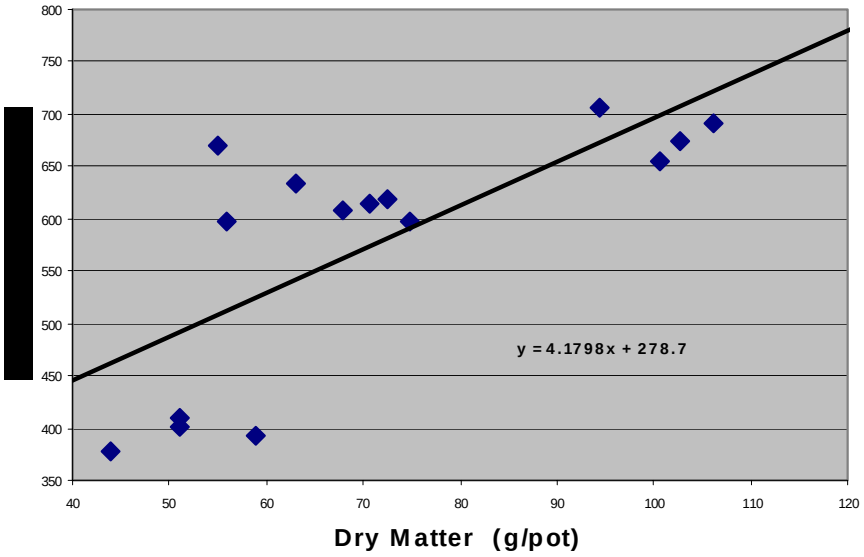


R & D ON BIOMASS PRODCTION AND WATER USE



Dry matter yield of vetiver over the 12-week period

Relationship between water use and dry matter (r = 0.7286)



