EFFECTIVENESS OF VETIVER GRASS IN PHYTOSTABILIZATION AND/OR PHYTOREMEDIATION OF DIOXIN-CONTAMINATED SOIL AT BIEN HOA AIRBASE, VIETNAM - AN OVERVIEW AND PRELIMINARY RESULT

Ngo Thi Thuy Huong[1], Tran Tan Van[1], and Paul Truong[2], Nguyen Hung Minh[3]

[1]Vietnam Institute of Geosciences and Mineral Resources, 67 Chien Thang, Ha Dong, Hanoi, Vietnam.

[2]TVNI Technical Director, 23 Kimba St., Chapel Hill, Brisbane Q. 4069, Australia.

[3]Dioxin Laboratory, Center for Environmental Monitoring; Nr. 556 Nguyen Van Cu Str., Long Bien, Hanoi

INTRODUCTION

Dioxins: - persistent organic pollutants with high toxicity. These substances are attributed to cancers, diabetes, mutation and congenital defects, etc.

INTRODUCTION

Dioxins

☞ Natural sources

☞Anthropogenic sources (mainly):

- Primarily from herbicides (war)

INTRODUCTION

- Dioxin contamination in Vietnam is primarily from herbicides (ca. 80 mil. liters) being sprayed during the war (1961-1971).
- Dioxins sprayed in Vietnam > 50 times compared to the recommended conc. ➔ dioxins are still found very high at "Hot Spots"

INTRODUCTION

Dioxins

☞ Natural sources

☞ Anthropogenic sources (mainly):

- Primarily from herbicides (war)

Soils, sediments and food chains polluted with dioxins (TCDD) → Practical importance

Practical requirement

Appropriate technology to remediate dioxins contaminated soils:

- Active Landfill technology, Ball Milling, Bio-remediation and Thermal Desorption Destruction technology ➔ expensive and only suitable in hot spots (small to medium scales)
- **Phytoremediation using vetiver grass** ➔ low cost, environmental friendly and suitable to apply in large scale (with low and moderate dioxins levels).

INTRODUCTION

<u>Vetiver (*Chrysopogon zizanioides* L.) characteristics:</u> tolerant of extreme conditions, i.e., high heavy metals conc., highly acidic soils (pH 2.7), highly arsenic, saline, lack of major nutrients and organic materials.

- Vetiver: grow quickly, high biomass, a dense root system ➔ suitable for **phytostabilization** of dioxins contaminated soils.
- Vetiver: produces an extremely chemically complex essential oil, a huge rhizosphere for bacterial and fungal growth ➔ enabling absorption and/or breakdown of contaminants, and perhaps also toxic chemicals/dioxins (**phytoremediation).**

➔ sustainable technology implemented in a large-scale for remediation of moderately dioxins contaminated soils in southern Vietnam.

INTRODUCTION

I.2. Objectives:

The objectives of this project are to investigate:

1. The capability of vetiver grass in **phytostabilization** of dioxin-contaminated sites, preventing its offsite contamination; and
2. Its effectiveness in the **bioremediation** of the dioxin-contaminated soils.

MATERIALS AND METHODS

Study site:

Figure 1: A map showing the geographical location of the investigated site in a general view (upper image) and in a close-up view (lower image).

MATERIALS AND METHODS

<u>Monto cultivar:</u>

- Site of 300 m^2 with a moderate dioxin-contaminated level (about 1000 – 2000 ppt TEQ).
- Monto vetiver grass (*Chrysopogon zizanioides* L.) of 5 tillers each in plastic cups filled with coir particle media was used.

