Can cropland management practices lower net greenhouse emissions without compromising yield?

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Abstract

Smart cropland management practices can mitigate greenhouse gas (GHG) emissions while safeguarding food security. However, the integrated effects on net greenhouse gas budget (NGHGB) and grain yield from different management practices remain poorly defined and vary with environmental and application conditions. Here, we conducted a global meta-analysis on 347 observation sets of non-CO_2 GHG (CH_4 and N_2O) emissions and grain yield, and 412 observations of soil organic carbon sequestration rate (SOCSR). Our results show that for paddy rice, replacing synthetic nitrogen at the rate of 30–59% with organic fertilizer significantly decreased net GHG emissions (NGHGB: –15.3±3.4 (standard error), SOCSR: –15.8±3.8, non-CO_2: 0.6±0.1 in Mg CO_2 eq ha^{-1} yr^{-1}) and improved rice yield (0.4±0.1 in Mg ha^{-1} yr^{-1}). In contrast, intermittent irrigation significantly increased net GHG emissions by 11.2±3.1 and decreased rice yield by 0.4±0.1. The reduction in SOC sequestration by intermittent irrigation (15.5±3.3), which was most severe (>20) in alkaline soils (pH>7.5), completely offset the mitigation in CH_4 emissions. Straw return for paddy rice also led to a net increase in GHG emissions (NGHGB: 4.8±1.4) in silt-loam soils, where CH_4 emissions (6.3±1.3) was greatly stimulated. For upland cropping systems, mostly by enhancing SOC sequestration, straw return (NGHGB: –3.4±0.8, yield: –0.5±0.6) and no-tillage (NGHGB: –2.9±0.7, yield: –0.1±0.3) were more effective in warm climates. This study highlights the importance of carefully managing croplands to sequester soil organic carbon without sacrifice in yield, while limiting CH_4 emissions from rice paddies.

1. Introduction

Croplands are vital in tackling two great challenges facing humanity: ensuring food security and mitigating greenhouse gas (GHG) emissions (1). Non-CO_2 GHG emissions from croplands, i.e., methane (CH_4) and nitrous oxide (N_2O), accounted for ~20% of global total anthropogenic emissions during recent decades (2, 3). With an increase of 25-70% in food demand by 2050 (4) driven by population growth and increasing demand for animal products, global crop productivity needs to be increased on limited arable land. Agricultural intensification under conventional cropland management practices (e.g., intensive tillage and excessive synthetic nitrogen (N) fertilization) creates a cascade of environmental problems, such as global warming due to increased SOC decomposition, and N_2O and CH_4 emissions. Soil organic carbon (SOC) represents the largest terrestrial organic carbon pool, storing about three times as much carbon (C) as the atmosphere (5). A change in cropland SOC caused by cropland management practices may lead to either a release of CO_2 emissions to the atmosphere, or net C sequestration into soils (6), with SOC sequestration representing the long-term CO_2 exchanges between croplands and atmosphere (7).

A number of smart cropland management practices have been advocated in recent decades to safeguard food security and to reduce GHG emissions. Conservation agriculture, which comprises no-tillage and straw return, in croplands has been widely acknowledged to increase SOC and improve the soil's ability to retain nutrients in both uplands and paddy fields (6, 8). Partial replacement of synthetic fertilizer with organic N can also enhance SOC by directly adding organic materials, while addressing the side effects of excessive synthetic N application (9). These alternative practices can change soil properties and microbial activities, and hence modify cropland GHG emissions and grain yield (6, 9-11), which may provide an opportunity for developing a win-win strategy for climate change mitigation and for delivering food security.

The most prominent smart practice suggested for paddy rice is intermittent irrigation, which delivers co-benefits to decrease both CH_4 emissions and water usage (11, 12), to meet the challenge of increasing water scarcity in rice production (13). In contrast to continuous flooding, intermittent irrigation keeps soil moist in rice paddies by water saving techniques (e.g., alternate wetting and drying) (14, 15). Because of the lower soil water content and less anaerobic conditions than continuous flooding, intermittent irrigation prevents CH_4 production and promotes CH_4 oxidation (11, 16). For tropical double rice cropping system across Southeast Asia, a meta-analysis (17) found water saving regimes (e.g., alternate wetting and drying)) significantly reduced CH_4 emissions by 35%, and the mitigation potential was greater in dry than wet seasons of the double rice cropping (17). The effect of intermittent irrigation on CH_4 emissions was also confirmed in the double and single rice cropping systems in South (18, 19) and Northeast China (19, 20) respectively, and other cropping areas (21) across sites, climates and rice variants.

Intermittent irrigation can also impact other GHG emissions, and a previous study showed that it generally increased CO_2 emissions by 44.8% and reduced SOC concentrations by 5.2% of the first 20-cm depth (21). In addition, a meta-analysis showed that it increased N_2O emissions across Southeast Asia (17), but this did not outweigh the climate benefit from the decrease in CH_4 emissions. Despite the lack of consistent benefits on all GHG emissions, intermittent irrigation has been rapidly disseminated in many Asian countries, such as the Philippines, Bangladesh, Vietnam, China and India (13).

The integrated effects of alternative management practices on net GHG budget (NGHGB, including SOC, CH_4 and N_2O) and crop grain yield are understudied and poorly understood. The return of crop residue or straw to the field can increase SOC sequestration and yield of paddy rice, compared to straw removal (10). However, straw return may increase CH_4 emissions by enhancing organic substrates for methanogens (22, 23). Similarly, the reduction in CH_4 emissions through intermittent irrigation in rice paddies may be partially offset, or even reversed, by the associated reduction in SOC sequestration (21). Cropland management practices can impact SOC sequestration, CH_4 and N_2O emissions and crop yield simultaneously, but most studies have focused on only one or two of these effects, which may result in inconsistency when making comparisons between effects, or when aggregating to assess total effects on net GHG emissions. Thus, an integrated assessment of the impact of conversions of cropland management practices on grain yield and net GHG emissions, on a CO_2 equivalents basis (24), is essential.

