Intercropping wheat with maize under conservation practices decreases CO_2 emissions in dry areas

Hu, F.[1,2], Feng, F.[1], Zhao, C.[1,2], Chai, Q.[1,2,*], Yu, A.[1,2], Yin, W.[1,2], Liu,C.[1,2] and Gan, Y.[3]

[1]Gansu Provincial Key Laboratory of Aridland Crop Science, Lanzhou 730070, China; [2]College of Agronomy, Gansu Agricultural University, Lanzhou 730070, China; [3]Agriculture and Agri-Food Canada Research and Development Centre, Swift Current, SK, S9H 3X2, Canada

Introduction

Intercropping a cool-season crop with a warm-season crop in strips has been shown to increase crop productivity through improved soil water use in arid areas, but little is unknown if the increased productivity is at the expense of large crop input that increased greenhouse gas footprints. Here, we determined crop yield, water consumption, and greenhouse gas footprints of wheat-maize intercropping under different tillage and crop residue management options.

Materials & methods

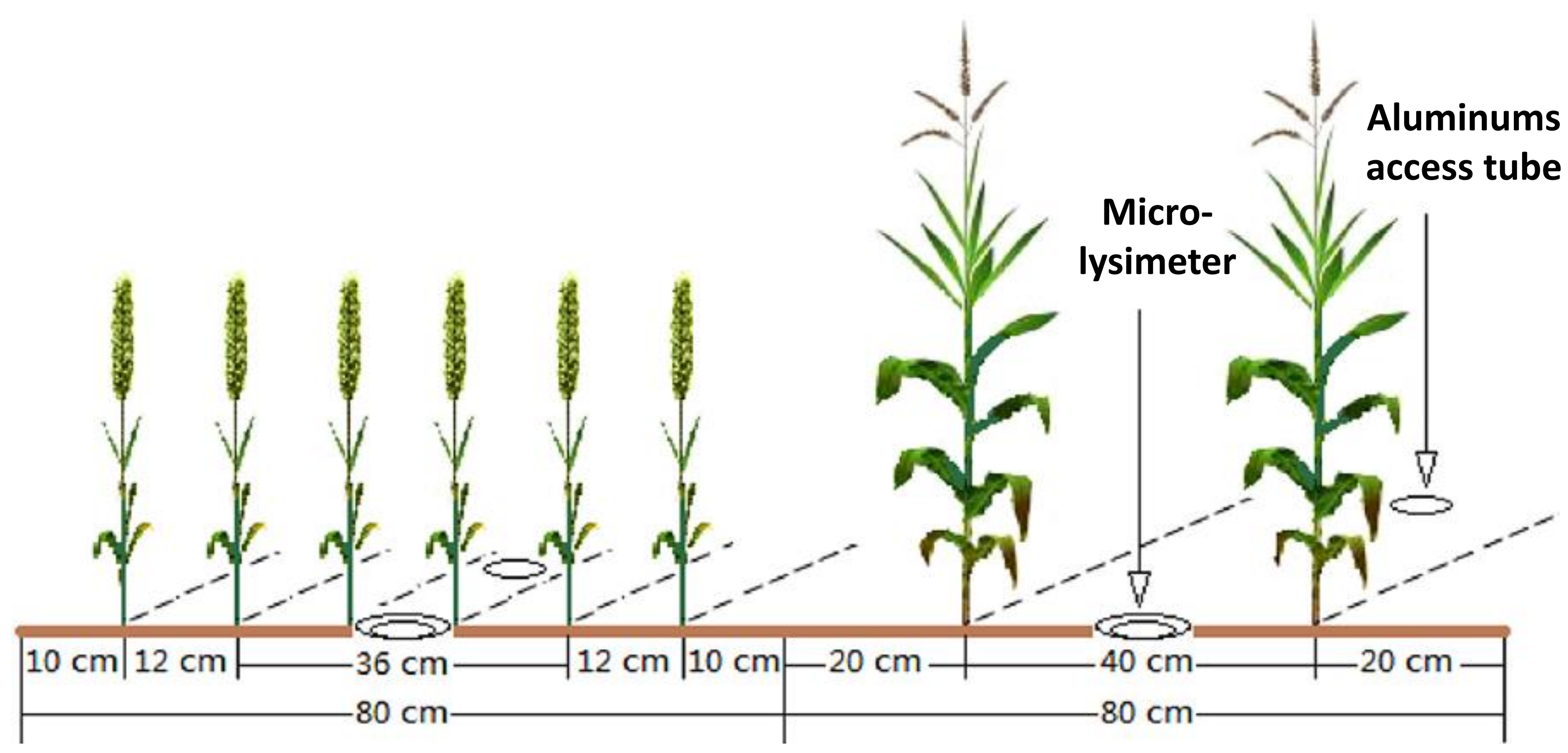

Fig. 1 Strip structure of wheat-maize intercropping. Micro-lysimeter and access tubes indicate where soil samples were taken

A field study was conducted at the Gansu Agricultural University Research Station in Wuwei (37◦96′N, 102◦64′E), northwest China, in 2011-2012. Four tillage and crop residue options were applied to wheat-maize intercropping (**Fig. 1**): (i) no-till with stubble standing (NTS), (ii) no-till with stubble mulching (NTM), (iii) reduced tillage with stubble incorporated into the soil (RTS), and (iv) conventional tillage without stubble retention (CT). The different tillage and stubble retention practices were applied to the wheat strips, and the maize strips were tilled. Sole wheat (CT-W) and sole maize (CT-M) with conventional tillage were included in the study as the control treatment.

