Use of compost by farmers as an adaptation strategy to combat climate change: Land application & Simulation studies.

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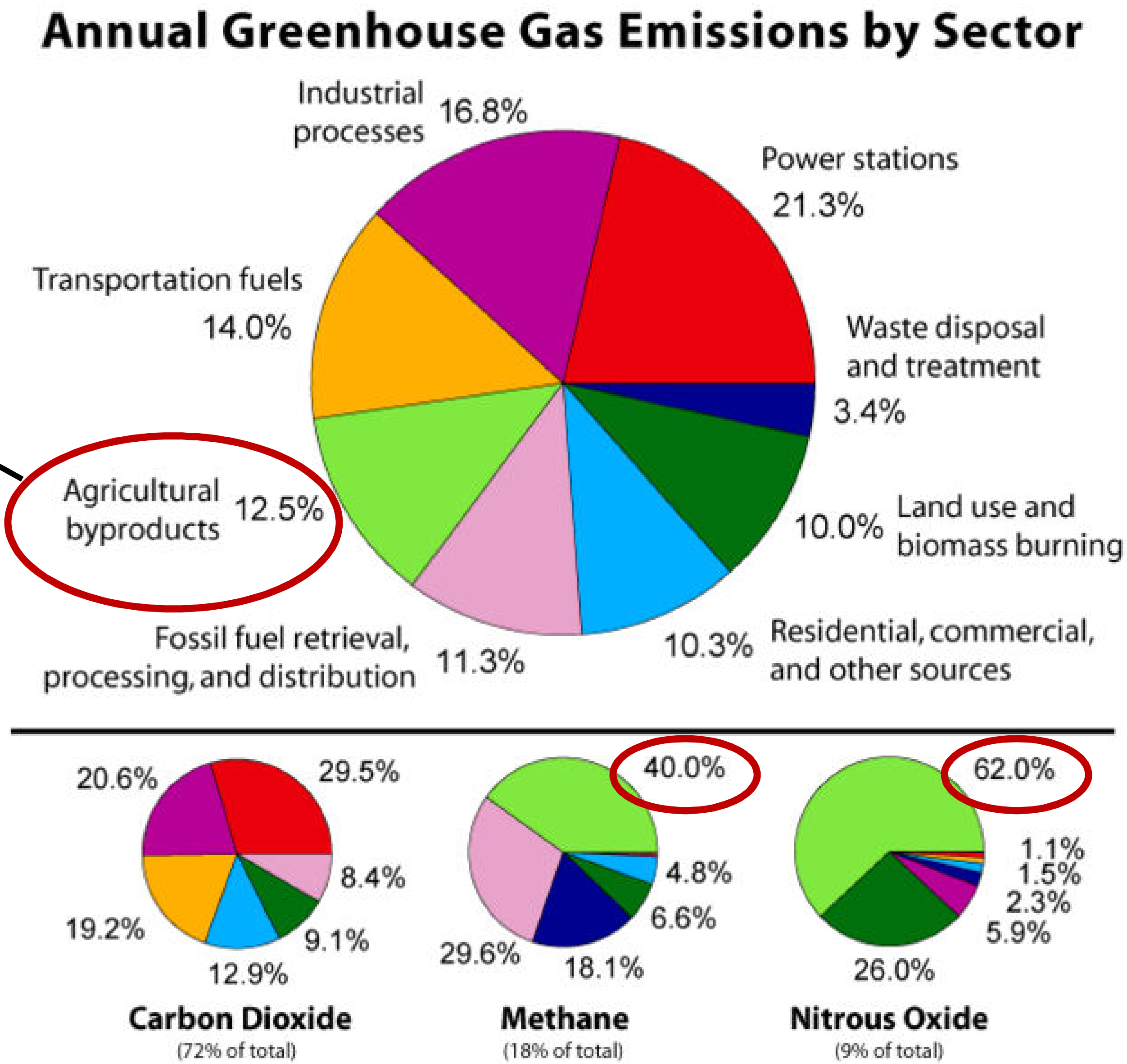
30th October 2012

Agriculture & Climate Change

5.1 to 6.1 Gt CO_2 equivalents (IPCC, 2007)



Global Warming Potentials

GHG	*Global warming potential over 100 years (tonnes CO_2-equivalent/tonne GHG)*
Carbon dioxide	1
Methane	21
Nitrous oxide	310
Halofluorocarbons	120-12 000
Perfluorocarbons	7 850
Sulphur hexafluoride	34 900

Carbon Sequestration

GWP decreased by 80% (Kustermann et al., 2007) → Compost Use

Reduction measures for GHG emissions

Improved cropland management

Improved graze land management

Restoration of degraded soil

Overview of Studies

- Boldrin et al. (2010) showed that from a life cycle perspective, compost performs better regarding global warming (savings in the range of 70–150 kg CO_2-eq. Mg^{-1}) and nutrient enrichment (savings in the range of 1.7–6.8 kg NO_3 Mg^{-1} compost).