The effects of cropland management practices on GHG emissions and crop yield vary with environmental factors (i.e., soil properties and climate) and application conditions (e.g., duration, N application rate and fertilizer type) (6, 9-11). Conversion from tillage to no-till has differing effects on SOC sequestration (25, 26), with no-tillage in dry climates relating to higher SOC sequestration and grain yield than wet climates (6). Xia et al. (2017) (27) found the effects of synthetic fertilizer N replacements with manure on grain yield were related to replacement proportions: replacements with rates no more than 75% improved grain yields by ~ 8%, but for those with the rates >75% the changes in yield became insignificant. Hence, a mitigation practice which is effective at one place or under a specific environmental or application conditions, may not be effective in other situations. The effects of cropland management practices, to varying environmental and application conditions, can be investigated by the approach of meta-analysis, which pools observations with different conditions to determine a general understanding or an overall trend against important factors (28). Moreover, combined application of individual practices may be adopted into practical actions for GHG mitigation; for example, no-tillage combined with residue retention can avoid its negative effect on grain yield by returning straw into croplands (6, 8).

However, the effects between individual practices maybe not additive, and the combined effect can be more or less than the sum of the individual effects (29).

The objective of this study was to evaluate the integrated effects of alternative management practices on cropland NGHGB and grain yield. The influences of key environmental and application conditions on the responses of NGHGB and yield were investigated. To achieve these objectives, we conducted a global meta-analysis, based on 347 observations of non-CO_2 GHG emissions and grain yield from 73 papers, and 412 observations of SOC sequestration rate from 117 papers. The alternative management practices investigated relative to conventional practices were no-tillage vs tillage, straw return vs removal, intermittent irrigation vs continuous flooding, and synthetic fertilizer N replacements with organic N.

2. Materials and Methods

2.1. Study selection and data collection

We used several databases, such as Web of Science, Google Scholar and Scopus to search peer - reviewed publications (before April 2020) The keywords used in the search were “cropland or crop or wheat or maize or barley or rice”, “soil organic carbon (SOC) or soil organic matter (SOM)”, and/or “methane (CH_4), nitrous oxide (N_2O) and yield (grain)”. Studies related to the management practices investigated were then selected. Each study selected contains measurements of GHG emissions for both control and treatment management practices. Studies with the following measurements were excluded: (i) measurements made in pot, laboratories or greenhouses, (ii) measurements conducted in organic (peaty) soils where N_2O are much higher than those in mineral soils and where soil carbon fluxes are different (30).

To investigate the effect of cropland management practices, the paired control and treatment measurements of GHG emissions and grain yield under each management practice were collected, for example, pairs of CH_4 emission measurements with and without straw return in the same study. In terms of synthetic N fertilizer replacements with organic fertilizer, control plots were receiving synthetic N fertilization only, whilst treatment plots had a mix of synthetic and organic N fertilizations, but at the same total N application rate as the control ones. For annual non-CO_2 GHG emissions (CH_4 and N_2O) and grain yield that measured simultaneously, the measurements ranging from a crop growing season to a year were collected. As a surrogate measure of net CO_2 exchange between the atmosphere and croplands (7), annual SOC sequestration rate (SOCSR, Mg CO_2 eq ha^{-1} yr^{-1}) measured for at least a year was collected. Averaged values were taken for measurements with multiple years. We collected observations from experiments of different duration, as can be seen in Table S2. Changes in SOC sequestration rate are generally more rapid at the beginning of the experiment than at the end, and it slows down as the duration increases (31), as shown in Figure 2c, for example. Nevertheless, the observations were treated in an equivalent way, and the duration was considered as a factor in the analysis of the effect of management practice.

In addition to GHG emissions and grain yield, related variables collected were sorted into three categories: (i) climatic factors, (ii) soil properties, and (iii) application parameters. For climatic factors: mean annual air temperature (MAT) and mean annual precipitation (MAP) were obtained from the original papers. For soil properties: pH, bulk density, clay and sand contents were also collected from the articles to represent soil substrate availability and aeration conditions. For application parameters: N fertilizer type (synthetic or organic) and application rate, and duration of application were extracted. Crops were categorized into two types: upland crops and paddy rice. The percentage application rate of organic N fertilizer (i.e., manure or compost) to total rate was then calculated and categorized into low (0-29%), median (30-59%), high (60-99%), and complete (100%) groups. Information on fertilization methods (e.g. broadcast, injection, or deep placement) and application timing were mostly not available and therefore, not considered for further analysis. Missing values of MAT and MAP (21% and 11% for non-CO_2 GHGs; 21% and 23% for SOCSR) for 1970-2000 were extracted from WorldClim v2.1 (32); soil bulk density (45% and 58% for non-CO_2 GHGs and SOCSR), pH (11% and 32%), clay (42% and 46%) and sand (49% and 54%) contents were supplemented from the 1-km Harmonized World Soil Database (HWSD v1.2) (http://www.iiasa.ac.at/) using site latitudes and longitudes. About 89% of the SOCSRs were directly provided by original papers, whilst the remainder were calculated based on measured initial and final SOC contents and BD. Details of these variables can be found in Table S1.

The final compiled dataset contains 347 pairs of treatment and control observations of non-CO_2 GHG (CH_4 and N_2O) emissions and grain yield at 68 sites from 73 papers, and 412 pairs of SOCSR at 130 sites from 117 papers (Figure S1 and Table S2). For upland crops, it includes 44 and 170 paired observations of non-CO_2 GHGs and SOCSR for no-tillage, 27 and 138 pairs for straw return, 19 and 23 pairs for synthetic fertilizer replacement with organic fertilizer. For paddy rice, it includes 11 and 7 pairs of non-CO_2 GHGs and SOCSR for no-tillage, 119 and 28 pairs for straw return, 50 and 18 pairs for synthetic fertilizer replacement with organic fertilizer, 77 and 28 pairs for intermittent irrigation (Figure S1).

2.2. Net greenhouse gas budget (NGHGB)

The NGHGB (Mg CO_2 eq ha^{-1} yr^{-1}) was calculated as the sum of CO_2 equivalents from SOCSR, and CH_4 and N_2O emissions in croplands (Equations 1a-c). SOCSR measurements were reported by studies with various soil depths. To improve comparability, we normalized the SOCSR to the top 30 cm depth (30), using a depth distribution method developed by Jobbágy and Jackson (33) (Equations 1c).

$$NGHGB = 1 \cdot CO_2 + 28 \cdot CH_4 + 265 \cdot N_2O \tag{1a}$$

$$CO_2 = -44/12 \cdot SOCSR_{d30} \tag{1b}$$

$$SOCSR_{d30} = \left(\left(1-\beta^{30}\right)/\left(1-\beta^{d0}\right)\right) \cdot SOCSR_{d0} \tag{1c}$$

where

CO_2, CH_4 and N_2O represent the amounts of the greenhouse gas emissions, Mg mass ha^{-1} yr^{-1}; 1, 28, and 265 are the global warming potentials of CO_2, CH_4 and N_2O at 100-year time horizon without climate change feedback, respectively (24, 30); $SOCSR_{d30}$ is SOC sequestration rate up to 30 cm soil depth (Mg C ha^{-1} yr^{-1}); –44/12 is the coefficient to transfer the value of $SOCSR_{d30}$ to CO_2 emissions (Mg

CO_2 eq ha^{-1} yr^{-1}); $SOCSR_{d0}$ is SOCSR at original depth d0, Mg C ha^{-1} yr^{-1}; β is the relative rate of decrease (0.9786) with soil depth in croplands (33).