R & D ON MODELLING


Photographed the sward weekly to measure % Cover
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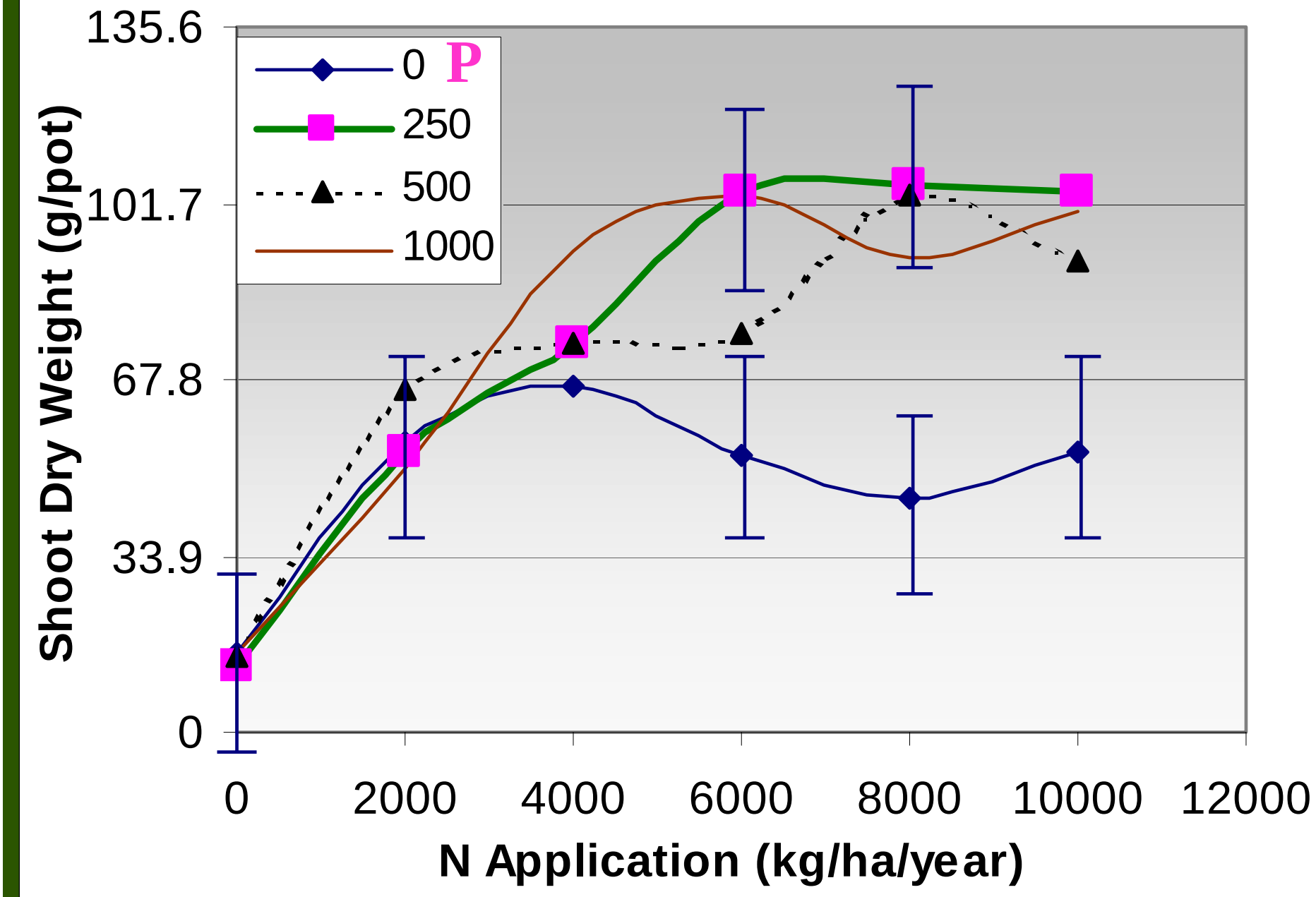
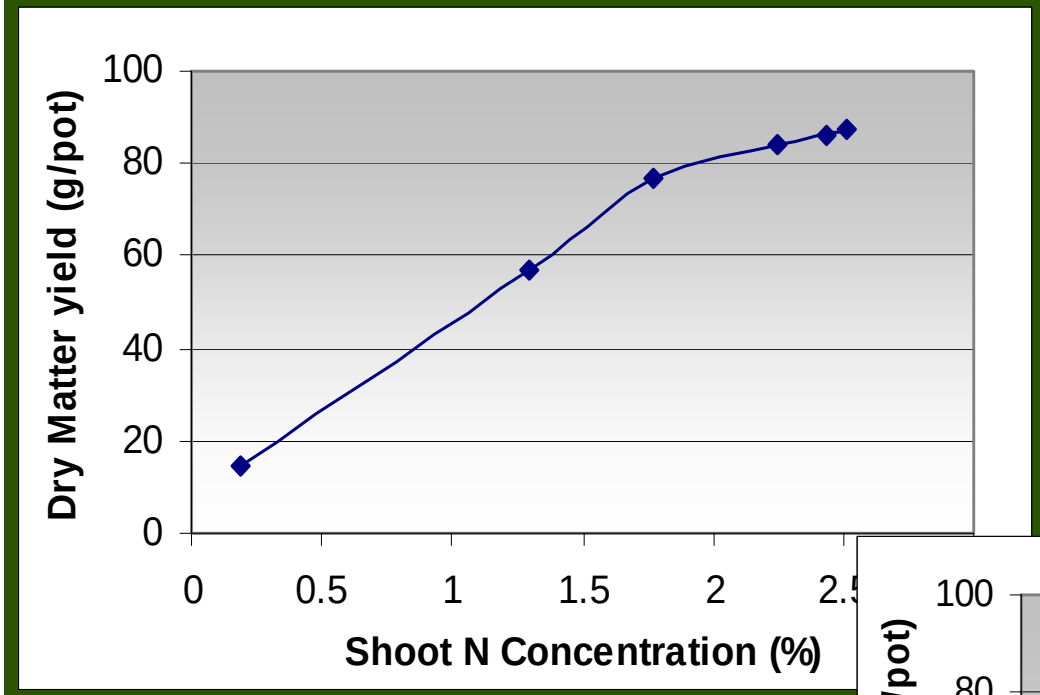
Hand harvested 1 m^2 quadrants to measure weekly shoot yield, nitrogen and phosphorus contents.
2002