- Fronning et al. (2008) found that manure had the highest flux of 39.0 g N_2O-N ha^{-1} d^{-1} as compared to compost, which was 13.7 g N_2O-N ha^{-1} d^{-1}. Also, application of manure resulted in emissions of 1.3 g CH_4–C ha^{-1} d^{-1} compared with bare soil which produced a flux of –0.9 g CH_4–C ha^{-1} d^{-1}.

Objectives of the study

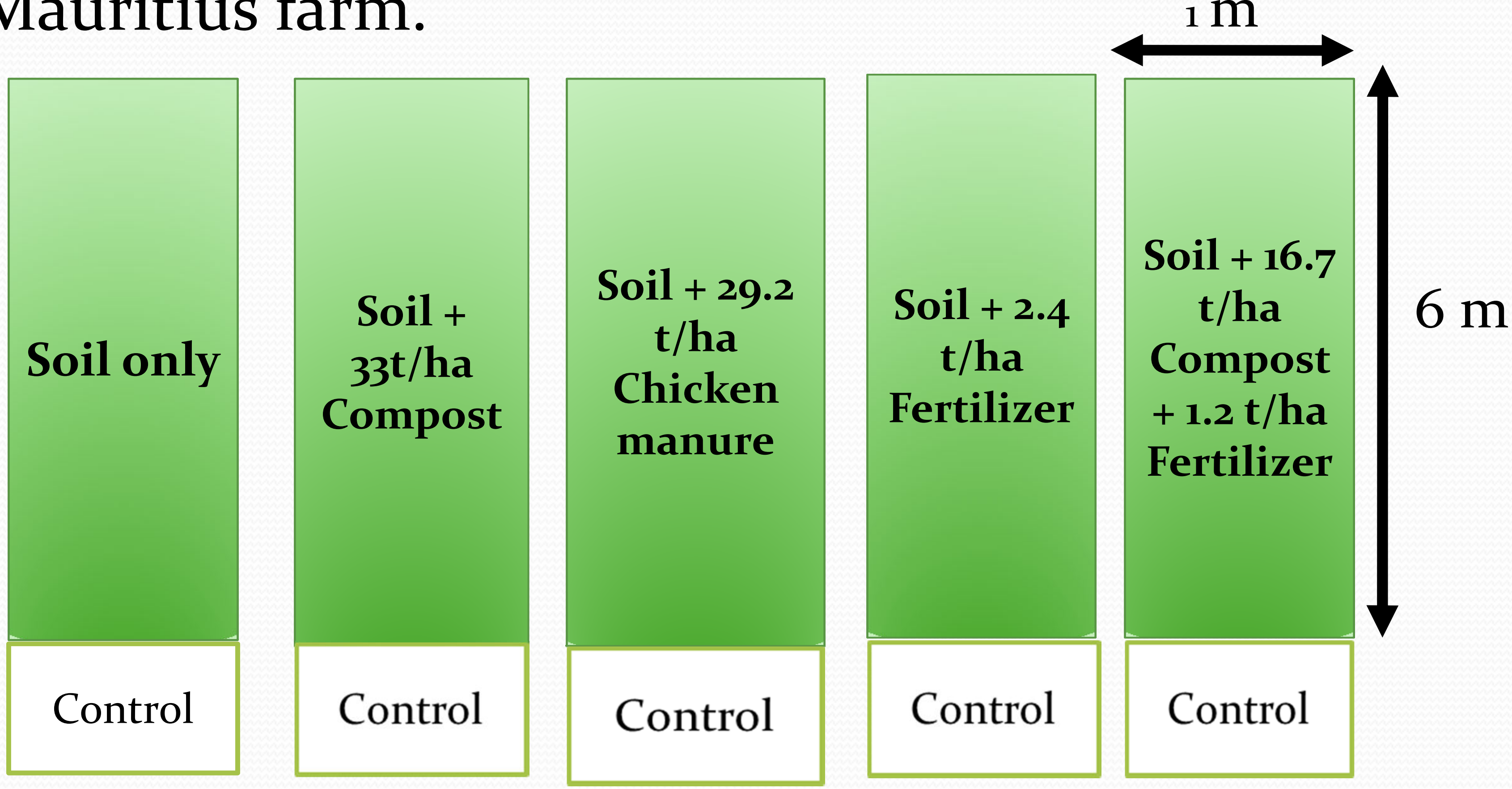
- To assess the use of compost in view of reducing greenhouse gas emissions and adapting to climate change.
- To set up different treatments namely: (a) Soil only; (b) Compost and Soil; (c) Soil and Chemical Fertilizers; (d) Soil and Manure, and (e) Compost, Soil and Chemical Fertilizers; for comparing GHG emissions.
- To devise an experimental set-up for quantification of Greenhouse gases (GHGs), namely; Methane and Carbon dioxide.
- To assess the environmental impacts associated with the different treatments
- To integrate the strategy of compost usage in farming as a means of adapting to climate change