2.3. Effects of an individual management practice

In this meta-analysis, the individual effect of each management practice on cropland NGHGB emissions and grain yield were estimated by the response size mean difference (MD), using the following equation (34, 35):

$$MD = X_T - X_C \tag{2}$$

where X_T and X_C are the treatment and control means of variable X (i.e., SOCSR, CH_4 and N_2O emissions, NGHGB, and grain yield), respectively. The MD can indicate the direction and absolute value of the change of variable X, and the values of MD, expressed in Mg CO_2 eq ha^{-1} yr^{-1}, are comparable between different GHG emissions.

We performed our analysis on MD weighted by study replication, on unweighted effect sizes (36, 37). Then, a weighted random-effects model, which are more adaptable to ecological synthesis compared to fix-effects model (28), was selected to estimate the MD of the variable X for a certain cropland management practice. The effect of the management practice was considered not significant if 95% confidence interval (CI) of the MD overlapped with zero. The estimations of the MD and associated 95% CI of were conducted in R version 4.0.1 with “meta” and “metaphor” packages (38, 39).

2.4. Combination of effects on SOCSR and non-CO_2 GHG emissions

To assess the effect of an alternative management practice on NGHGB, bootstrapping resampling was preformed to combine the MDs of SOCSR and non-CO_2 GHG emissions. These two datasets were obtained from different environmental and application conditions, and they had different numbers of observations from various papers. We used the bootstrapping function in R to generate the normal distributions of the means of MD for SOCSR and non-CO_2 GHG, with replacements of the equal sizes of the initial datasets repeated n=100,000 times. Then, the means of SOCSR and non-CO_2 GHG emissions were added together to create a normal distribution of the means of NGHGB MDs, according to Equation 1a. 95% CIs of the means was compared with zero to identify the significance of the impact of the practice.

2.5. Response of individual management effect to important factors

We used linear, stepwise forward regression to identify significant explanatory variables regulating response (estimated as MD) for an alternative management practice. Environmental and application factors acted as dependent variables; the MD for SOCSR acted as independent variable, because it accounted for the majority of NGHGB in general. A list of cumulative R^2 was calculated with gradual inclusion of significant variables by order. Backwards regression was also explored and gave broadly similar results for the relative importance of factors, but because of co-linearity between variables (see Figure S2, for example), the method was insensitive to removal of variables (i.e. R^2 did not decrease with variable removal) when assessing the relative importance of correlated variables. Because of this, forward regression was better able to discriminate the most influential variables, so was used in this analysis. The joint interactions of two factors, which explained most variation of the MD for SOCSR, were used to interpolate the response of the effect on SOCSR and non-CO_2 GHG emissions and yield. The interpolation was performed in R using “akima” package (40).

2.6. Combined and interactive effects of management practices

Combined and interactive effects were estimated for paired management practices. For combined effects (MD_{A+B}), X_T in Equation 1a was replaced by the measurements under simultaneous application of practice A and B (X_{AB}, Equation 3a). For interactive effect (MD_{A*B}), the interaction between practice A and B was calculated by Equation 3b:

$$MD_{A+B} = X_{AB} - X_C \tag{3a}$$

$$MD_{A*B} = \left(X_{AB} - X_A\right) - \left(X_B - X_C\right) \tag{3b}$$

where X_A and X_B are means of variable X under treatments of alternative practice A and B, respectively. As mentioned in the estimation of individual effect, MD_{A+B}, MD_{A*B} and associated 95% CIs were estimated in R. The interaction between A and B is additive if MD_{A*B} is not significantly different from zero; If MD_{A*B} was greater than zero the interaction was synergistic, if it was less than zero the interaction was antagonistic, when the individual effects of A and B are both positive (29). Studies reporting observations measured simultaneously under paired management practices, two individual practices, and control were selected for the assessment of interactive effects. The selected studies are shown in Table S2.

3. Results

3.1. Effects of an individual management practice

Across all crops, only no-tillage and organic fertilizer N (ON) replacements of low (0-29%), median (30-59%) and high (60-99%) percentages consistently decreased NGHGB whilst maintaining or increasing grain yield (Figure 1a b and c). However, intermittent irrigation and complete (100%) organic fertilizer substitution substantially decreased grain yield and increased or had no effect on NGHGB.

For upland crops, all management practices (i.e. no-tillage, straw return at median, high and complete ON replacements) decreased NGHGB while maintaining grain yield (Figure 1d). The reduction in the NGHGB (all expressed in Mg CO_2 eq ha^{-1} yr^{-1}) was largest in the high ON replacement (–3.7), followed by straw return (–2.7), no-tillage (–1.8), complete (–1.4) and median (–1.2) ON replacements. The overall average reduction in NGHGB (–2.2±0.5, mean ± SE) for upland crops were mostly (97%) attributed to the enhanced SOC sequestration (Figure 1f).

For paddy rice, the best practice in terms of decreasing NGHGB (–15.3) and improving grain yield (0.4) was median ON replacement (30-59%), and the least effective were complete ON replacement (NGHGB: 3.1, yield: –0.6) and intermittent irrigation (NGHGB: 11.2, yield: –0.4) (Figure 1g). Straw return to paddy rice significantly increased grain yield (0.2, $p<0.001$), but greatly increased the non-CO_2 GHG emissions (4.2, $p<0.001$, Figure 1h), which is partly offset by the increase in SOC sequestration (–3.0, $p<0.001$, Figure 1i). Overall, straw return had a small effect on NGHGB (1.2, $p>0.05$, Figure 1g). Similarly, although no-tillage significantly decreased the non-CO_2 GHG emissions by 3.0 Mg CO_2 eq ha^{-1} yr^{-1} for paddy rice, the total effect on NGHGB was negligible ($p>0.05$, Figure 1h and g). Intermittent irrigation, instead of continuous flooding resulted in a significant increase in NGHGB (11.2, $p<0.05$), mainly due to decreased SOC sequestration (15.5, $p<0.001$). Here, the non-CO_2 GHG emissions (–4.3, $p<0.001$) were simultaneously decreased due to the largely reduced CH_4 emissions (Figure S3). Additionally, rice yield was also significantly reduced by 0.3 Mg ha^{-1} yr^{-1} ($p<0.05$) by intermittent irrigation.