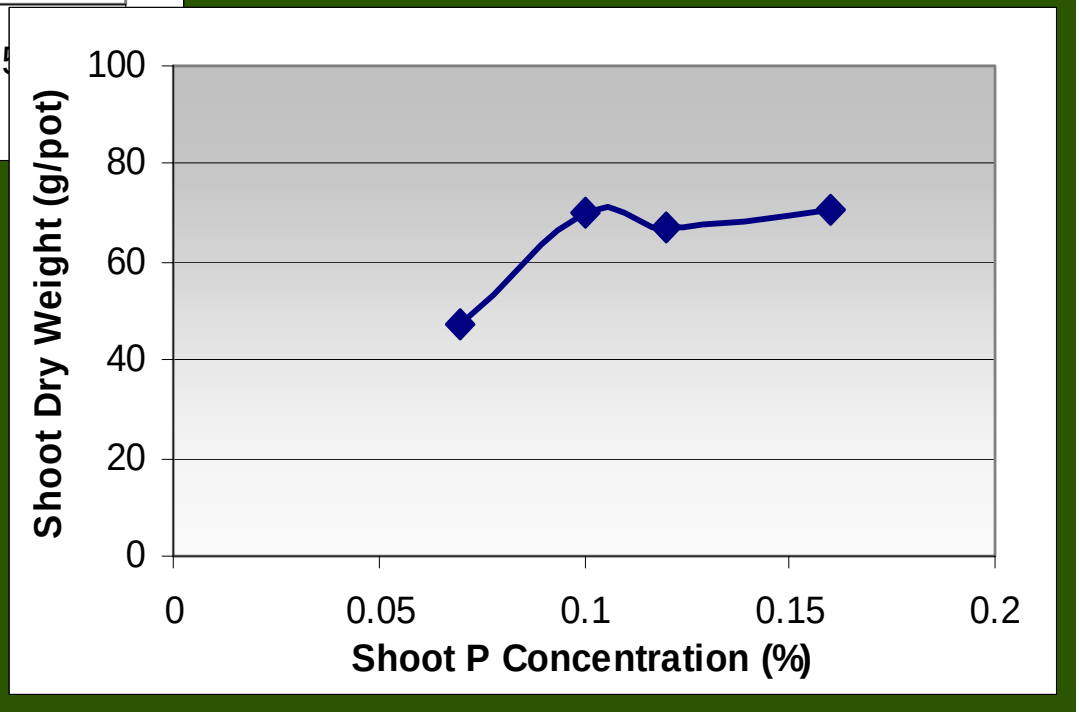
Measured weekly shoot heights

N and P interaction on biomass

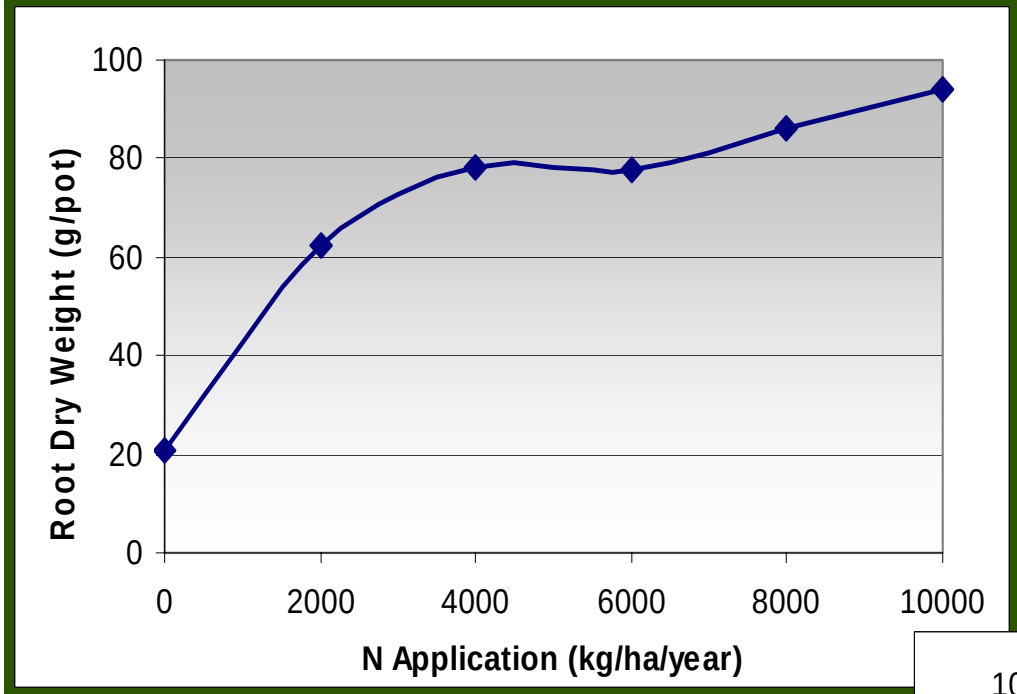


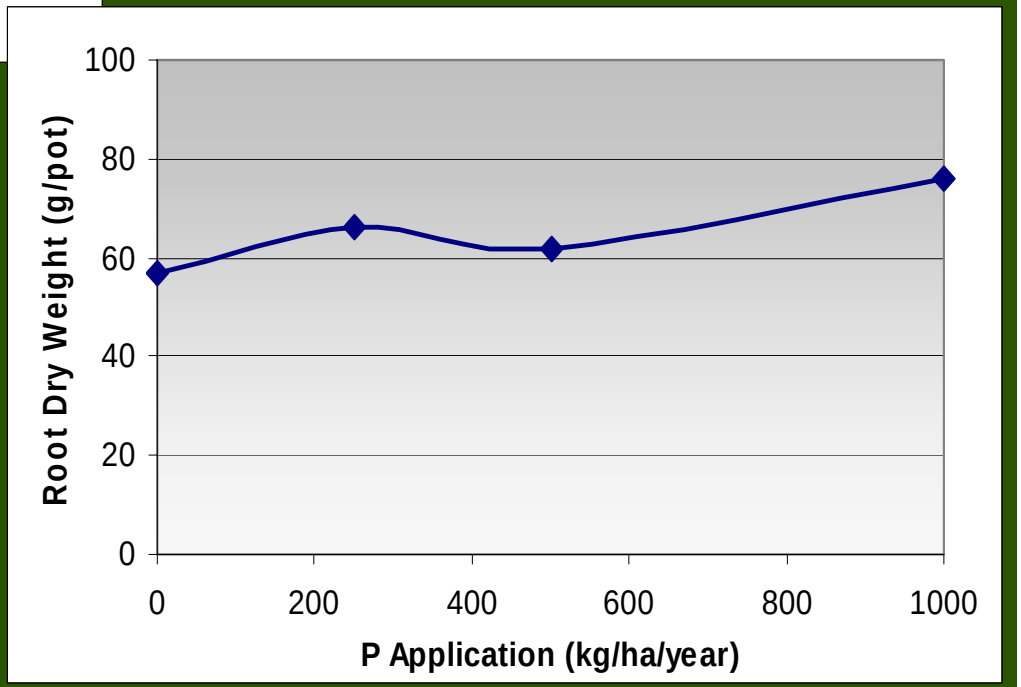
Correlation between yield and shoot N and P concentrations





Root growth response to N and P applications





Recovery rates of N and P by vetiver grass.

Treatment	%Recovery by Shoot	%Recovery by Root	% Recovered in Soil	Total
N2 (t/ha)	76.3	20.4	0.3	97
N4 (t/ha)	72.1	23.1	0.1	95
N6 (t/ha)	67.3	21.2	0.4	89
N8 (t/ha)	56.1	30.0	0.4	87
N10 (t/ha)	46.7	17.0	0.1	64
P250 (kg/ha)	30.5	23.3	46.3	100
P500 (kg/ha)	20.5	14.6	48.7	84
P1000 (kg/ha)	16.5	14.2	40.8	72

