The Role of Rice Genotypes in Mitigation of Methane Emissions

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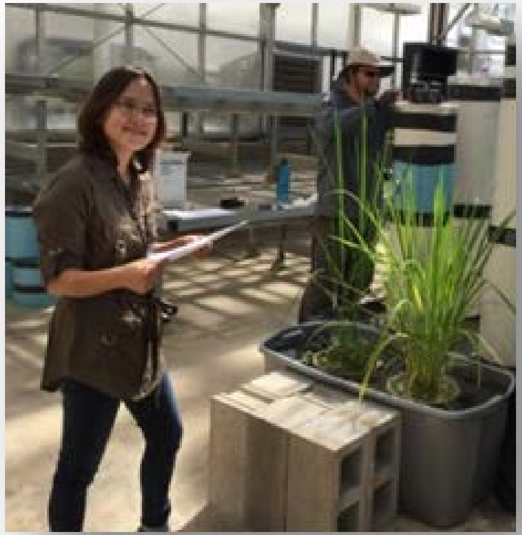
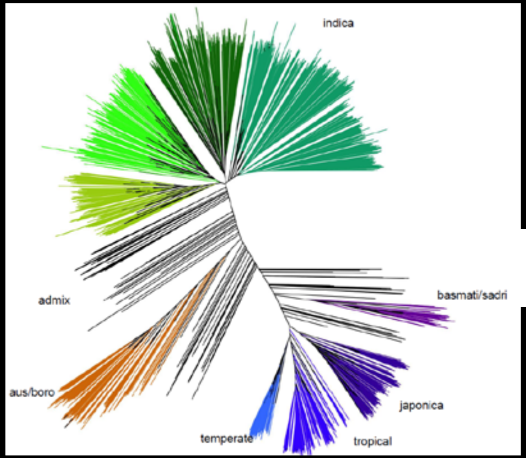


The Mission of the DBNRRC

- Explore global genetic diversity
- Understand Trait-Gene relationships
- New breeding tools and varieties

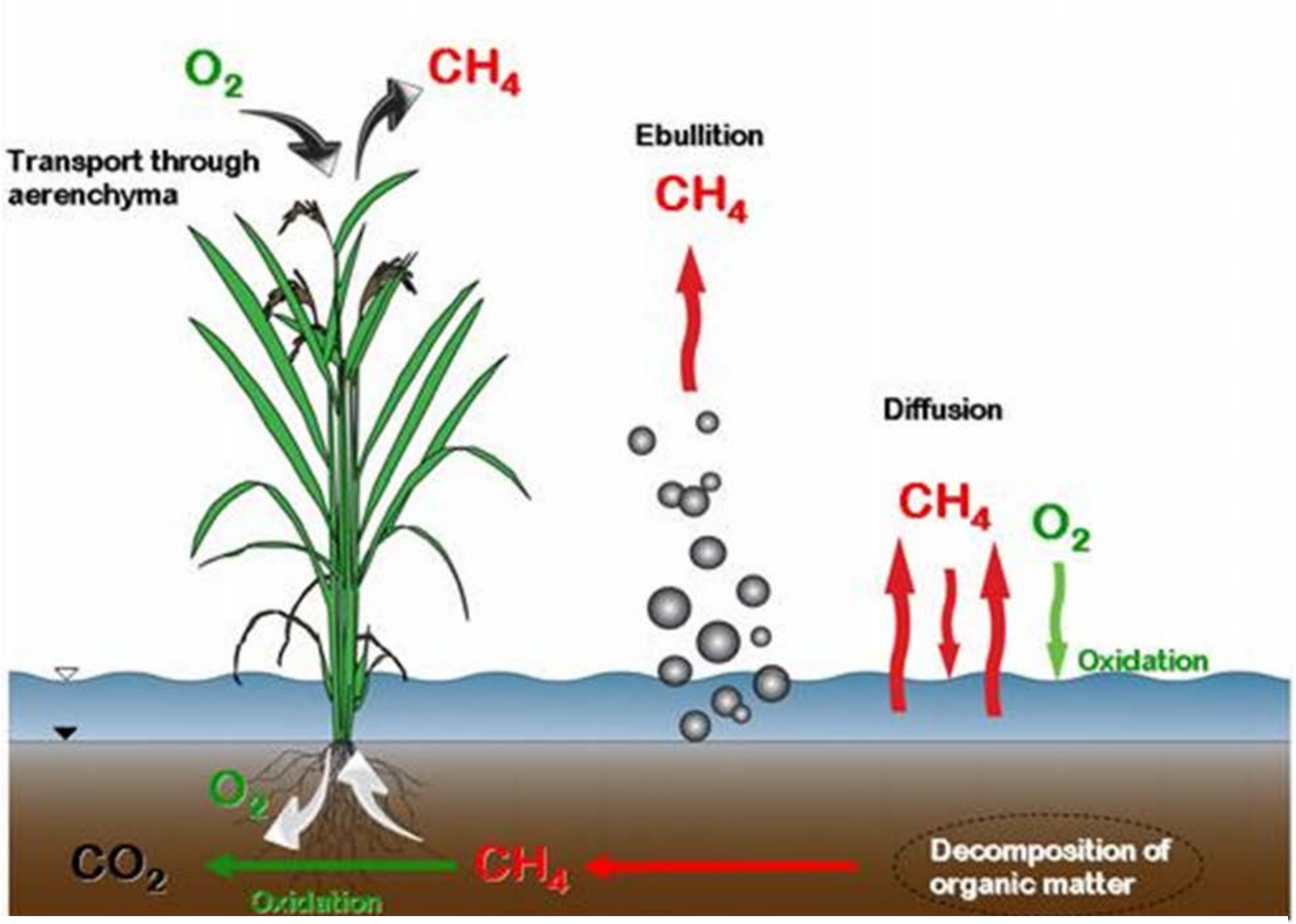
Germplasm



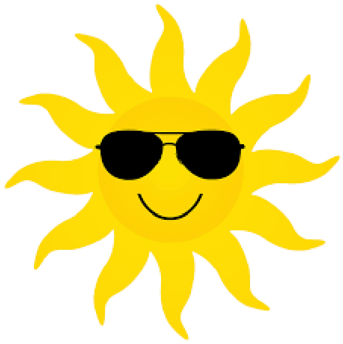
Genomics

Traits

How does rice genetics contribute to this process as well as serve as a means of mitigation?



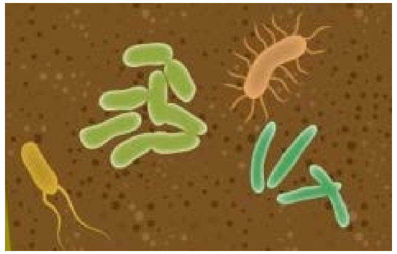
Sources of methane emissions from flooded rice fields