3.2. Response of individual management effect to important factors

The most significant factors affecting the impact of no-tillage on SOC sequestration for upland crops were mean annual air temperature (MAT) and nitrogen application rate (Nrate) (cumulative R^2=0.07, N=136, Figure 2a). It was most effective for SOC sequestration (SOCSR<–10 Mg CO_2 eq ha^{-1} yr^{-1}) at temperatures above 12°C and nitrogen fertilizer rates above 200 kg N ha^{-1} yr^{-1}, whereas non-CO_2 GHG emissions and grain yield were slightly affected (Figure 2a).

The two factors explaining the most variations in the effect of intermittent irrigation as a replacement of continuous flooding in paddy fields were soil pH and Nrate (cumulative R^2=0.78, N=27, Figure 2b). Intermittent irrigation was most effective for SOC sequestration and non-CO_2 GHG mitigation at low pH (<7) and high Nrate (>200kg N ha^{-1} yr^{-1}) respectively, whereas yield varied within ±2 Mg ha^{-1} yr^{-1} (Figure 2b).

For straw return for upland crops, the two factors explaining the most variation in effect were application duration and MAT (cumulative R^2=0.27, N=135, Figure 2c). SOC sequestration and non-CO_2 GHG reduction were greater within higher MAT (>12°C) and short application duration (1-10 years for SOC and <200 days for non-CO_2 GHG), while yield tended to decline (Figure 2c). However, these reductions decreased with the increasing duration of application.

For straw return for paddy rice, the two factors explaining most variation in the response were the sand and clay content of the soil (cumulative R^2=0.48, N=25, Figure 2d). Unlike other practices which had greater effects on SOC sequestration than non-CO_2 GHG emissions, straw return to rice paddy mainly increased CH_4 (6.8 Mg CO_2 eq ha^{-1} yr^{-1}, Figure 2c and Figure S3), especially for sand content in the range of 20-30%, and clay content in the range of 20-40%, reducing the benefit gained from enhanced SOC sequestration. Meanwhile, the effect on yield was negligible, varying mostly within the range of ±1 Mg ha^{-1} yr^{-1} (Figure 2d).

For synthetic fertilizer replacement for upland crops, the two most significant factors in explaining variation in response were the percentage of replacement of mineral N with organic fertilizer and MAT (cumulative R^2=0.48, N=21). As shown in Figure 2e, this practice was most effective at lower temperatures (<15 °C) and with the replacement percentage rates of around 60-70 and above, which increased SOC sequestration (SOCSR<–3 Mg CO_2 eq ha^{-1} yr^{-1}) and also increased the yield (>2 Mg ha^{-1} yr^{-1}), with negligible effects on non-CO_2 GHG emissions (<0.2 Mg CO_2 eq ha^{-1} yr^{-1}).

The variation in the effect of synthetic fertilizer replacement for paddy rice was mostly (cumulative R^2=0.91, N=18, Figure 2f) explained by pH and clay content of soil. Higher pH led to greater SOC sequestration, while clay content showed strong positive correlation with the non-CO_2 GHG emissions (Figure 2f). The grain yield was little affected and mostly varied within 1 Mg ha^{-1} yr^{-1}.

3.3. Interactive effects between management practices

The interactions between paired management practice on non-CO_2 GHGs and grain yield are shown in Figure 3. For synthetic and organic fertilizer N applications, there were significant antagonistic interactive effects (–0.1 Mg CO_2 eq ha^{-1} yr^{-1}, $p<0.001$, Figure 3a) on N_2O emissions from rice paddies. In this case, individual synthetic and organic fertilizer applications increased N_2O emissions by 0.2 and 0.1 Mg CO_2 eq ha^{-1} yr^{-1} respectively, but the combined application only raised the emissions by 0.2 Mg CO_2 eq ha^{-1} yr^{-1}, significantly less than the sum of the individual effects (0.3 Mg CO_2 eq ha^{-1} yr^{-1}). For combined applications of no-tillage and straw return (Figure 3b) and no-tillage and synthetic N fertilizer application (Figure 3c), the interactive effects were additive (i.e. the combined effect is not significantly different from the sum of the individual effects).

4. Discussion

Integrated assessment of smart cropland management practices on GHG emissions and grain yield is essential for developing win-win strategies to produce more grains with lower environmental costs.

4.1. No-tillage

No-tillage significantly decreased net GHG emissions, mainly through improved SOC sequestration rate for upland crops (Figure 1b), especially in warm climates (MAT>12 °C) and under high N fertilizer application rates (>200 kg N ha^{-1} yr^{-1}, Figure 2a). No-tillage can reduce disturbance of soil surface layers and protect SOC aggregates from fragmentation and microbial decomposition (41). Based on 170 paired observations of SOC sequestration rates, we found no-tillage generally increased the SOC sequestration rate by 1.8 Mg CO_2 eq ha^{-1} yr^{-1} for upland crops, which falls within the range (0.7-1.8 Mg CO_2 eq ha^{-1} yr^{-1}) from a recent meta-analysis (6). Compared to SOC sequestration, changes in CH_4 and N_2O emissions were insignificant and much smaller (Figure S3 and Figure 1b). In warm climates (MAT>12 °C), high temperature improves enzymatic reactions and accelerates SOC decompositions (33, 42). This can be counteracted by the conversion of no-tillage from tillage, which protects SOC from decomposition and thereby, increases SOC sequestration (6, 41, 43). This is further supported by the significant positive relationship between SOC sequestration rate and temperature (R=0.22, N=170,

$p<0.01$). Under high N fertilization (>200 kg N ha^{-1} yr^{-1}), no-tillage can accumulate more SOC through microbial activities and crop growth (41, 43), and protect SOC from enhanced microbial activity. Although temperature and N fertilizer application rate hardly explained the variance of the effect of no-tillage on SOC sequestration (Figure 2a), the effect was significantly greater in warm regions with high N fertilization areas (SOCSR: –6.7 Mg CO_2 eq ha^{-1} yr^{-1}) than in cool areas with lower fertilization rates (SOCSR: 0.2 Mg CO_2 eq ha^{-1} yr^{-1}) (Figure S4). Grain yield was found generally unaffected by no-tillage ($p>0.05$, Figure 1d and e). A recent global meta-analysis (6) found no-tillage in dry areas in China and India, can maintain or increase grain yield. Therefore, our study suggests that warm-dry areas with high N fertilizations, such as North China Plain, North India and East Pakistan (44, 45), where traditional tillage is widely practiced (6), are likely to deliver GHG mitigation while maintaining grain yield under no-tillage.