MATERIALS AND METHODS

Soil preparation:

Soil: hard and compact, limestone rocks

Excavator

Dug up and mixed up

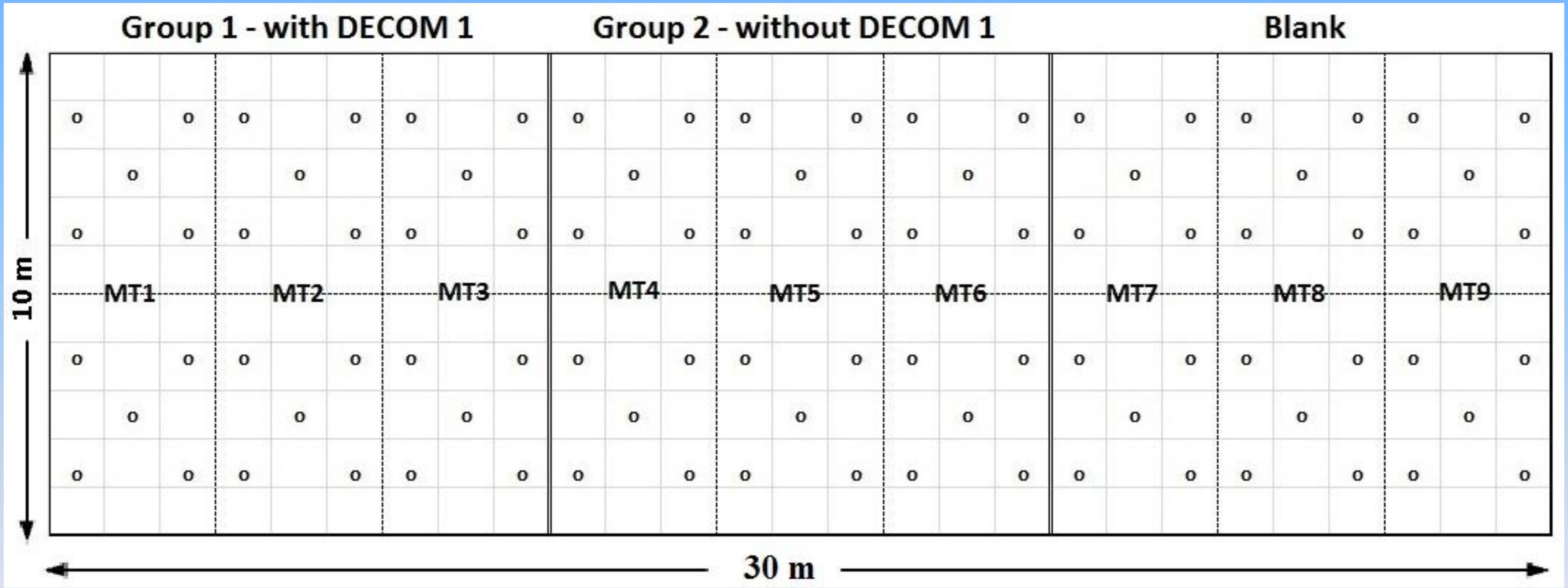
Remove weeds, big stones and leveled

Collect initial samples

Transplant vetiver grass slip

MATERIALS AND METHODS

Initial sample collection and experimental design:



A schematic representation of experimental design and sampling method.