R & D ON HYDRAULIC CHARACTERISTICS

Hydraulic Flume: **The flume consists of two concrete testing channels, 2m wide and 20m long**

Side view of row planting, at 2m spacing

At 60cm depth the first row vetiver was bent over but not the second row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Over the distance of less than 20m, the water level in the flume was dropped by 50cm

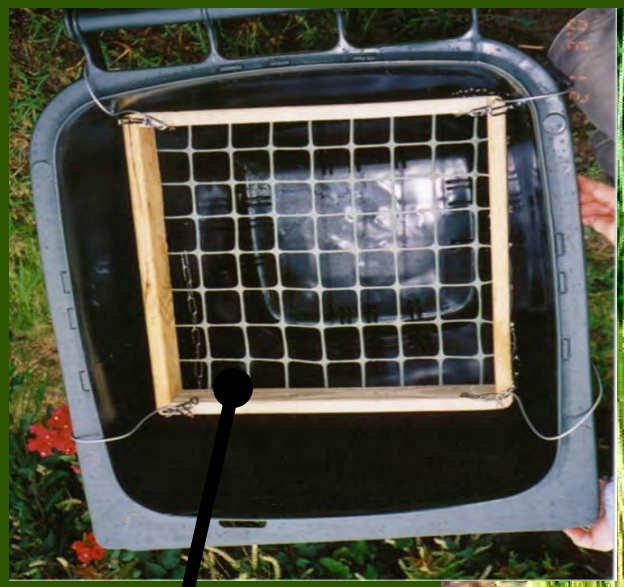
Note relatively uniform flow through hedge and strong turbulence after the hard structure (drop board)

R & D ON HYDROPONICS

DIFFERENT GROWING MEDIA

- Broken glass
- River stones
- Sand
- Road base
- No medium, just Vetiver
- No medium, Vetiver, 2 circulations a day
- **No medium, no Vetiver (controls)**