4.2. Straw return

Straw return to rice paddy was risky in increasing net GHG emissions in silt-loam soils with stimulation in CH_4 emissions. We found that straw return increased SOC sequestration for paddy rice by 3.0 Mg CO_2 eq ha^{-1} yr^{-1} (Figure 1i). However, straw decomposition can provide substantial methanogenic substrates for CH_4 production (23, 46). We found that the enhanced SOC sequestration was completely offset by straw induced CH_4 emissions (Figure S3 and Figure 1c), with relatively small changes in N_2O emissions (Figure S3). We found the increase in non-CO_2 GHGs (mostly CH_4, Figure S3) emissions were greatest in silt-loam soils with median clay (20-30%) and sand (20-40%) contents (Figure 2c). Kristofor et al. (47) reported 23% higher CH_4 emissions from silt-loam soils than clay (=50%) soils in rice paddies under the same environmental conditions. This was because of the delayed reducing conditions for methanogenesis, substantial alternative electron acceptors preventing CH_4 production, and lower diffusivity of clay soils (47). Although having not significant impact on net GHG emissions (1.2 Mg CO_2 eq ha^{-1} yr^{-1}, $p>0.05$), straw return significantly increased net GHG emissions by 4.8 Mg CO_2 eq ha^{-1} yr^{-1} in silt-loam soils. This suggests silt-loamy paddy fields, mainly located in Chinese Middle and Lower Yangtze River Basin, North and East Bangladesh and South Myanmar (45), are likely to act as a net GHG emitter under straw return.

In contrast, straw return to upland crops significantly decreased net GHG emissions, mainly due to the enhanced SOC sequestration especially in warm climates (MAT>12°C) and in first 10 implementing years (NGHGB: –6.9±1.3, Figure 1d). Compared to non-CO_2 GHG emissions, straw return mostly (89%) impacted on SOC sequestration for upland crops (Figure 1e and f). Microbes are more active in warm climates, which facilities faster decomposition of applied straw for SOC accumulation (48, 49). The rate of SOC sequestration decreases with the continuous application of straw return, and would eventually become zero, when a new equilibrium level of SOC is reached (31). Our results suggest straw return can be most effective for sequestrating SOC within first 10 years after application for upland crops. For 44 observations of SOC sequestration rates which were greater than the average (2.4 Mg CO_2 eq ha^{-1} yr^{-1}) of the dataset, 89% of them were either from warm climates or within the implementation of first 10 years. Only five outliers were from Canada (50) and Northern US (51, 52) with long-term (13-16 years) application of straw retention combined with no- or chisel-tillage, which needs further investigation.

4.3. Intermittent irrigation

Our results showed that replacing continuous flooding by intermittent irrigation increased net GHG emissions and decreased rice yield (Figure 1g). Typical intermittent irrigation, such as alternate wetting and drying, keep soil moist but avoid continuous flooding in rice paddies (14, 15). We found the intermittent irrigation significantly decreased CH_4 emissions by 4.6 Mg CO_2 eq ha^{-1} yr^{-1} ($p<0.01$, Figure S3), within the reported range of 3-7 Mg CO_2 eq ha^{-1} yr^{-1} (53, 54). It is widely known that intermittent can lead to lower water content and less anaerobic conditions than continuous flooding in the soil, and hence prevents CH_4 production and promotes CH_4 oxidation (11, 16). Interestingly, we found that the mitigation effect on CH_4 emissions was completely offset and reversed by the reduced SOC sequestration (SOCSR: 15.5 Mg CO_2 eq ha^{-1} yr^{-1}, Figure 1g, h and i), with a slight increase in N_2O emissions. The reduced SOC sequestration can be explained by the increased SOC decomposition under intermittent irrigation (55).

Intermittent irrigation avoids extreme dry and waterlogged conditions which constrain the availabilities of soluble substrates and oxygen for microbial decomposition, respectively (56). We found rice yield was significantly decreased by intermittent irrigation in general (–0.3 Mg ha^{-1} yr^{-1}, Figure 1g). Unsaturated soil moisture under intermittent irrigation can inhibit rice growth, especially during the flowering period (57, 58).

Our analysis suggests that soils with higher pH (>7.5) were more likely to suffer from losses in SOC sequestration and rice yield under intermittent irrigation. The reduction in SOC sequestration was most severe (>20 Mg CO_2 eq ha^{-1} yr^{-1}) in soils with higher pH (>7.5) (Figure 2b). Through improving microbial growth (59, 60), soil pH can enhance SOC decomposition rate (61), with pH only capturing 74% of the effect variation of intermittent on SOC sequestration (Figure 2b). Aciego Pietri and Brookes (59) also found significant relationships between soil pH and microbial biomass C (R^2=0.80) based on a long-term field study with controlled pH gradients (3.7-8.3). Severe reductions to SOC sequestration (20-42 Mg CO_2 eq ha^{-1} yr^{-1}) were reported in India at soils with pH=7.9 (62), and the reductions caused by intermittent irrigation declined with increasing N application rates of both synthetic and organic fertilizers (0-150 kg N ha^{-1}) in this field experiment. Higher application rate of fertilizer N can lead to more organic carbon to soils from root and root exudate by supporting crop growth (63-66), which partially offsets the reduction in SOC sequestration. Yang et al. (2017) (67) reported less, but still severe, reduction of SOC sequestration (12 Mg CO_2 eq ha^{-1} yr^{-1}) in clayey alkaline soils (clay content=75% and pH=7.4), where the high soil clay content, associated with long water retention (68), may also affect the impact of intermittent irrigation. Since SOC is important for maintaining nutrients and soil water for crop growth (21, 69), the decreased SOC sequestration may further impact rice yield. We found rice yield was significantly decreased by intermittent irrigation especially under low SOC content (Figure S5). This suggests that we should avoid a potential long-term negative feedback on SOC stock and yield in alkaline soils when adopting intermittent irrigation. Since intermittent irrigation has been widely promoted in Bangladesh (13), where alkaline paddy fields prevail in Ganges Delta (45), special attentions on SOC and grain yield in Bangladesh are needed.