Weather

Irrigation

Fertilizer and Soil Chemistry



Soil Microbiome

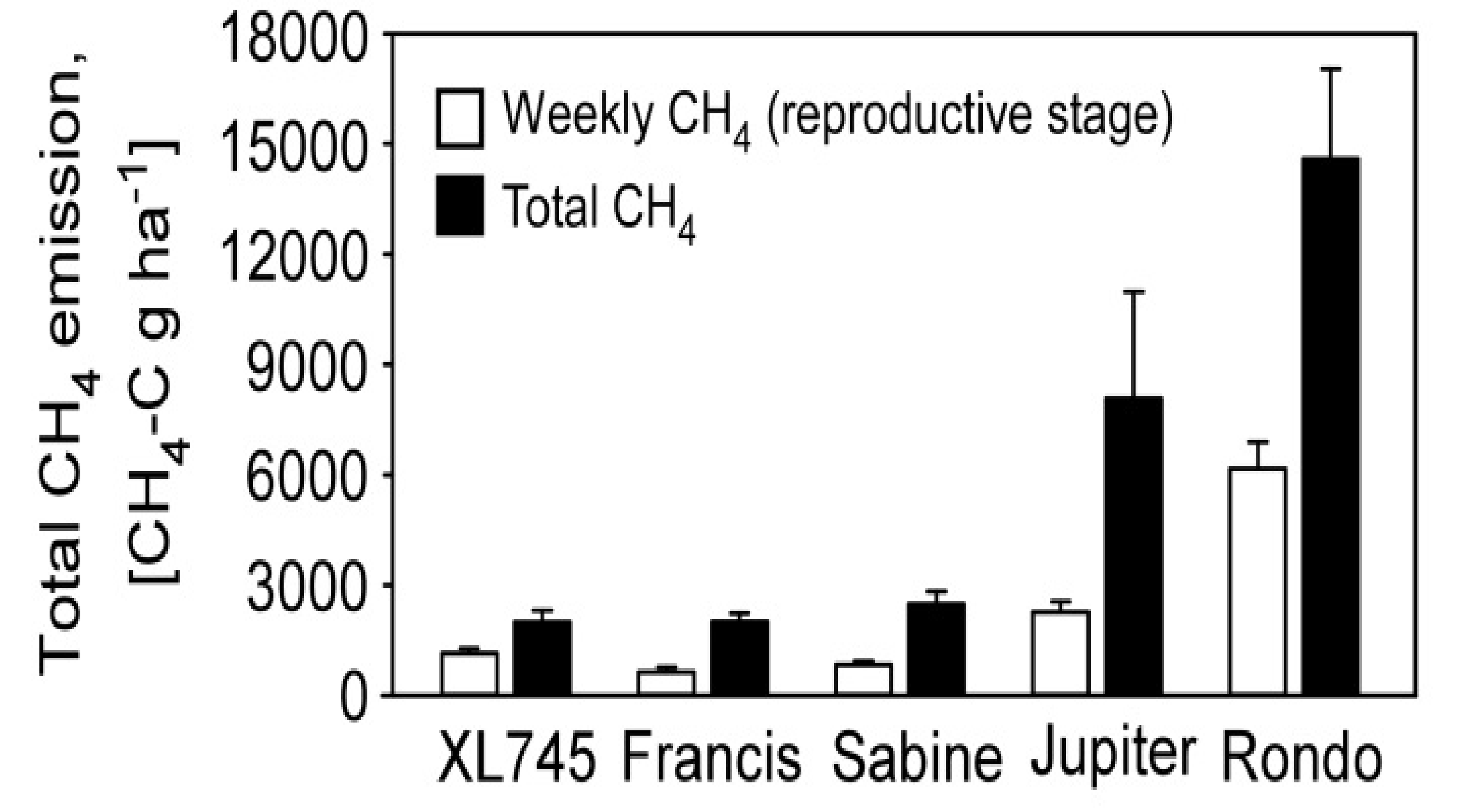
Cultivar	Seasonal CH_4	Seasonal N_2O	Seasonal GWP†	Seasonal GWP_Y‡
	kg CH_4–C ha^{-1}	kg N_2O–N ha^{-1}	kg CO_2 eq ha^{-1}	kg CO_2 eq^{-1} Mg^{-1}
				CA-1§
Calmati-202	58 (2.9)a¶	0.05 (0.021)a	1988 (90)a	277 (19)a
L206	60 (12)a	0.06 (0.004)a	2074 (399)a	218 (29)a
M206	69 (9.6)a	0.06 (0.018)a	2370 (319)a	225 (30)a
				CA-2
Calmati-202	6.7 (0.9)b	−0.15 (0.016)a	83 (31)b	10 (3.6)b
CLXL745	11 (3.1)ab	−0.19 (0.025)a	309‡ (99)ab	29# (12)ab
CLXP4534	11 (0.4)ab	−0.16 (0.037)a	229 (40)ab	22 (2.6)ab
L206	14 (2.2)a	−0.13 (0.016)a	353 (62)a	33 (6.1)a
M206	11 (1.1)ab	−0.11 (0.028)a	277 (61)ab	23 (6.1)ab
				AR-1††
CLXP4534	25	0.17	981	140
Francis	43	0.10	1526	282
Jupiter	15	0.08	573	83
Sabine	55	0.10	1936	384
				AR-2
CLXL745	56 (9.2)b	0.02 (0.047)a	1899 (344)b	232 (44)b
Francis	77 (14)a	0.10 (0.052)a	2677 (459)a	381 (81)a
Jupiter	72 (16)ab	−0.01 (0.022)a	2397 (534)ab	345 (59)ab
Sabine	75 (7.5)ab	0.11 (0.114)a	2623 (154)a	397 (30)a

Direct seeded, flood, CA and AR

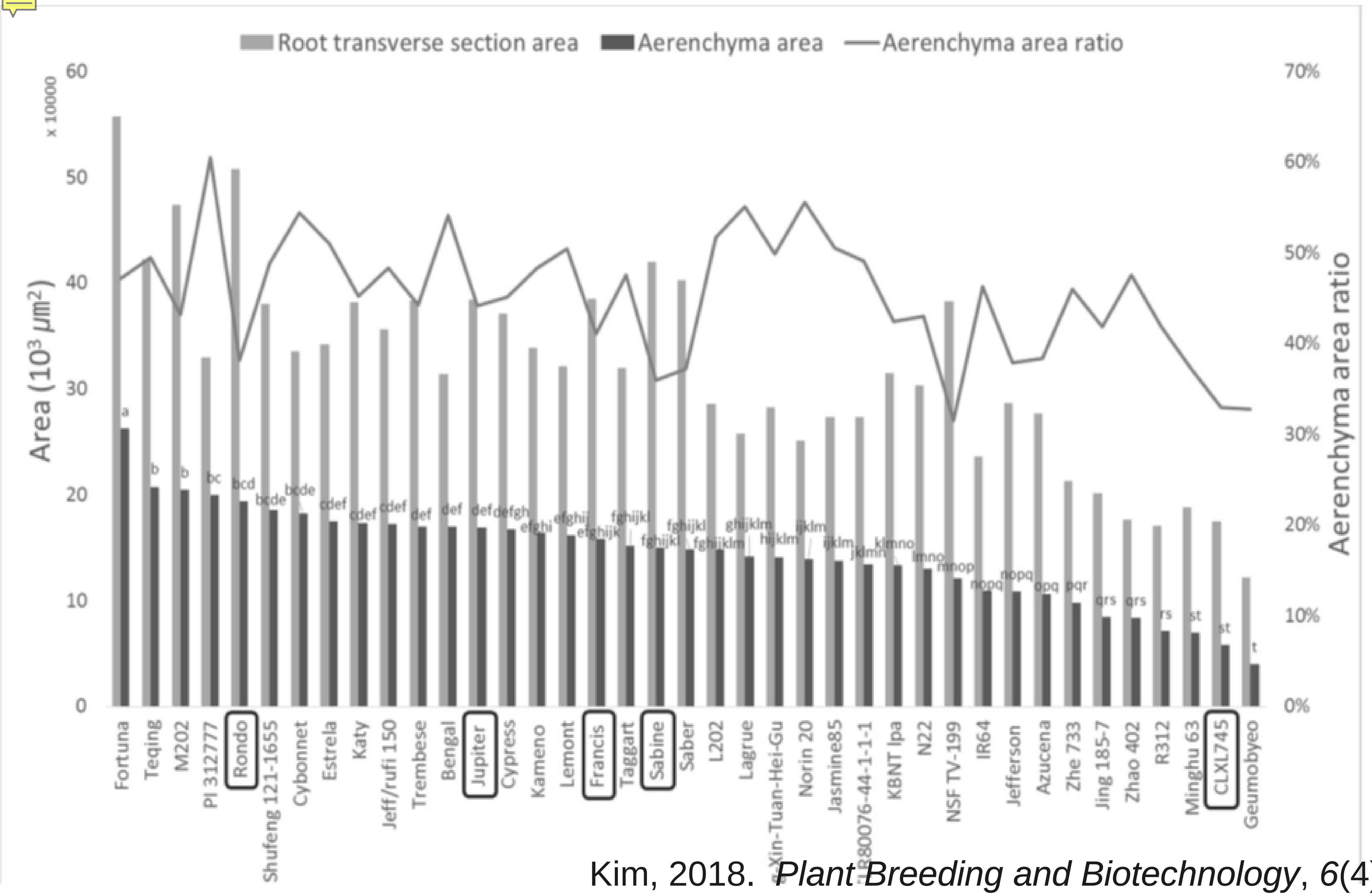
Environmental Variability
Cultivar Differences,
Unstable
N20 of little effect

Simmonds, 2015. *Journal of Environmental Quality*, *44*(1), pp.103-114.

2016 Conducted greenhouse study comparing five cultivars – three US tropical japonica cultivars from the previous field study, a hybrid, and a high yielding indica cultivar.



What is the genetic basis for these differences?