Results & Discussion

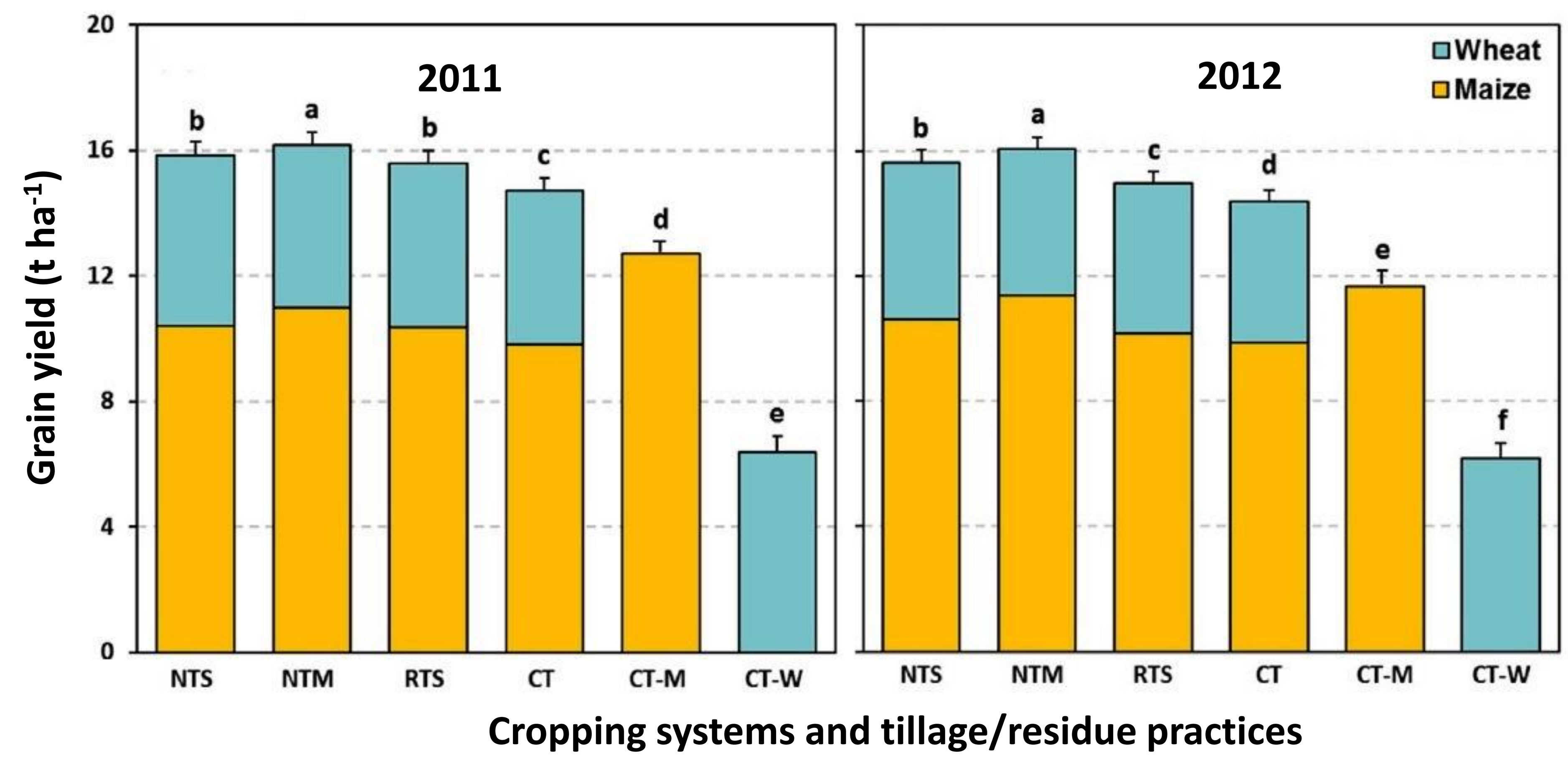

Fig. 2 Grain yield of wheat and maize in various intercropping systems

- Wheat/maize intercropping increased grain yield by 61% in 2011 and 63% in 2012 compared with the corresponding monoculture crops (**Fig. 2**).
- The intercrops under reduced tillage with crop straw mulching produced yield of 15.8 t ha^{-1} which was 8% greater compared to conventional tillage (**Fig. 2**).
- Measured using soil respiration, wheat/maize intercropping had a carbon equivalent (eq.) emission of 2400 kg CO_2eq ha^{-1} during the growing season, which was about 7% less compared to monoculture maize (**Table 1**).
- Compared to conventional tillage, reduced tillage decreased carbon emission by 6.7, 5.9 and 7.1% in intercropping, monoculture maize, and monoculture wheat, respectively (**Table 1**).
- Compared to monoculture maize, wheat/maize intercropping emitted 3.4 kg CO_2 eq per hectare per mm of water used, which was 23% lower compared to monoculture maize (**Table 1**).

Conclusions