4.4. Synthetic N fertilizer replacement by organic N

Replacing synthetic fertilizer N with organic sources for paddy rice can increase net GHG emissions at some levels of substitution, but median proportion (30-59%) was identified to significantly decrease the net GHG emissions while increasing grain yield (Figure 1g). Synthetic N fertilizer replacement promotes SOC accumulation by directly adding exogenous organic materials, and increasing the inputs of root and root exudate to soils through stimulating crop growth (63-66). However, the decomposition of organic addition enhanced methanogens activities for CH_4 production (23, 46). All proportions of synthetic N fertilizer replacements significantly stimulated CH_4 emissions, with the largest at 100% replacement (p<0.05, Figure S3). Median organic proportion (30-59%) increased CH_4 emissions by 0.5 Mg CO_2 eq ha^{-1} yr^{-1}, but it was completely offset by the enhanced SOC sequestration (15.8 Mg CO_2 eq ha^{-1} yr^{-1}, Figure 1g). Partial replacement with organic N not only provides macronutrients from synthetic fertilizer, but also provides micronutrients such as phosphorus, potassium, copper and zinc from organic sources, and improves soil texture, water and nutrient holding capacities for crop growth (64, 70). We found median organic proportion (30-59%) significantly increased the rice yield by 0.3 Mg ha^{-1} yr^{-1}, which was decreased under 100% replacement ($p<0.05$, Figure 1g and h). Since organic N requires longer time to be mineralized than synthetic N which is immediately available, insufficient N supply for early crop growth in complete replacement can negatively impact grain yield (71, 72). Similarly, complete replacement for upland crops decreased grain yield, while 50-70% replacement proportions improved grain yield (–0.5 vs 0.7 Mg ha^{-1} yr^{-1}, $p<0.05$) (Figure 2e). It is risky for paddy rice to completely replace synthetic fertilizers with organic materials, which may both result in grain yield loss and increase in net cropland GHG emissions.

The synthetic and organic N fertilizations had antagonistic interaction on the N_2O emissions for paddy rice (Figure 3a), i.e., the combined effect of synthetic and organic N fertilizations was significantly smaller than the sum of individual effects. The combined application of synthetic and organic N fertilizers can enhance crop nitrogen use efficiency (27, 73) and microbial immobilization (74, 75), and hence reduce the soil nitrogen availability for N_2O production. Based on field measurements from Bhattacharyya et al. (2013), the combined application of synthetic and organic N showed 20% lower conversion of fertilizer N to soil ammonium and nitrate nitrogen than individual applications, and its N_2O emission factor (N_2O-N/fertilizer N) was 18% and 57% lower than those for synthetic and organic N applications, respectively. Besides, the combined application of synthetic and organic N fertilizers promotes the reduction of N_2O to N_2 in denitrification which prevails in rice paddies, due to the supply of dissolved organic carbon by organic fertilizer addition (10).

4.5. Limitations

Some limitations exist during the estimation of integrated effects of cropland management practices investigated. More observations were available in China and North America, where temperate and sub-tropic climate prevail, and there were fewer studies in Africa and South America (Figure S1). Sample numbers among different GHG emissions may differ during the integration of all GHG emissions for a certain management practice. Environmental conditions, experimental techniques and durations, and other management practices may also vary between the integrated or individual assessment of GHG emissions and grain yield. These differences may influence the magnitude of the effects of cropland management practices on GHG emissions and grain yield. However, the approach of pooling observations with different conditions to determine a general understanding or an overall trend has been widely adopted by other meta-analysis studies (27, 28). In the integration of emissions of the three GHG, we have tackled the difference in sample numbers by collecting data from studies that at least measure the emissions of CH_4 and N_2O simultaneously, to ensure the observation numbers of two kinds of GHG emissions are at least the same. In addition, we have adopted bootstrapping (100,000 iterations) to generate the 95%CIs of the integrated effects to make a reliable assessment. In the individual assessment, we used a random-effects model, which is more adaptable than a fixed-effects model in ecological synthesis (28), to evaluate the effect of management practice, and to deal with the variability across studies in environmental, experimental and other conditions (28).

4.6. Implications and looking forward

We comprehensively assessed the integrated effects of cropland management practices on net GHG emissions and grain yield. Our study shows straw return, no-tillage in warm climates (MAT>12 °C), synthetic N fertilizer replacements with median organic proportion (30-59%) for paddy rice generally decreased cropland net GHG emissions and maintained or increased grain yields. In contrast, intermittent irrigation for paddy rice increased the net GHG emissions and reduced rice yield. We found it is essential to comprehensively consider impacts on SOC and non-CO_2 GHG emissions, especially for paddy rice. Although straw return and complete synthetic N fertilizer replacements (100% organic) for paddy rice increased SOC sequestration, the organic additions stimulated substantial CH_4 emissions, leading to a net balance or even an increase in cropland GHG emissions (Figure 1g). We should take a systematic view of the agroecosystem to deal with environmental problems (76). The changes in N_2O emission are relatively small compared to the net GHG emissions, however, there are other N-cycling related environmental impacts (NH_3, N leaching and running) needed to be included in the future integrated assessment of cropland management practices. For example, NH_3 emissions increased by 17% under straw return (10). It may be challenging to integrate all environmental aspects of agroecosystem (e.g., water usage and storage, and biodiversity), but this study has taken the first step toward the integrated assessment of cropland management practice.

Interactive effects between management practices have great influences on the combined application of multiple practices for mitigating GHG emissions and ensuring food provision. A number of studies have investigated the effects of combined management practices applied together (6, 8), but few studies have quantified the interactions between these practices. We found synthetic and organic N fertilizations antagonistically interacted on N_2O emissions for paddy rice (Figure 3a). This means the combined synthetic and organic N fertilizations can reduce N_2O emissions relative to individual fertilizations, apart from increased SOC sequestration by organic addition. The combined application of multiple management practices can compensate for the disadvantages of a single practice.

For instance, to combat reductions in SOC and yield, intermittent irrigation for paddy rice was applied together with straw or biochar (55, 77-79). Still, little is known about the interactive effects between the management practices, which can be additive, synergistic or antagonistic (29) on GHG emissions and grain yield. Despite there are limited observations, our study provided an approach and initially quantified the interactive effects between management practices. Future studies should provide more data and bridge the gap for the interactions between cropland management practices for GHG mitigation and food security.