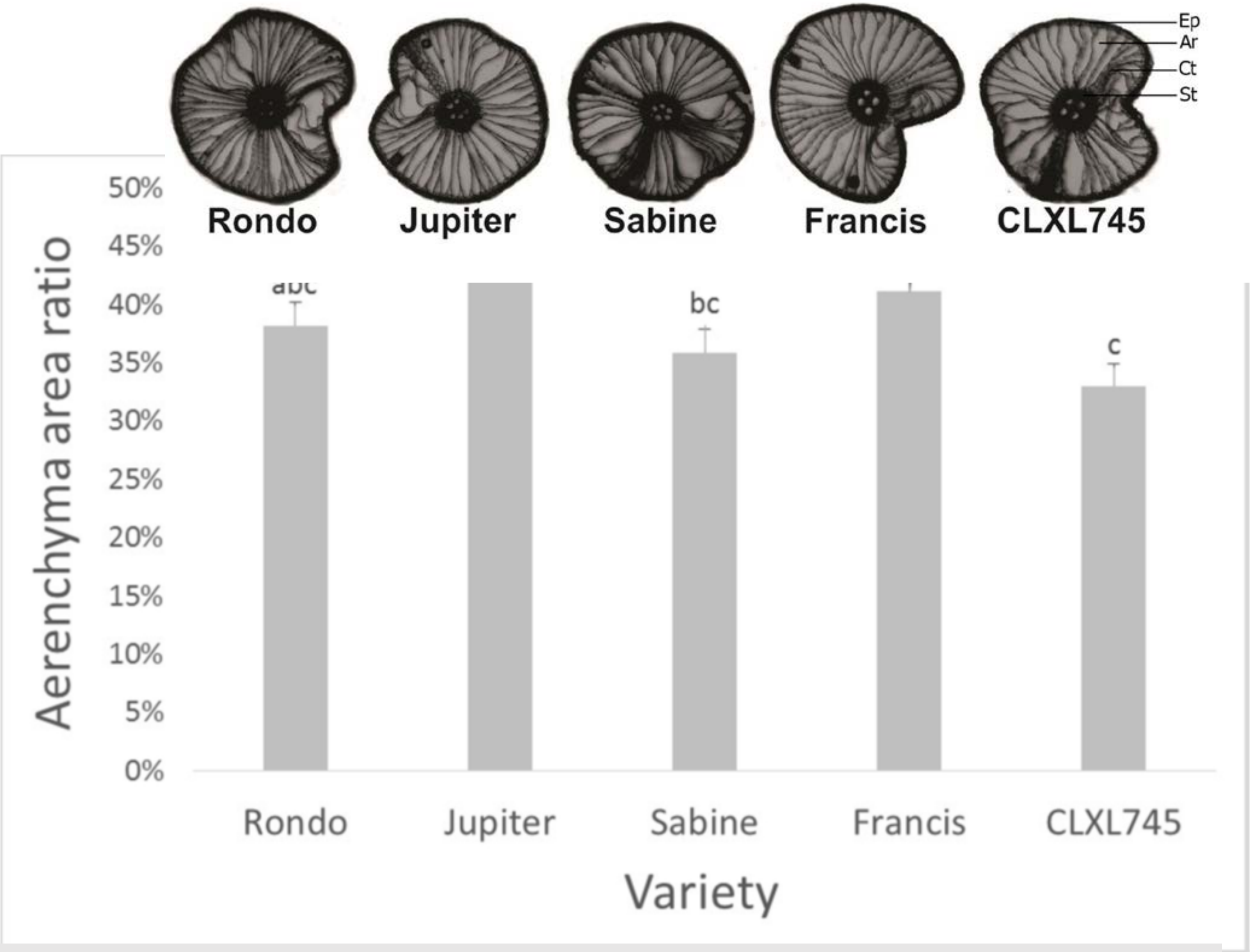
A survey of 39 global varieties grown under flooded field conditions was performed to determine genetic variability for root size and aerenchyma traits.

Kim, 2018. *Plant Breeding and Biotechnology*, *6*(4), pp.381-390.

Cultivars differing in CH4 emissions showed moderate positive correlations with root size parameters but not % aerenchvma.

Root size (RTS) r = 0.61

Aerenchyma area r= 0.57



CH4 Emissions: Very High | Mod. High | Low | Low | Low

Kim, 2018.