Hanging frame for hydroponic Vetiver



Waiting for roots to grow

~250 mm per month

- 6 weeks

- 14 weeks

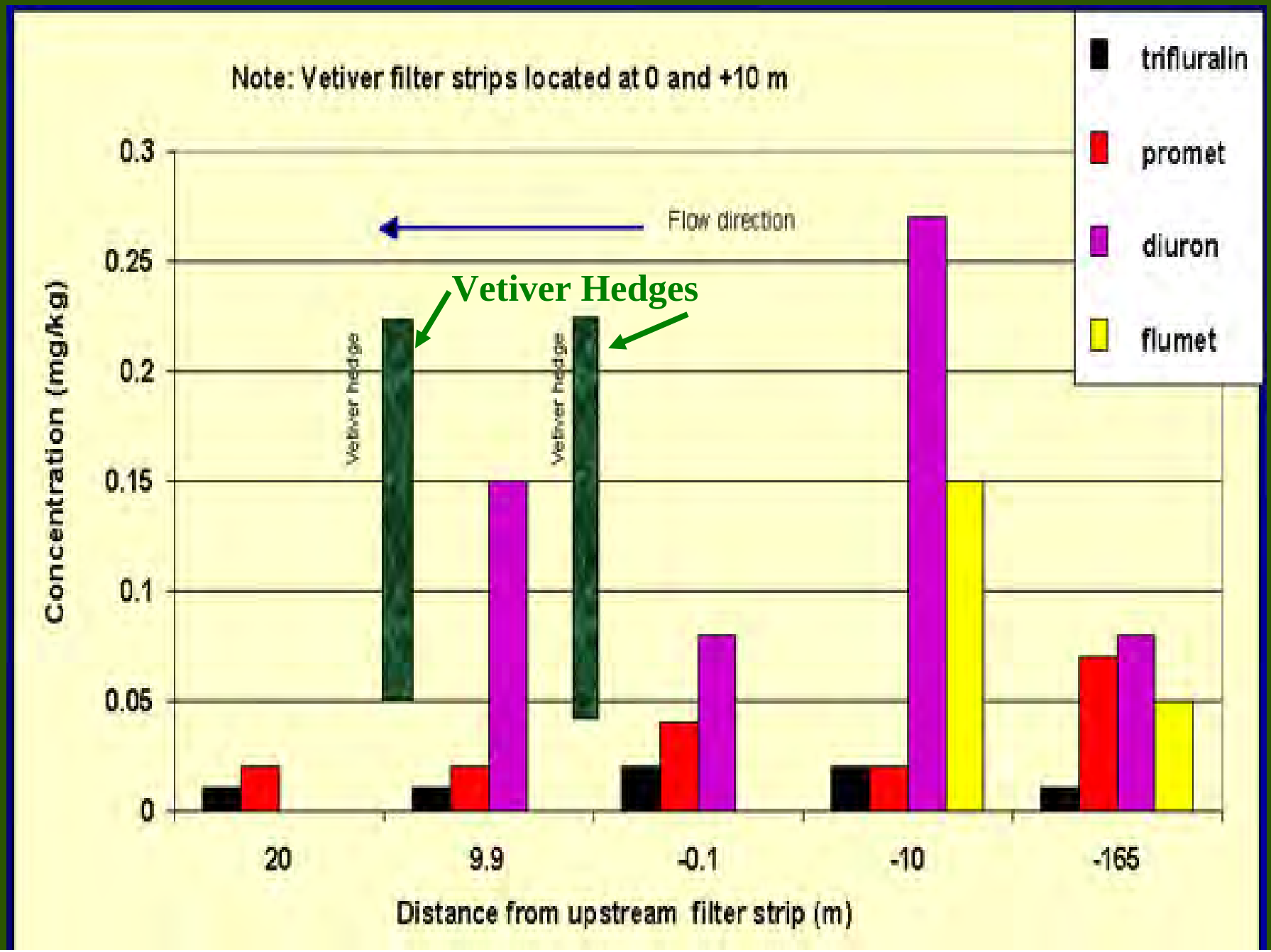
- 22 weeks

- 35 weeks