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Supplementary material

Additional Supplementary Information can be found in the online version of this article.

Competing Interest Statement

The authors declare no competing interests.

Author Contributions

Ziyin Shang: Conceptualization, Methodology, Investigation, Formal analysis, Visualization, Writing - original draft. Mohamed Abdalla: Conceptualization, Methodology, Writing - review & editing, Resources. Longlong Xia: Methodology, Writing - review & editing. Feng Zhou: Visualization, Writing - review & editing. Wenjuan Sun: Writing - review & editing. Pete Smith: Supervision, Conceptualization, Methodology, Writing - review & editing.

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Figures

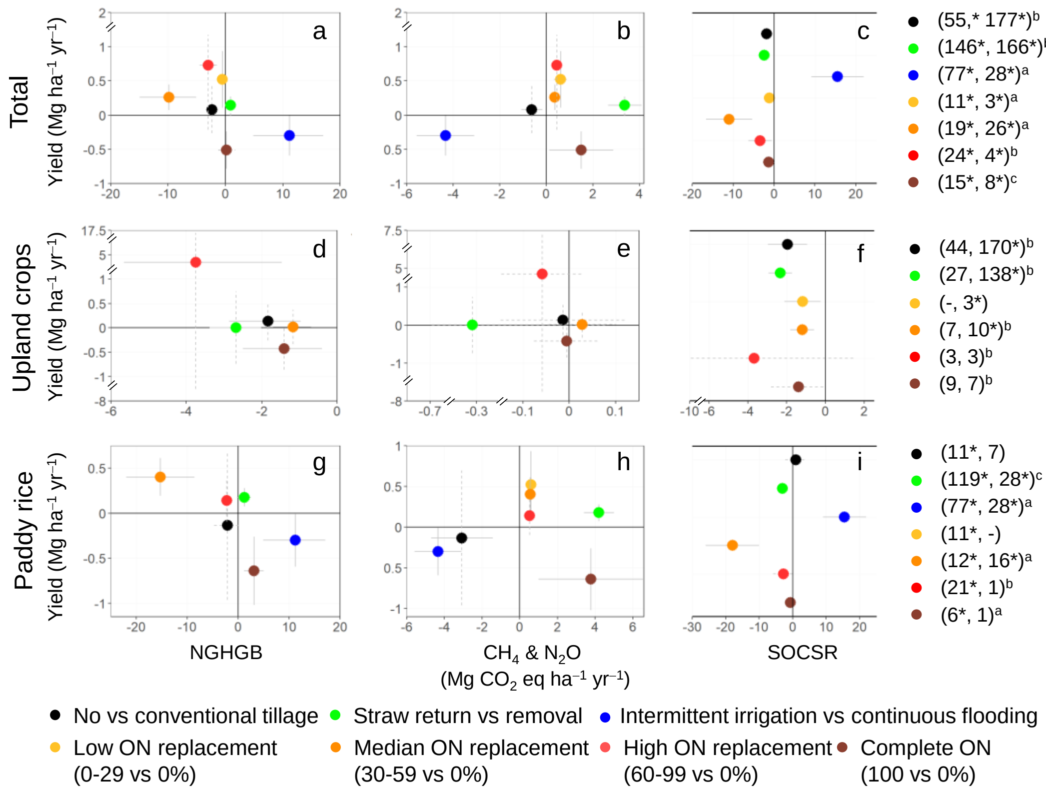

Figure 1. Overall effect of individual management practice on cropland net greenhouse gas budget (NGHGB), non-CO_2 GHG (CH_4 and N_2O), SOC sequestration rate (SOCSR), and grain yield. Data is presented as absolute mean difference between alterative and conventional practices, with 95% confidence intervals (CIs) as error bars, and number of observations noted in parentheses, for non-CO_2 GHG and grain yield (left) and SOCSR (right). The effects are significant when the 95% CIs do not overlap with zero. Asterisks and solid error bars represent significant, and dashed bars indicate the insignificant differences. Letters at the end of parentheses indicate the significances of differences in NGHGB and yield, with a for both, b for NGHGB only and c for yield only.

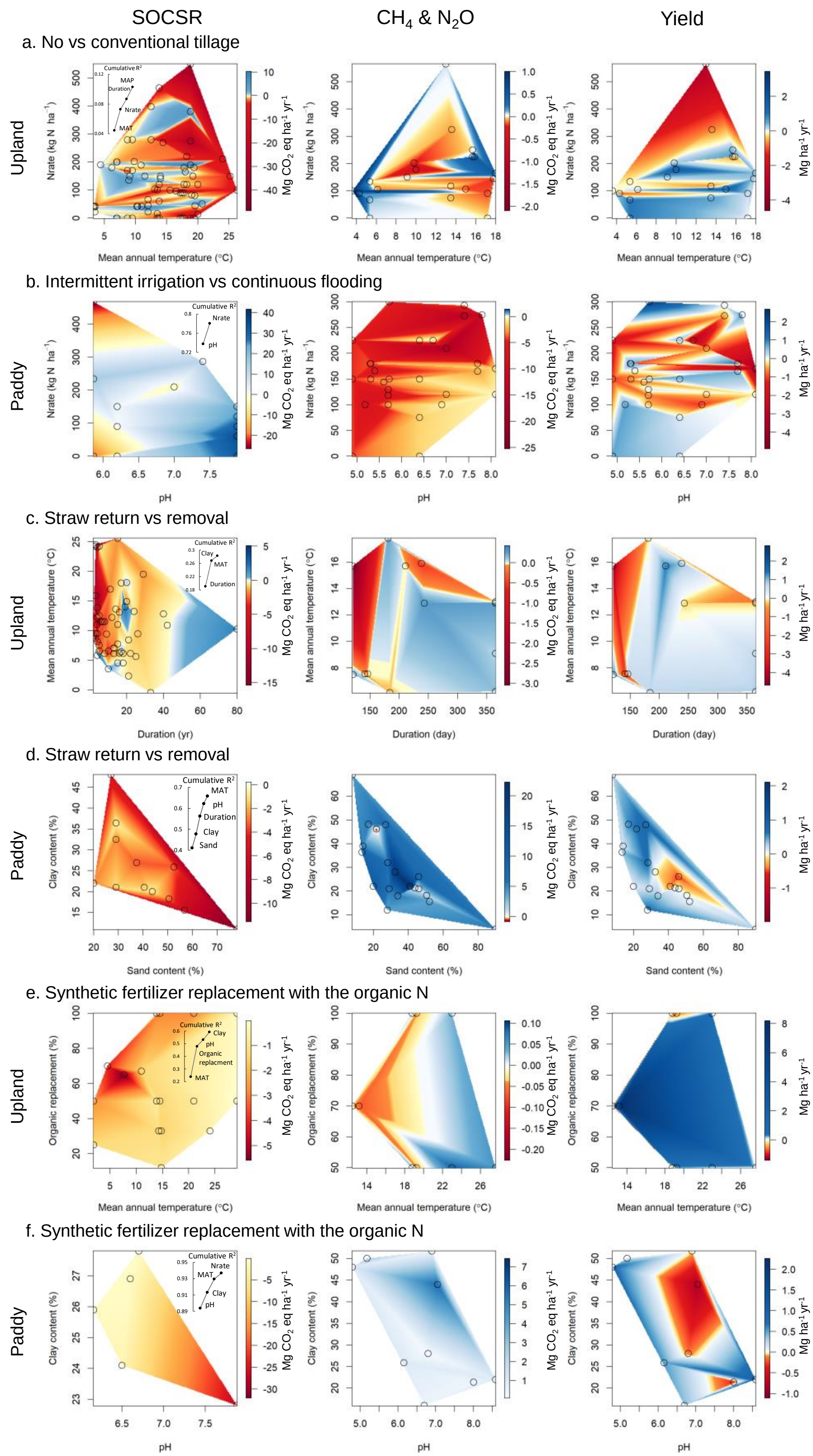
SOCSR
CH$_4$ & N$_2$O
Yield
a. No vs conventional tillage
Upland
b. Intermittent irrigation vs continuous flooding
Paddy
c. Straw return vs removal
Upland
d. Straw return vs removal
Paddy
e. Synthetic fertilizer replacement with the organic N
Upland
f. Synthetic fertilizer replacement with the organic N
Paddy
Cumulative R^2
Nrate (kg N ha^{-1})
Mean annual temperature (°C)
pH
Duration (yr)
Duration (day)
Clay content (%)
Sand content (%)
Organic replacement (%)
Mg CO$_2$ eq ha^{-1} yr^{-1}
Mg ha^{-1} yr^{-1}