CH4

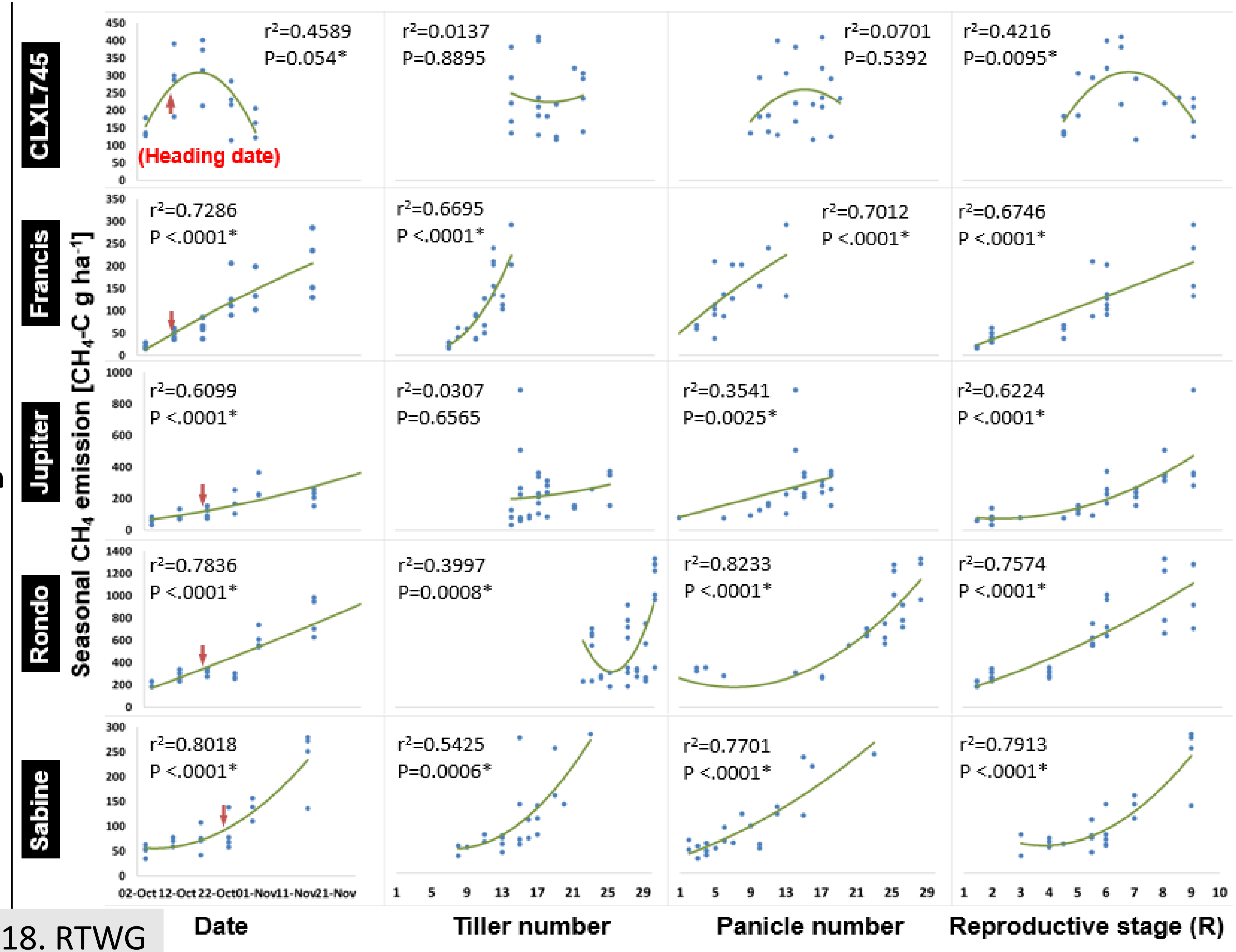
Low

Low

Mod. High

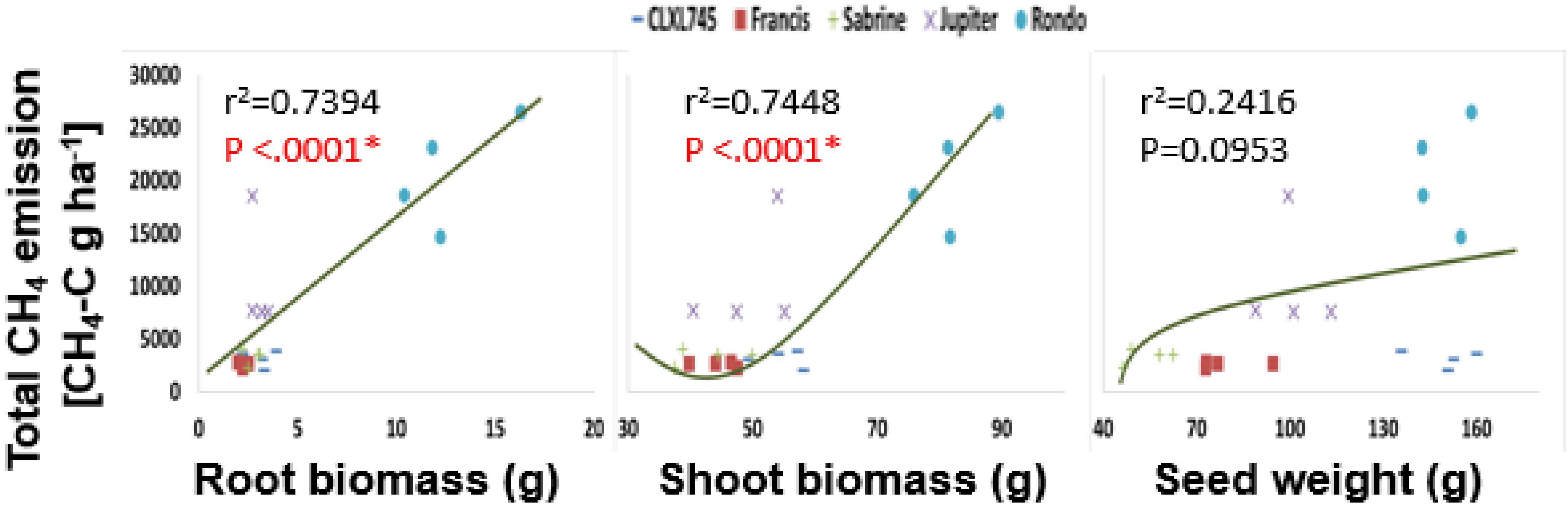
High

Low



Kim et al. 2018. RTWG

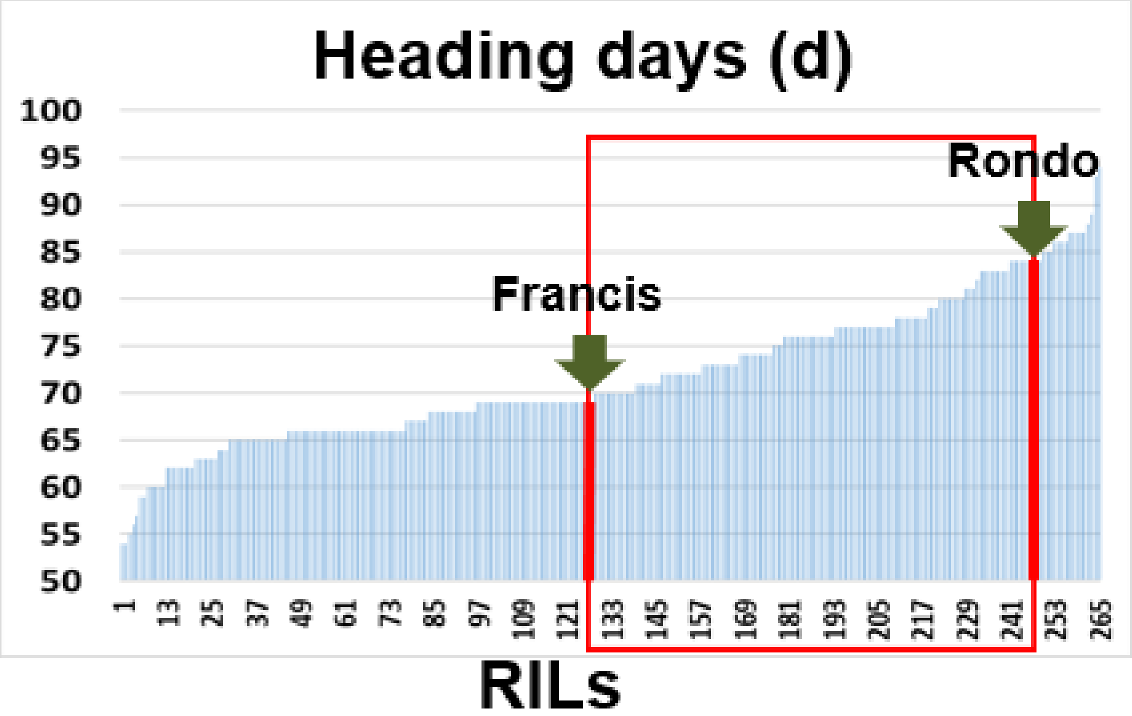
CH4 Emissions Were Highly Correlated with Root and Shoot Biomass at Maturity But Not Grain Yield

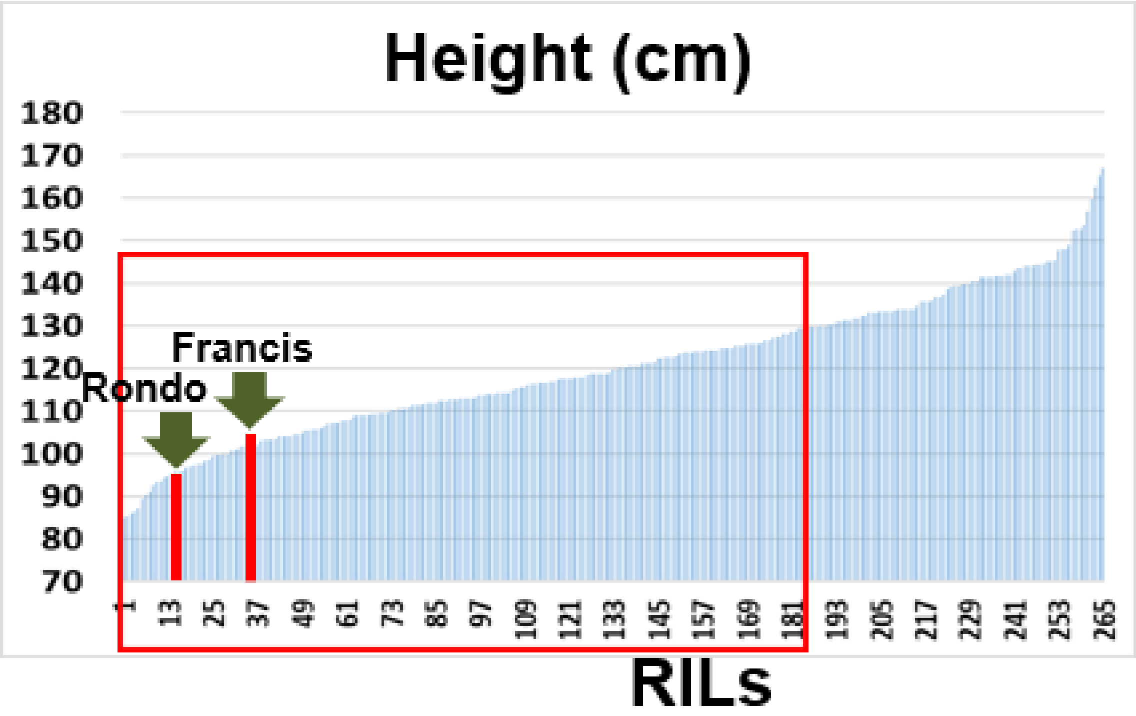


Francis (TRJ) and Rondo (Indica) Were Divergent for CH4 Emissions and Root and Shoot Biomass

Kim et al. 2018. RTWG

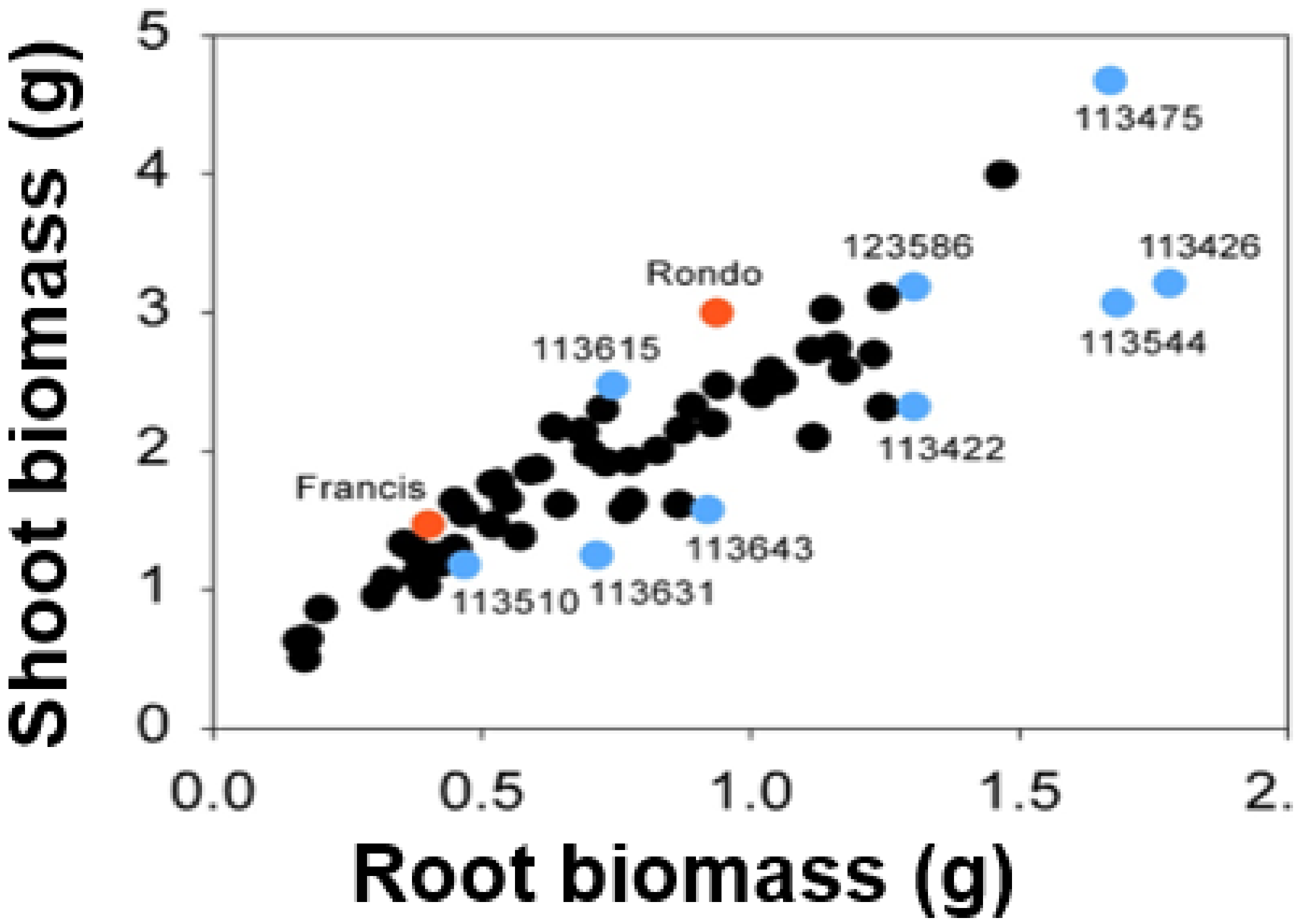
Francis x Rondo Mapping Population of 220 Recombinant Inbred Lines Were Used to Explore Traits Associated with CH4 Emissions in A Common Genetic Background