High crop yields were achieved through intercropping practices without increasing water consumption or carbon emissions per unit of input. Wheat/maize intercropping with reduced tillage coupled with straw mulching increased soil productivity and lowered greenhouse gas footprint compared to conventional practices.

Table 1 Soil CO_2 emission, water use efficiency (WUE_{EY}) and CO_2 emission per unit of water (WUE_{CE}) for various cropping systems

Treatment	Soil CO_2 emission ($t\,ha^{-1}$)						WUE_{EY} ($MJ\,ha^{-1}\,mm^{-1}$)		WUE_{CE} ($kg\,ha^{-1}\,mm^{-1}$)	
	2011			2012						
	Wheat	Maize	Total	Wheat	Maize	Total	2011	2012	2011	2012
CT-W	4.1 a	–	4.1 d	4.3 a	–	4.3 e	581 e	631 d	9.57 e	10.58 d
CT-M	–	10.4 a	10.4 a	–	9.7 a	9.7 a	682 cd	704 bc	16.09 a	17.21 a
Intercropping										
NTS	4.0 a	6.3 b	10.3 a	3.9 b	4.8 c	8.6 c	735 b	736 b	13.70 b	12.68 bc
NTM	3.0 d	4.9 c	7.9 c	3.8 b	4.6 c	8.4 d	791 a	795 a	10.72 d	12.32 c
RTS	3.5 c	4.8 c	8.4 c	3.8 b	4.7 c	8.5 cd	706 bc	698 bc	11.06 d	12.37 c
CT	3.9 b	5.7 b	9.6 b	3.9 b	5.2 b	9.1 b	652 d	676 c	12.41 c	13.01 b