Methodology - Land preparation

Site where treatments were carried out

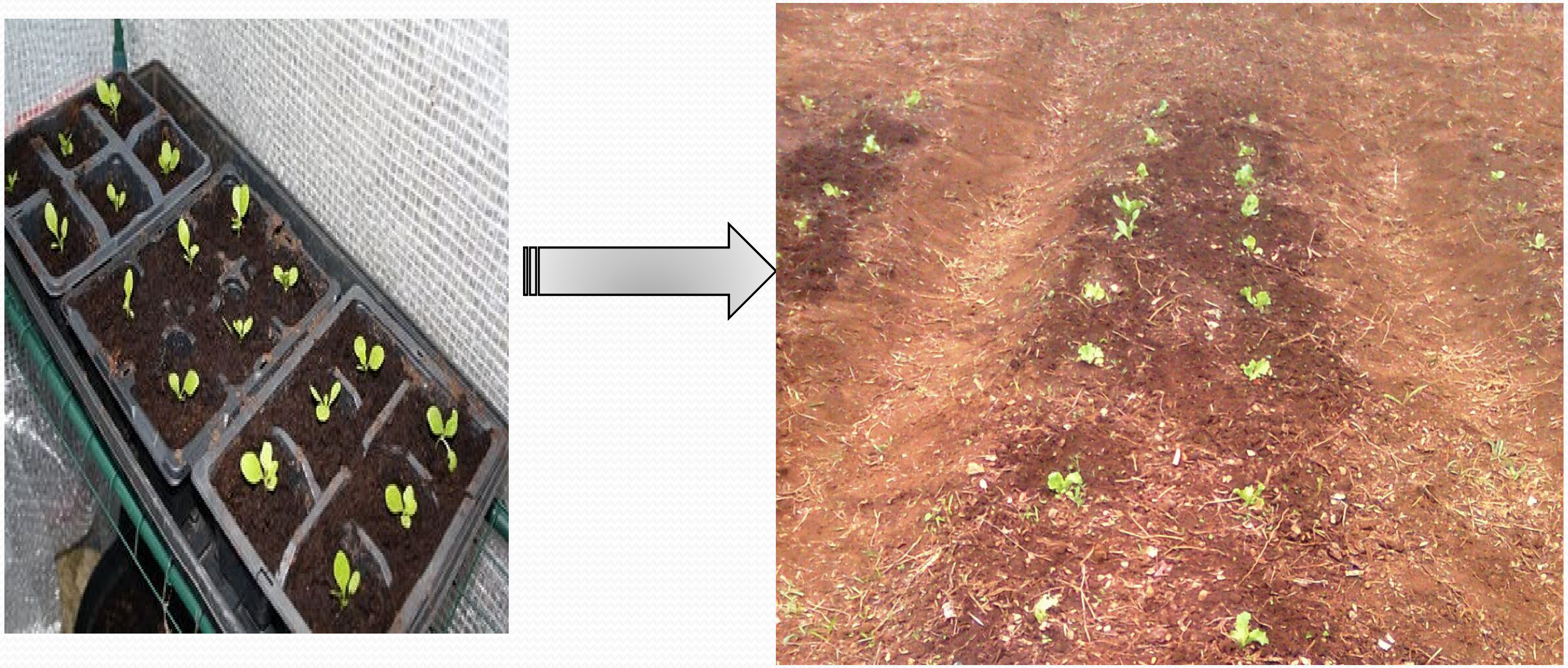
Set-up of treatments

5 different treatments were set up at the University of Mauritius farm.



Transplanting seedlings

Lettuce seedlings were transplanted from seed trays to each treatment.



Greenhouse gas measurement

Chamber method is the most widely used for measurement of trace gas emissions such as CO_2, CH_4, NH_3 and N_2O at landscape scale and is relatively cheap and simple to implement (De Klein et al., 2011; Andersen et al., 2010, Li et al., 2000 & Rochette and Ericksen-Hamel, 2008).