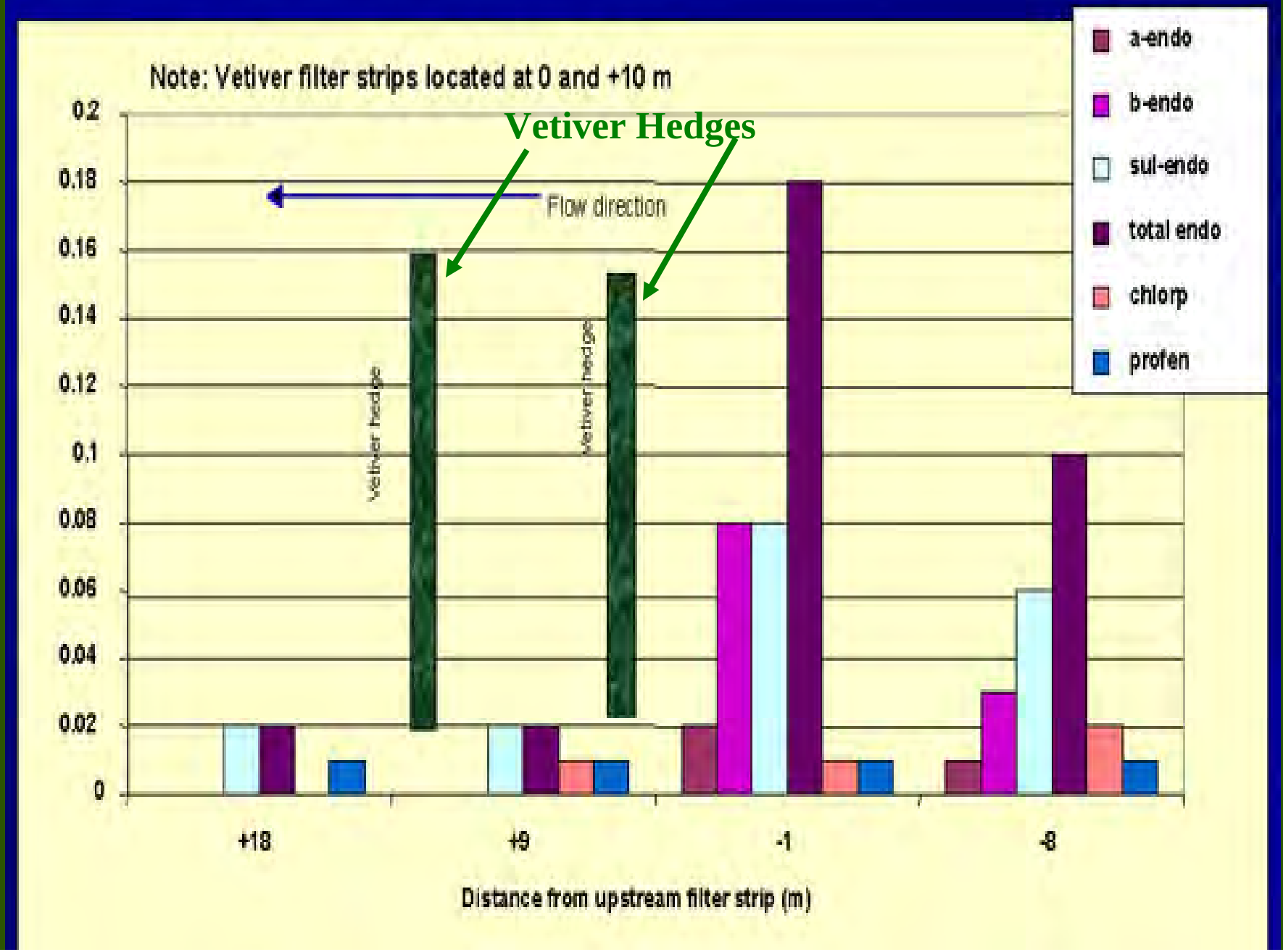
R & D ON WATER QUALITY

Vetiver strip trapped sediment

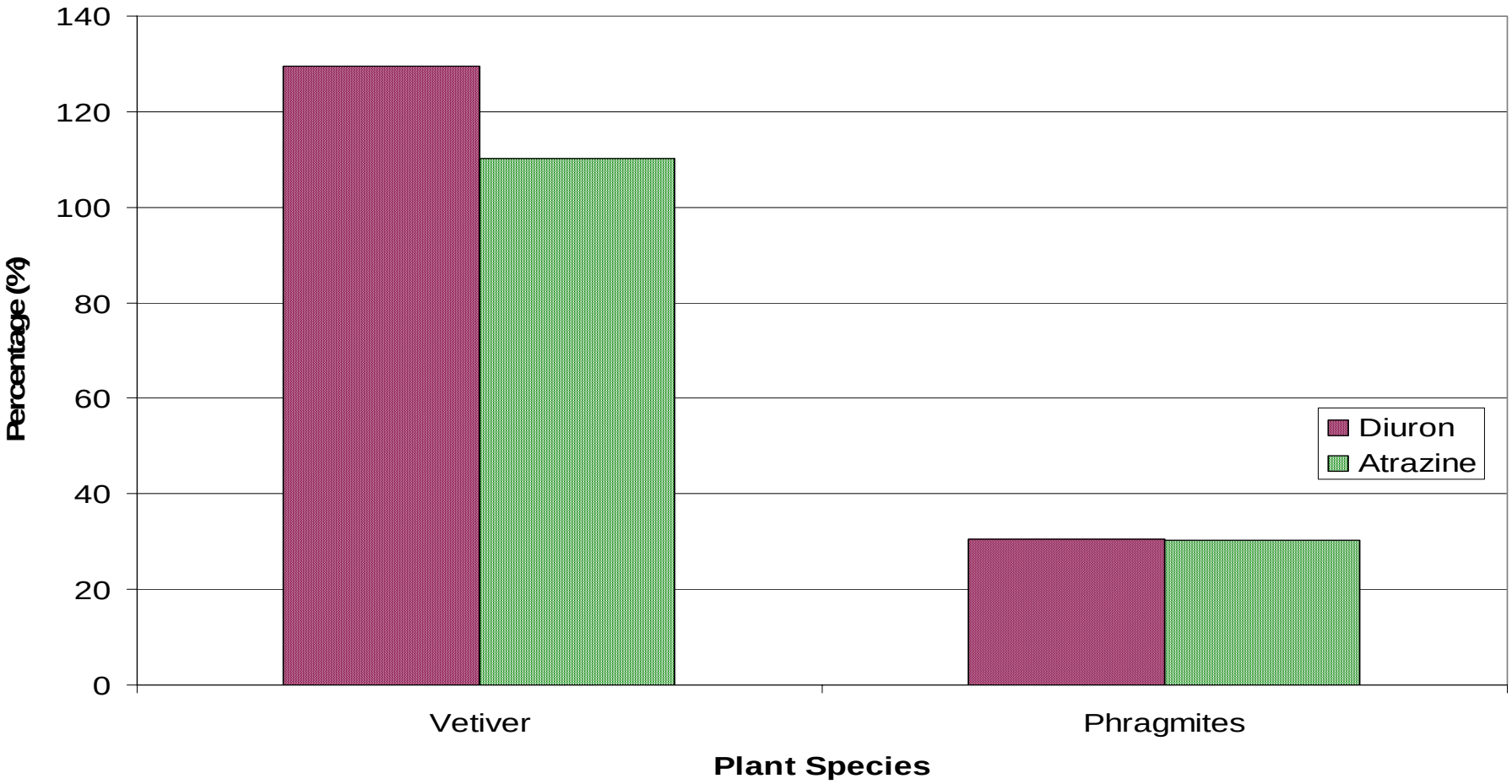
Trapping herbicides on cotton farms in central Queensland