MATERIALS AND METHODS

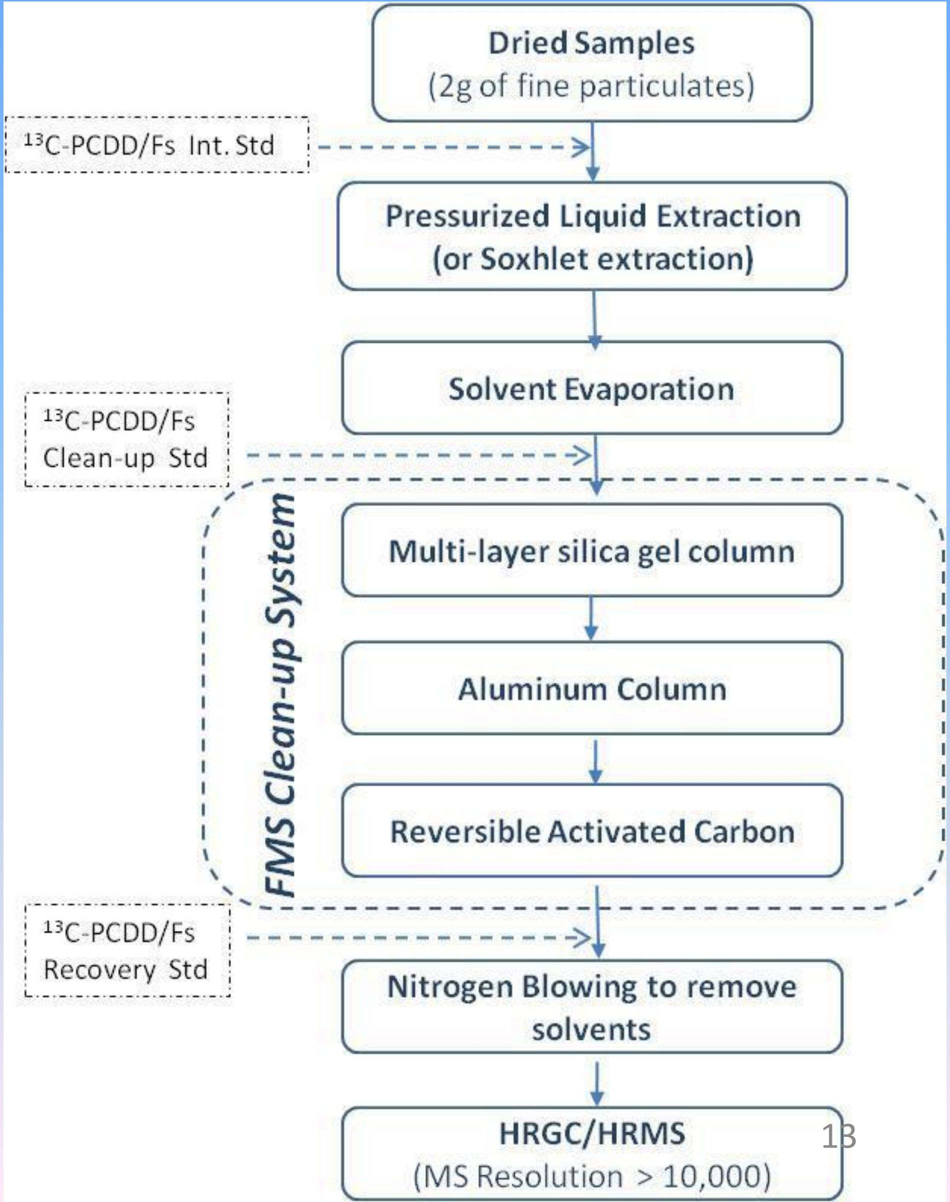
Experimental design and growth monitoring:

- Monto vetiver grass was planted on November 2014 in G1 and G2.
- Vetiver slip of 3-5 tillers each: 25 cm long shoots with 5 cm long roots.
- Transplanted in the rows: 50 x 25 cm spacing between plants.
- Vetiver grass: watered daily or twice daily.
- Growth rate of vetiver and levels of toxic chemicals/dioxins in soil, roots and shoots will be compared, as will soil samples from areas with and without vetiver grass (blank).
- Plant height and number of tillers are checked every two weeks.
- Soil, root and shoot samples: taken every 5 months for dioxins analyses.

MATERIALS AND METHODS

- All samples were processed and analyzed in Dioxin Laboratory, Vietnam Environment Administration.
- 17 PCDD/Fs congeners were determined.
- Results were converted to TEQ using TEF given by WHO and expressed on a dry weight basis.

Figure: Analytical scheme for the determination of PCDD/Fs.



MATERIALS AND METHODS

Statistical analysis:

- Two-way analysis of variance (ANOVA) and Student-Newman-Keuls multiple comparison test were used for differences.
- Pearson rank correlation test was used for correlation.