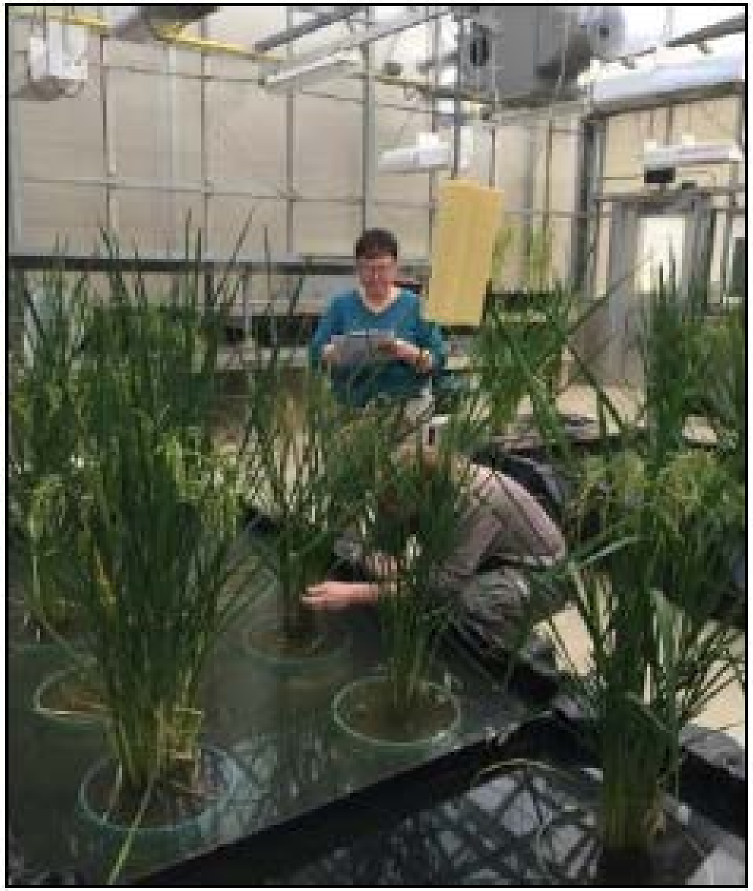




Selection of ~70 RILs Within a Similar Heading and Height Range

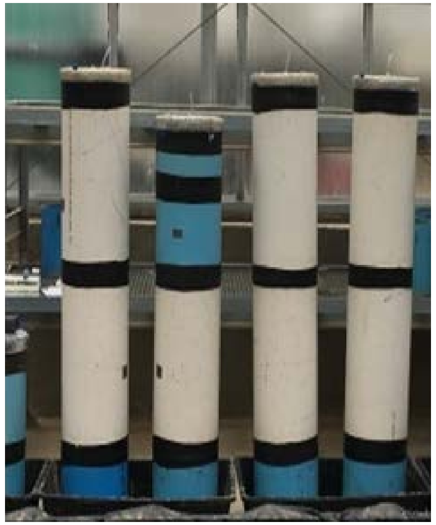
RILs and Parents Were Evaluated for Shoot and Root Biomass at 6 wk stage and 9 RILs Were Selected for CH4 Emission Evaluation



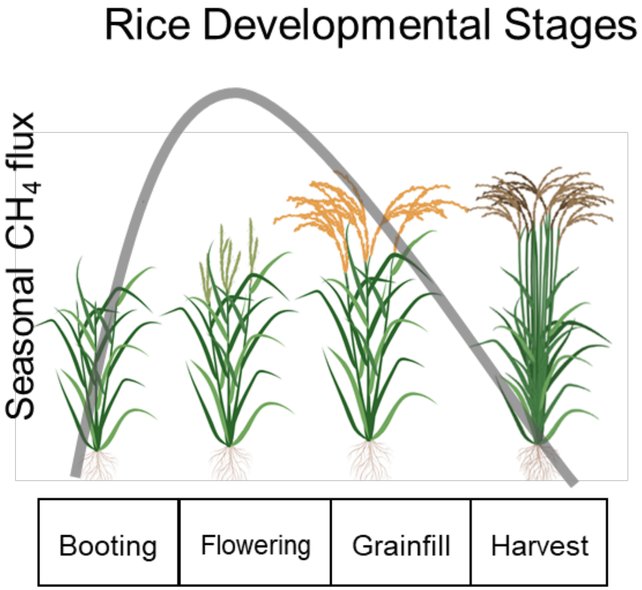


Barnaby, J.Y., Pinson, S.R., Chun, J. and Bui, L.T., 2019. Covariation among root biomass, shoot biomass, and tiller number in three rice populations. *Crop Science*, *59*(4), pp.1516-1530.

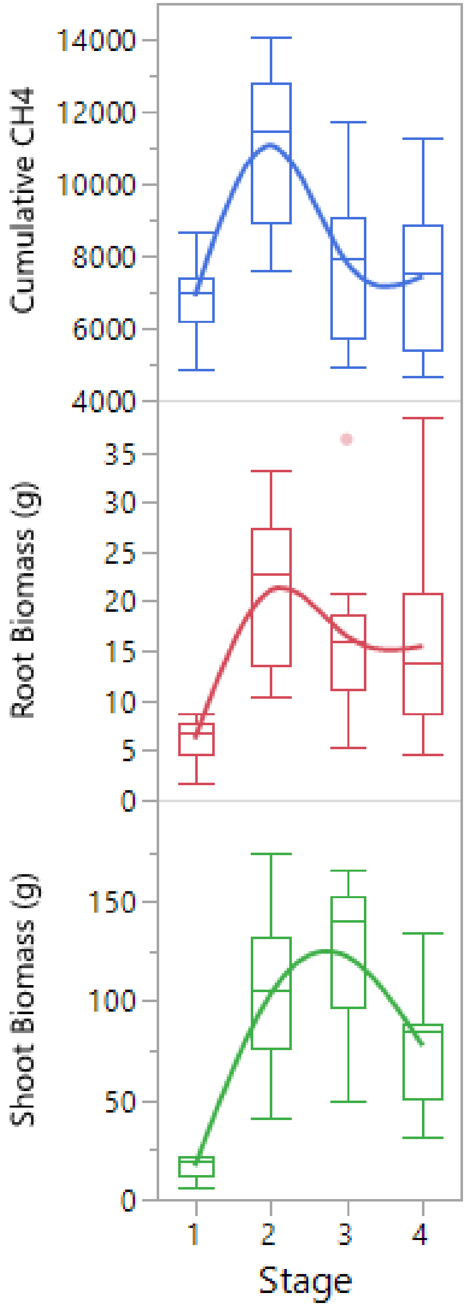
CH4 Measurements At the Heading Stage (2) and During Late Grainfill (3) Captured the Peak Emissions