Analysis of GHG emissions using gas analyzer

Gas analyser

%CO_2

%CH_4

Gas sampling bags

N_2O determination

Total N_2O emission

Direct emission + Indirect emission

Increase in N, increase in N2O | Atmospheric deposition , Leaching

$N_2O\text{-}N_{inputs} = (F_{SN} + F_{ON}) \times EF_1$

$N_2O\text{-}N_{Atm} = ((F_{SN} \times Frac_{GASF}) + (F_{ON} \times Frac_{GASM})) \times EF_4$

$N_2O\text{-}N_L = ((F_{SN} \times Frac_{Leach}) + (F_{ON} \times Frac_{Leach})) \times EF_5$

$N2O = N2O\text{-}N \times 44/28$

F_{SN} = Annual amount of synthetic fertilizer applied to soils ,kg N yr^{-1}

F_{ON}= Annual amount of compost added to soil, kg N yr-1

$Frac_{GASF}$ = Fraction of synthetic fertilizer N that volatilizes as NH_3 and NO_x

$Frac_{GASM}$ = Fraction of compost N that volatilizes as NH3 and NOx

$Frac_{Leach}$ = N loses by leaching

EF_1, EF_4, EF_5 = Emission factors

Assumption: Compost is added twice a year while fertilizer is added four times yearly.

Greenhouse gas emissions & TOC

Day	Treatments	Total Organic Carbon (%)	Carbon dioxide (%)	Methane (%)
1	Soil Only	1.841	0	0
	Soil + Compost	2.940	0.1	0
	Soil + Chicken manure	4.135	0.1	0
	Soil + Fertilizer	2.606	0	0
	Soil + Fertilizer + Compost	2.175	0	0
14	Soil Only	1.841	0	0
	Soil + Compost	3.347	0	0
	Soil + Chicken Litter	3.371	0.2	0
	Soil + Fertilizer	2.032	0	0
	Soil + Fertilizer + Compost	3.347	0	0

Greenhouse gas emissions & TOC

Day	Treatments	Total Organic Carbon (%)	Carbon dioxide (%)	Methane (%)
28	Soil Only	1.841	0	0
	Soil + Compost	4.130	0	0
	Soil + Chicken manure	3.930	0.2	0
	Soil + Fertilizer	3.440	0	0
	Soil + Fertilizer + Compost	3.340	0	0
42	Soil Only	1.841	0	0
	Soil + Compost	4.208	0	0
	Soil + Chicken manure	3.920	0.2	0
	Soil + Fertilizer	3.440	0	0
	Soil + Fertilizer + Compost	3.346	0	0

Greenhouse gas emissions & TOC

Day	Treatments	Total Organic Carbon (%)	Carbon dioxide (%)	Methane (%)
49	Soil Only	1.841	0	0
	Soil + Compost	4.320	0	0
	Soil + Chicken manure	3.840	0.3	0.1
	Soil + Fertilizer	3.440	0.1	0
	Soil + Fertilizer + Compost	3.346	0	0

N_2O emissions from Compost & Fertilizer application.

	Fertilizer	Compost	Chicken Litter	Compost & Fertilizer
Application amount	2.4t/ha	33t/ha	29.7 t/ha	16.7t/ha & 1.2 t/ha
Application rate for lettuce cultivation	Four times a year	Twice a year	Twice a year	Thrice a year
N_2O emission	31.98 kg N_2O/yr	25.86 kg N_2O/yr	25.80 kg N_2O/yr	31.63 kg N_2O/yr
CO_2 equivalent	9914 kg CO2 /yr	8017 kg CO2 /yr	7998 kg CO2 /yr	9805 kg CO2/yr

-20% CO_2 equivalent

-19 % CO_2 equivalent

-1 % CO_2 equivalent

Visual Observation- 3 weeks after transplantation

Soil only

Week 2 Week 3 Week 4

Soil + Compost

Visual Observation

Soil + Chicken Manure

Week 2

Week 3

Week 4

Soil + Fertilizer

Visual Observation

Soil +
Fertilizer
+compost

Week 2

Week 3

Week 4

Conclusions

- The use of compost showed an increase of 60% in the Total Organic Carbon content of soil, compared to other treatments.
- Over a period of 7 weeks, Chicken manure produced 90% more CO_2 than compost.
- Compost application reduces N_2O production by 20 % compared to the use of fertilizers.
- 5.61 g CH_4/m^2/day was emitted from the plot which was treated with chicken manure. No methane generation was detected in the other treatments.

Compost Application

Reduction of organic wastes to landfill

Reduction in use of chemical fertilizers

On-going research

- Determination of the carbon footprint of the different compost treatments in terms of environmental impacts as follows:
  - Scenario 1: Landfilling of organic waste, coupled with production and application of Chemical fertilizer, which will also serve as the baseline scenario.
  - Scenario 2: Production and application of compost, excluding application of chemical fertilizer
  - Scenario 3: Application of manure as organic fertilizer, excluding application of chemical fertilizer and compost
  - Scenario 4: Use of Compost and chemical fertilizer as soil amendment.

Thank You

With compost

Without compost