RESULTS AND DISCUSSION

Initial concentration of toxic chemicals/dioxins

Level of PCDD/Fs (ppt TEQ-WHO$_{2005}$) of the soil column (taken from 0-60 cm soil depth) from Pacer Ivy site, Bien Hoa airbase

Samples	Latitude	Longitude	2378-TCDD	TEQ$_{who}$	%TCDD
MT1	10°58'23.4"	106°48'21.7"	1,221.2	1,235.0	98.9
MT2	10°58'23.8"	106°48'21.6"	1,142.9	1,169.4	97.7
MT3	10°58'23.8"	106°48'21.5"	686.1	694.8	98.8
Average of lot 1 (G1)			**1,017 ± 167**	**1,033 ± 170**	**98.5 ± 0.4**
MT4	10°58'23.9"	106°48'21.5"	1,058.9	1,071.6	98.8
MT5	10°58'24.1"	106°48'21.5"	2,781.9	2,795.6	99.5
MT6	10°58'24.3"	106°48'21.4"	1,617.8	1,626.1	99.5
Average of lot 2 (G2)			**1,819 ± 507**	**1,831 ± 508**	**99.3 ± 0.2**
MT7	10°58'24.5"	106°48'21.4"	4,413.5	4,425.2	99.7
MT8	10°58'24.6"	106°48'21.3"	2,815.2	2,831.9	99.4
MT9	10°58'24.7"	106°48'21.4"	1,623.7	1,631.6	99.5
Average of lot 3 (Blank)			**2,950 ± 808**	**2,961 ± 809**	**99.6 ± 0.1**

RESULTS AND DISCUSSION

- ***As concentrations***: ranged from 16.2 to 39.5 mg/kg dry weight ➔ higher than Vietnamese allowable limits (12 mg/kg dry wt.) and the US EPA limit (1.6 mg/kg, for industrial soil).

  - No correlation between As and dioxin TEQ was found.

- ***2,4-D and 2,4,5-T concentrations:*** are quite low, i.e.

  0.012 – 0.067 mg/kg d.wt. (2,4-D);

  0.017 – 0.274 mg/kg d.wt. (2,4,5-T)

  Protection of Groundwater
  2,4-D: **0.5 mg/kg** and
  2,4,5-T: **1.9 mg/kg**

- Due to short half-lives: 7-10d (2,4-D) and 21-24d (2,4,5-T).
- 2,4-D and 2,4,5 T were tightly correlated to dioxins TEQ, r = 0.97 and 0.99, respectively ($p<0.0001$).