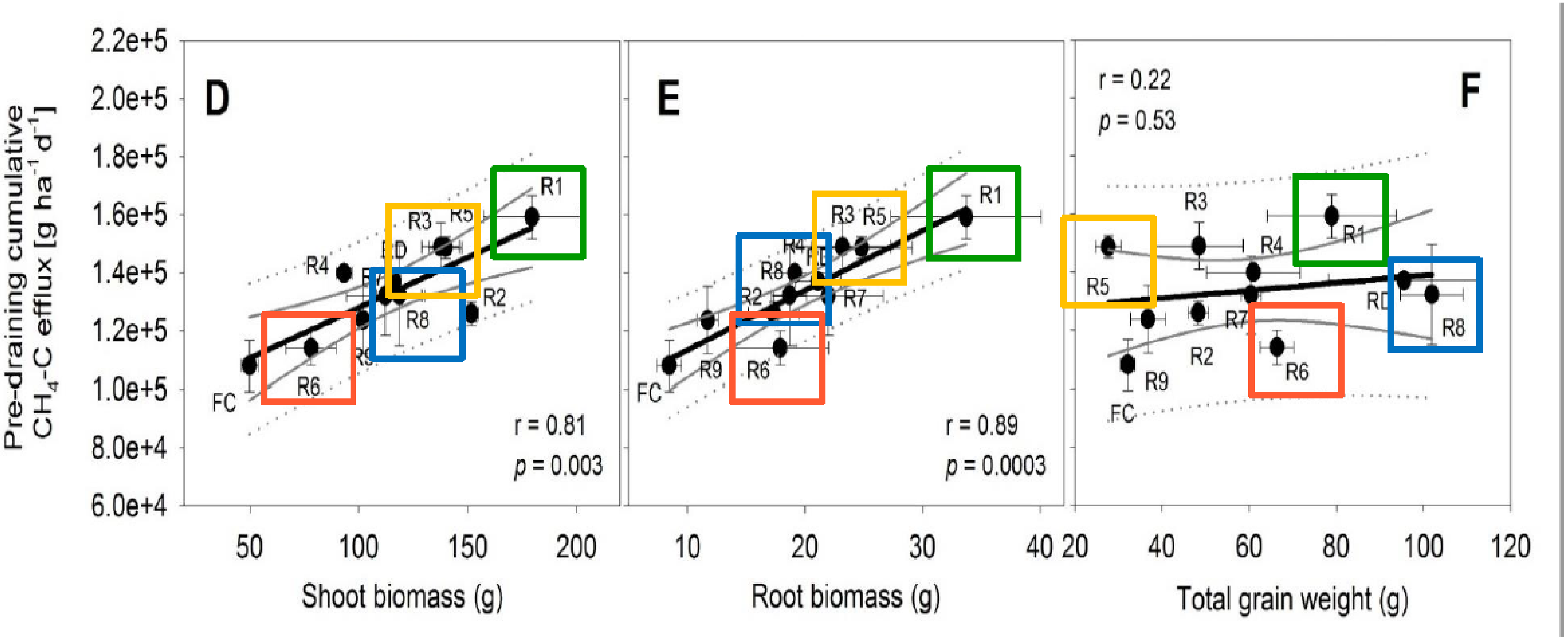
Pattern of Seasonal CH_4 Emissions



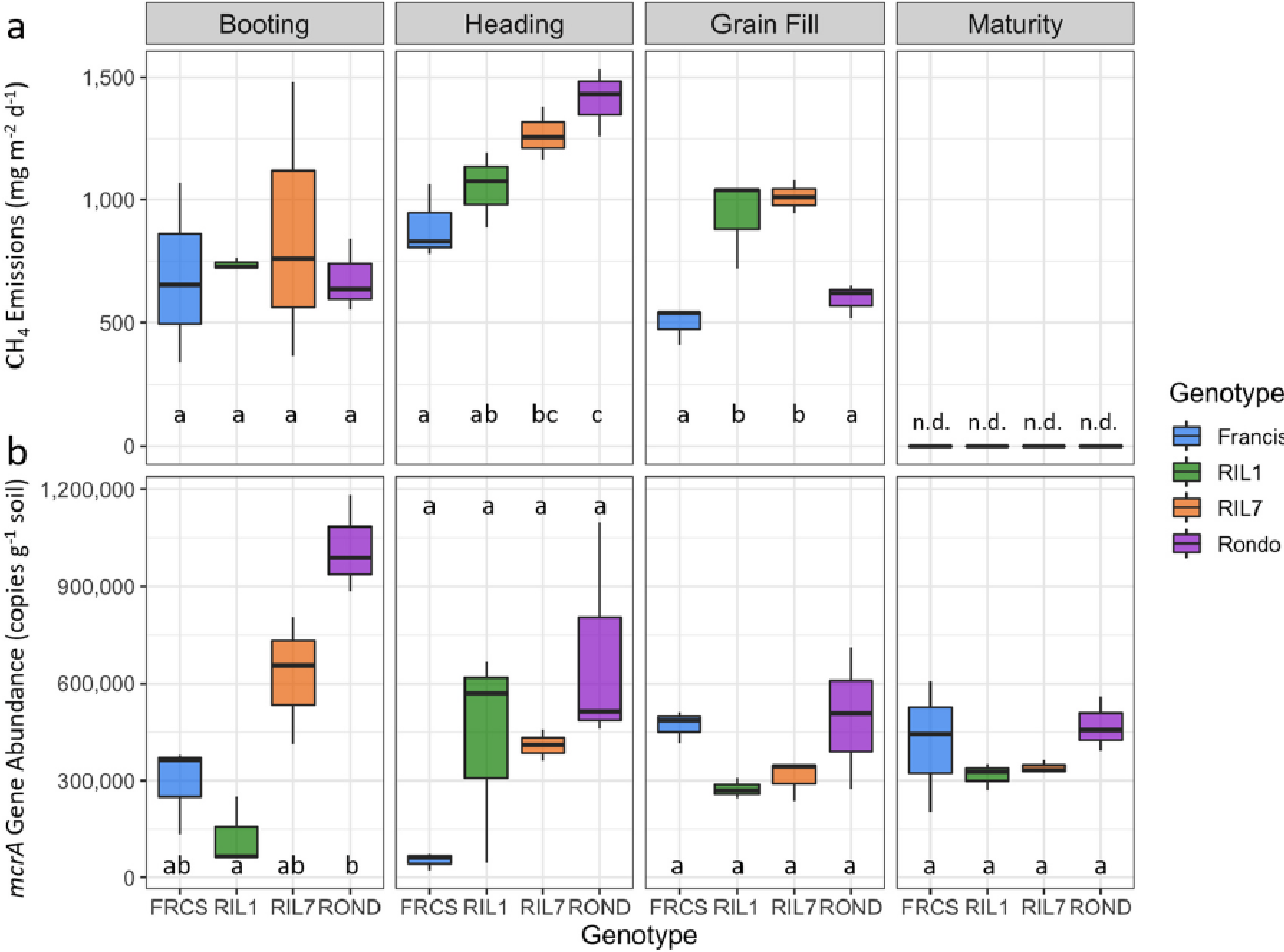
Methane emissions peak at the flowering stage



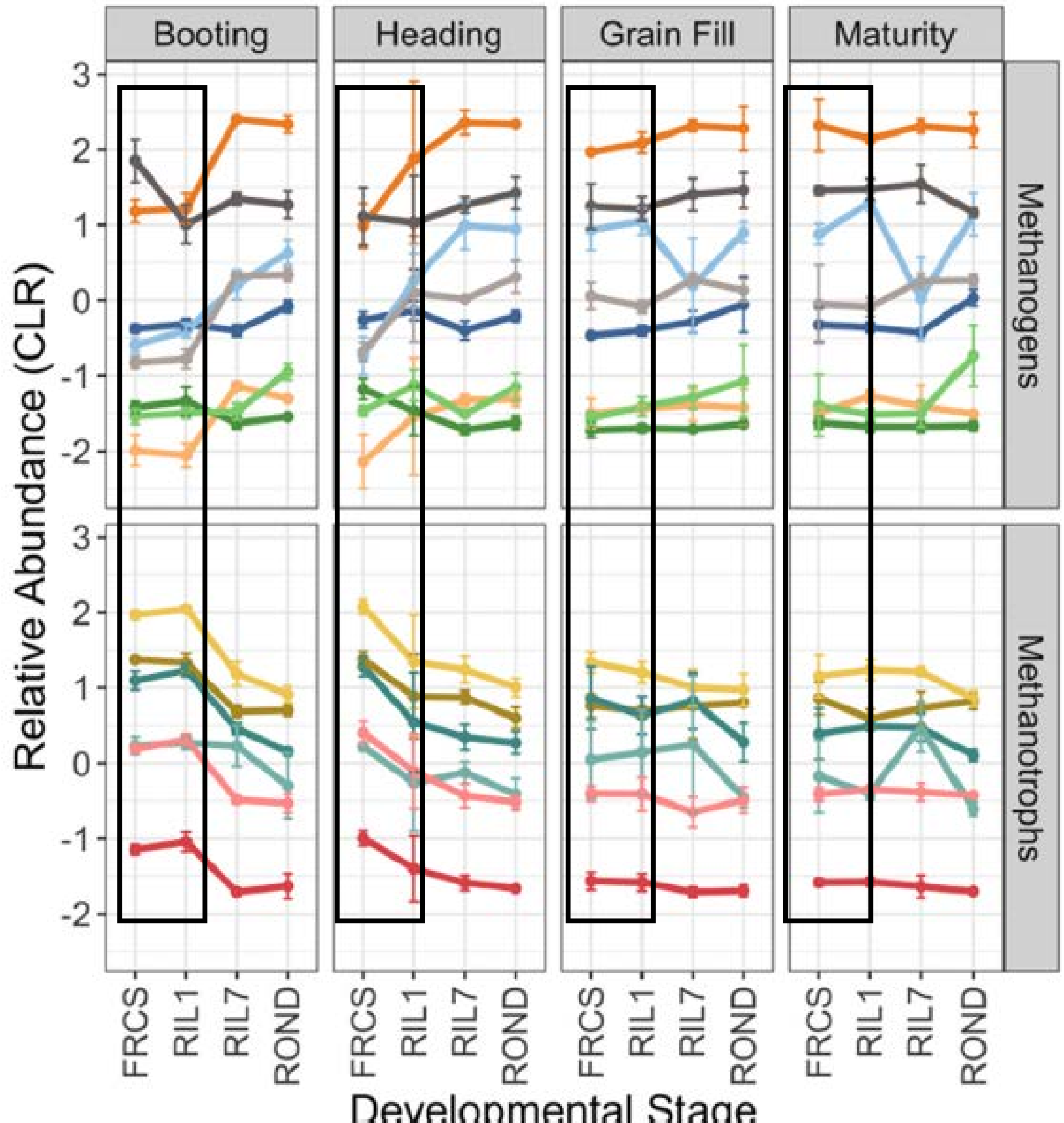
As Among the Different Cultivars, CH4 Emissions Were Correlated with Root and Shoot Biomass but Not Yield.