Trapping pesticides on cotton farms in central Queensland



Comparison of whole plant dry weights of vetiver and Phragmites at the high rates of herbicide application,



Industrial Effluent from an abattoir in Australia

Effectiveness of vetiver planting on quality of effluent seepage

Analytes	Nutrient levels		
	Inlet	Mean levels in monitoring bores	
		20m down slope from inlet	50m down slope from inlet
pH	8.0	6.5	6.3
EC (uS/cm)	2200	1500	1600
Total Kjel. N (mg/L)	170	11.0	10.0
Total N (mg/L)	170	17.5	10.6
Total P (mg/L)	32	3.4	1.5

R & D ON HEAVY METAL TOLERANCE

Threshold levels of heavy metals to vetiver growth as compared with other species

Heavy Metals	Threshold levels in soil ($mgKg^{-1}$)		Threshold levels in plant ($mgKg^{-1}$)	
	Vetiver	Other plants	Vetiver	Other plants
Arsenic	100-250	2.0	21-72	1-10
Cadmium	20-60	1.5	45-48	5-20
Copper	50-10	Not available	13-15	15
Chromium	200-600	Not available	5-18	0.02-0.20
Lead	>1 500	Not available	>78	Not available
Mercury	> 6	Not available	>0.12	Not available
Nickel	100	7-10	347	10-30
Selenium	>74	2-14	>11	Not available
Zinc	>750	Not available	880	Not available

Arsenic: Toxic threshold level between 100-250 mg/kg

Copper: Toxic threshold level between 35-60 mg/kg

Chromium: Toxic threshold level between 200-600 mg/kg

This Bentonite waste site is barren with an extremely erodible surface which has low water infiltration and high runoff rates.

Fourteen months after planting, note the growth of other species

Chemical analyses of the Bentonite tailings

Analyses	Overburden	Bentonite tailings
pH	5.4	5.4
EC (mS/cm)	0.18	0.14
Cl (mg/kg)	135.0	47.4
NO3-N (mg/kg)	1.9	0.7
P (mg/kg)	2.0	5.0
SO4-S (mg/kg)	66.0	101.0
Ca (meq/100g)	0.19	0.93
Mg (meq/100g)	4.75	6.44
Na (meq/100g)	2.7	7.19
K (meq/100g)	0.16	0.43
Organic Matter (%)	0.45	0.35
ECEC (meq/100g)	8	15
ESP (%)	**35**	**48**

China : Pb – Zn tailings rehabilitation with vetiver grass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THANK YOU
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