RESULTS AND DISCUSSION

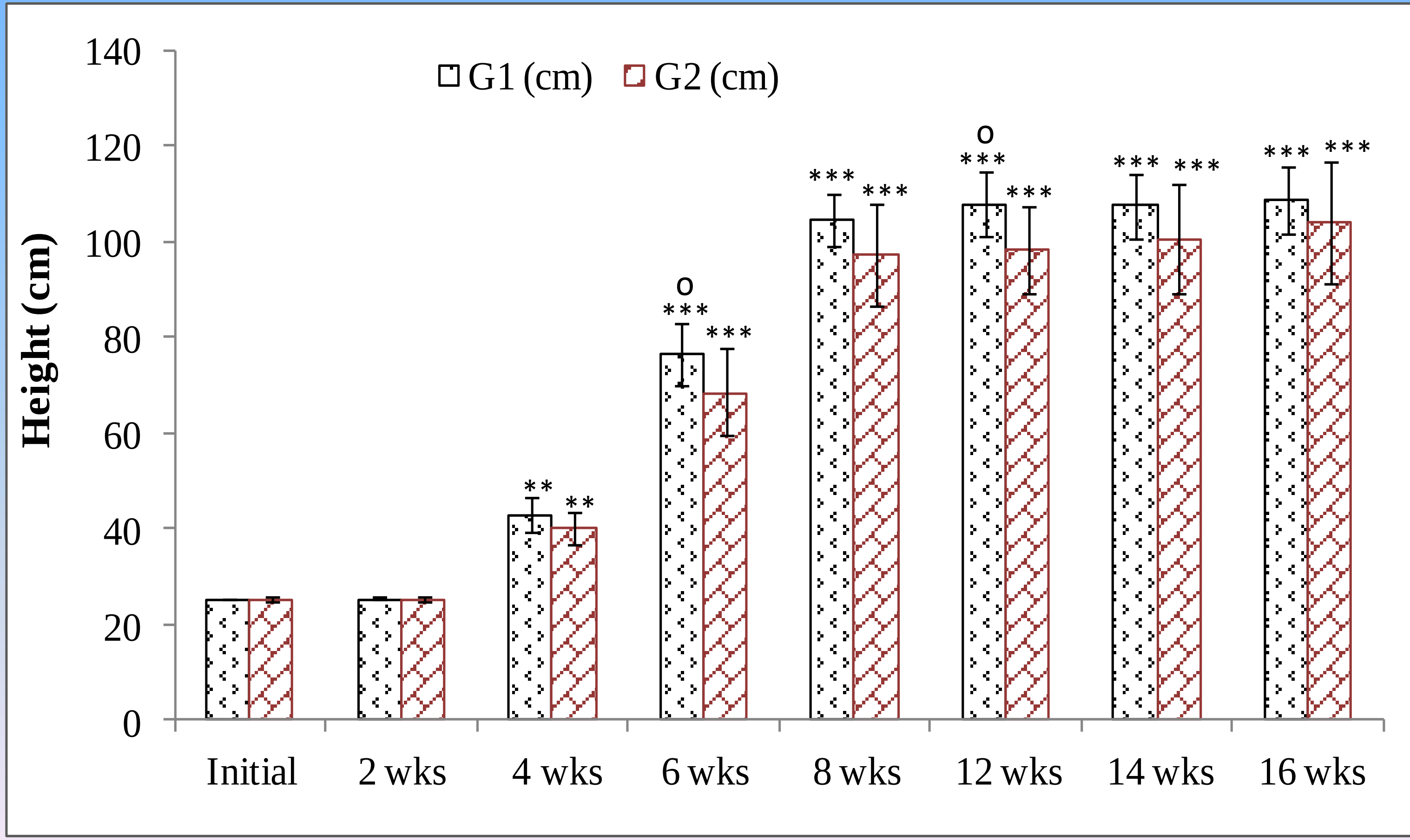
Characteristics of the experimental soils

- ***soil texture:*** mainly coarse sands mixed with very fine sand, clay and limestone.
- Soil shows its poor quality: high levels of reductants, low organic matter, low water holding capacity and the compact structure ➔ not suitable for growing many plants but vetiver.