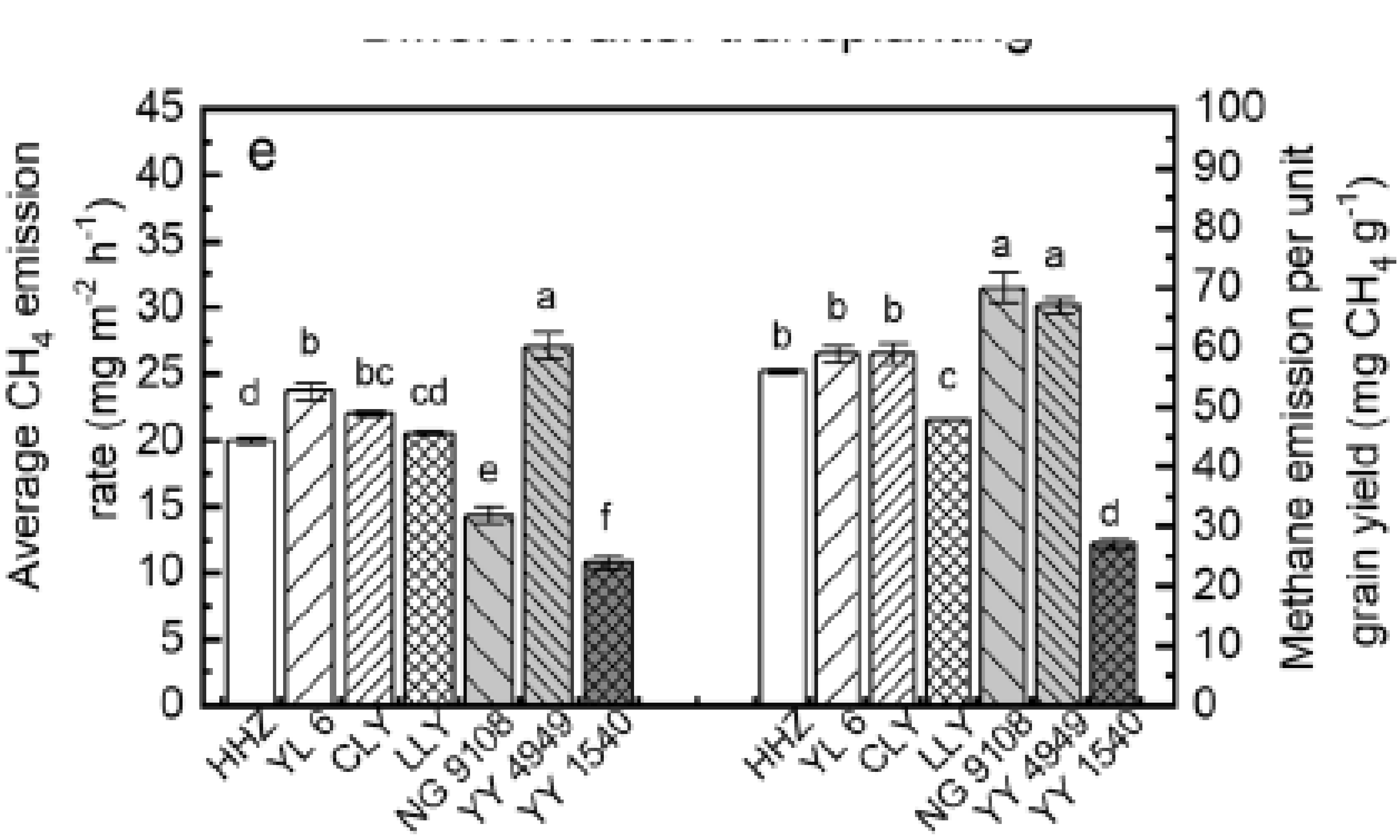
RILS Differing in CH4 Emissions Were Selected for Soil Microbiome Studies



Fernández-Baca, C.P., Rivers, A.R., Kim, W., Iwata, R., McClung, A.M., Roberts, D.P., Reddy, V.R. and Barnaby, J.Y., 2021. Changes in rhizosphere soil microbial communities across plant developmental stages of high and low methane emitting rice genotypes. *Soil Biology and Biochemistry*, *156*, p.108233.