RESULTS AND DISCUSSION

Growth performance

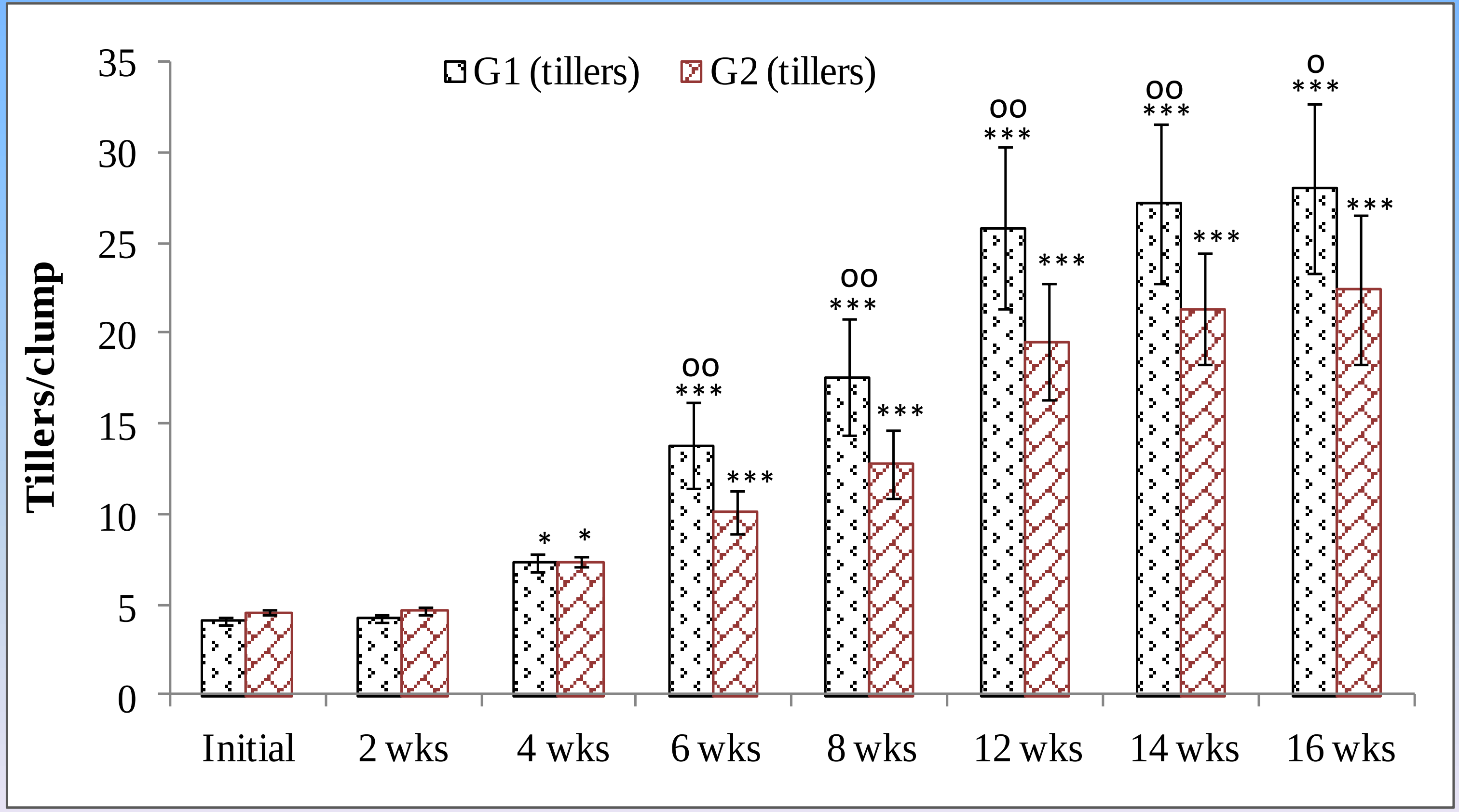
Height (cm) of vetiver grass (G1 and G2) planted in dioxins contaminated soil. Differences for height (cm) from the same group in comparison to the beginning (*) and between the two groups (o) are indicated (mean ± SD, n = 30).



RESULTS AND DISCUSSION

Growth performance

Size of vetiver grass clump (number of tillers/clump) for G1 and G2. Differences for the clump size from the same group in comparison to the beginning (*) and between the two groups (o) are indicated (mean ± SD, n = 30).



RESULTS AND DISCUSSION

Growth performance

At week 16:

- No difference between G1 and G2 in terms of circumference of grass clump.
- Some plants were flowering in both groups.

Vetiver can establish itself well on this type of soil.

G1, 1/2015

G2, 1/2015

G1, 1/2015

G2, 1/2015

CONCLUSIONS

- Vetiver grass can grow well on poor quality and moderately toxic chemical/dioxin-contaminated soil.
- G1 grows better than in G2 in terms of the number of tillers, but not in terms of the clump circumference and the plant height at week 16.
- Flowering started in week 16 for some plants → vetiver is well established on this kind of contaminated soil.
- A soil supplement in G1 further enhances its potential as an effective phytostabilization agent.

Monto vetiver is suitable for phytostabilization of moderately dioxin-contaminated sites.

Thank you very much for your attention!

For further information

Please contact: ngothithuyhuong@gmail.com