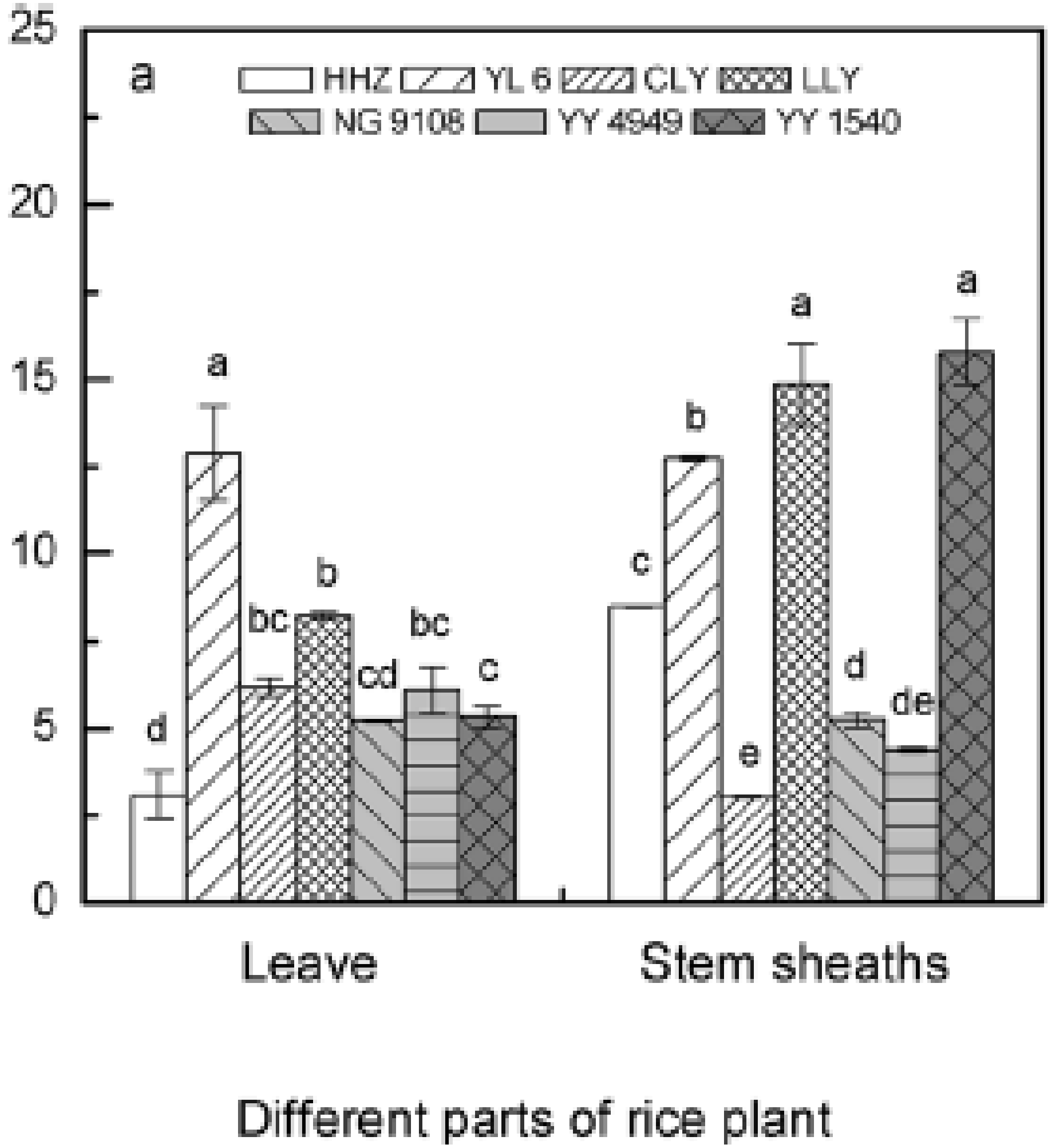


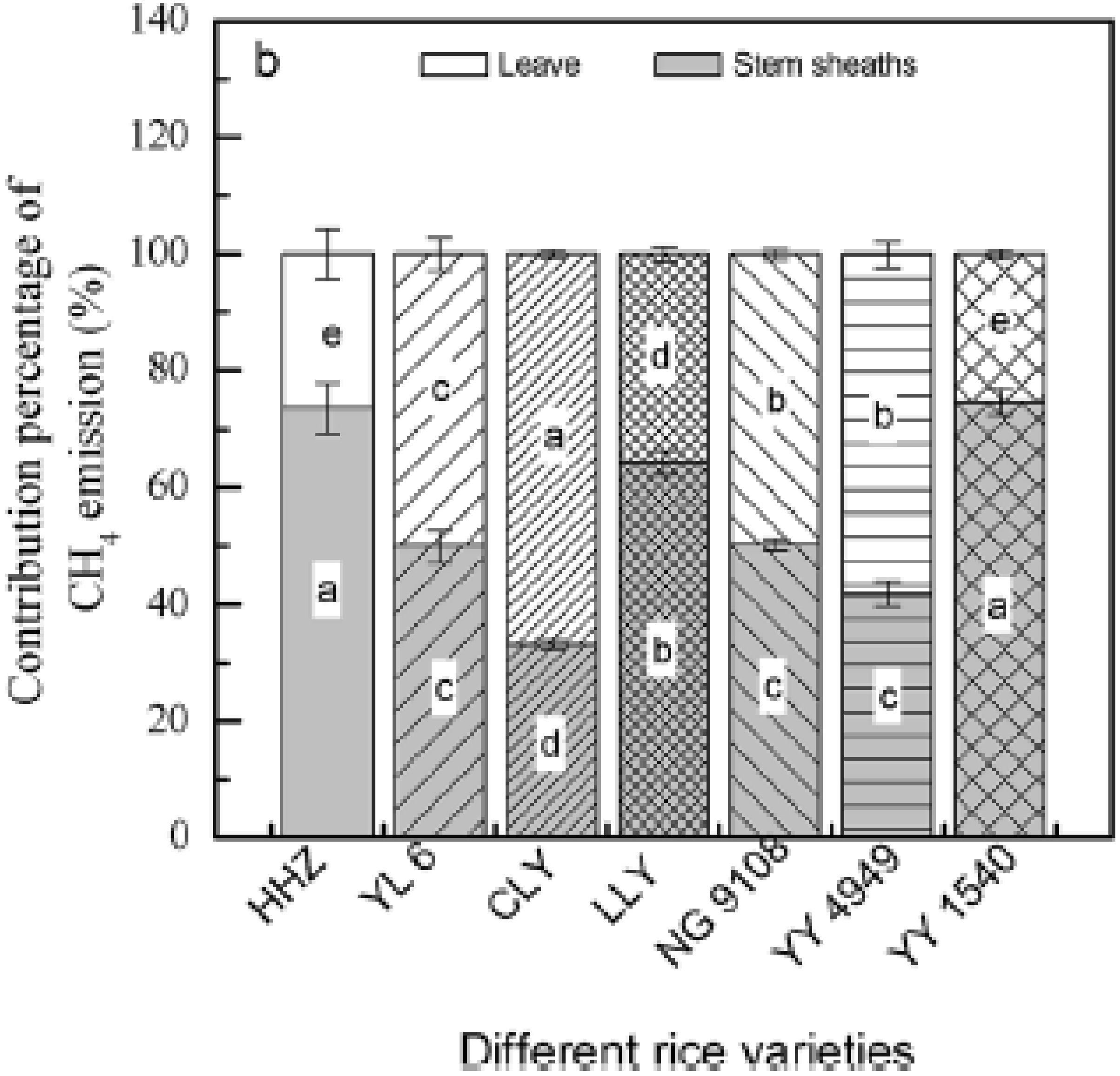
Low Emitters- lower methogens and greater methanotrophs during booting and heading

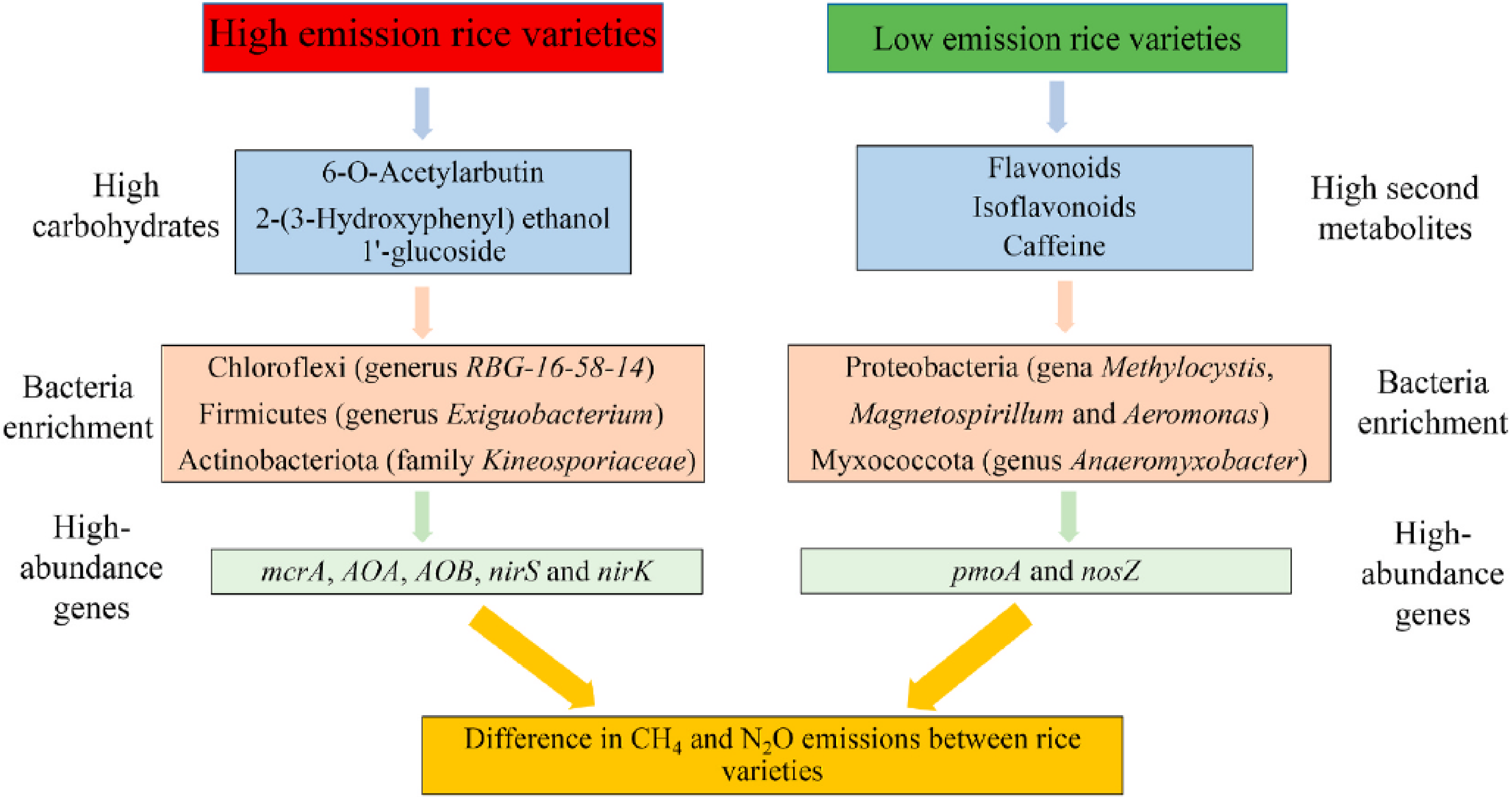


Ding et a. 2021.

Other Plant Parts Need to Be Studied for Their Role in GHGE







Ding 2022. Effect of microbial community structures and metabolite profile on greenhouse gas emissions in rice varieties. Env. Poll. 356

Summary

- Rice cultivars differ in methane emissions and can be part of the mitigation process
- Mapping populations serve as a means of identifying traits and QTL that are related to GHGE that may help in developing new low emitting varieties
- Results demonstrate that different genotypes can influence the soil microbiome that impact GHGE
- Considering the complex G x E X M interactions affecting GHGE, screening for varieties that support lower methanogen and higher methanotroph abundances, may be a means of a high throughput selection method valuable for breeding low GHGE rice