Figure 2. Responses of SOCSR, non-CO_2 emissions and grain yield to important factors under alternative management practices. The responses are expressed as absolute mean difference between alterative and conventional practices. Response surface was interpolated based on observations (open circles). Importance of factors was defined by the order of environmental and application variables selected in stepwise forward regression for SOCSR, which generally accounts for the majority of NGHGB. Cumulative R^2 with gradual inclusion of the significant factors was shown. Nrate: fertilizer N application rate; Organic replacement: the proportion of synthetic fertilizer N replaced by organic N; MAT: Mean annual air temperature; MAP: mean annual precipitation.

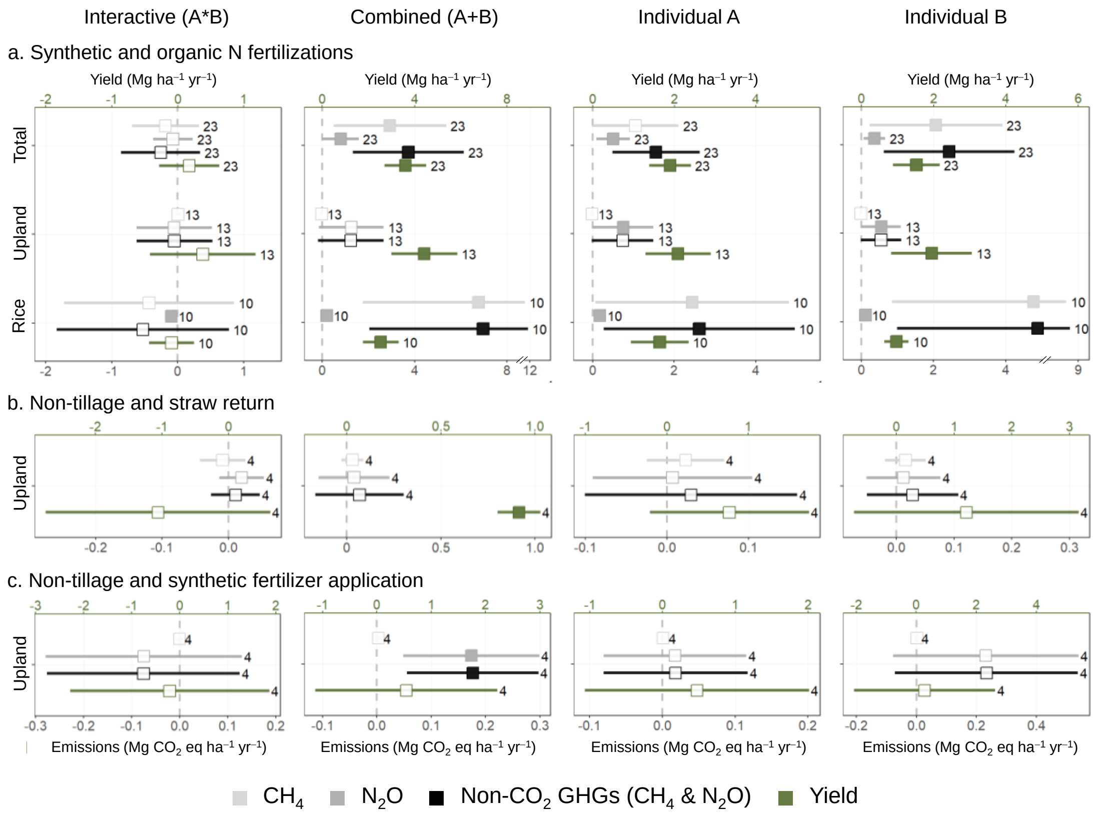

Figure 3. Interactive and combined effects on cropland non-CO_2 GHG (CH_4 and N_2O) emissions and grain yield between paired management practices of (a) synthetic and organic N fertilizations, (b) no-tillage and straw return, and (c) no-tillage and synthetic N fertilization. The results are expressed as mean difference, with 95% confidence intervals (CIs), and sample size numbers. If the 95% CI of interactive effect overlapped with zero, then the effect between the paired management practices was considered to be additive; otherwise, synergistic or antagonistic. Solid square indicates significant effect at 95% CIs, and open square represents insignificant.

Can cropland management practices lower net greenhouse emissions without compromising yield?

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Table S1. Variable descriptions of cropland GHG emissions and yield collected.

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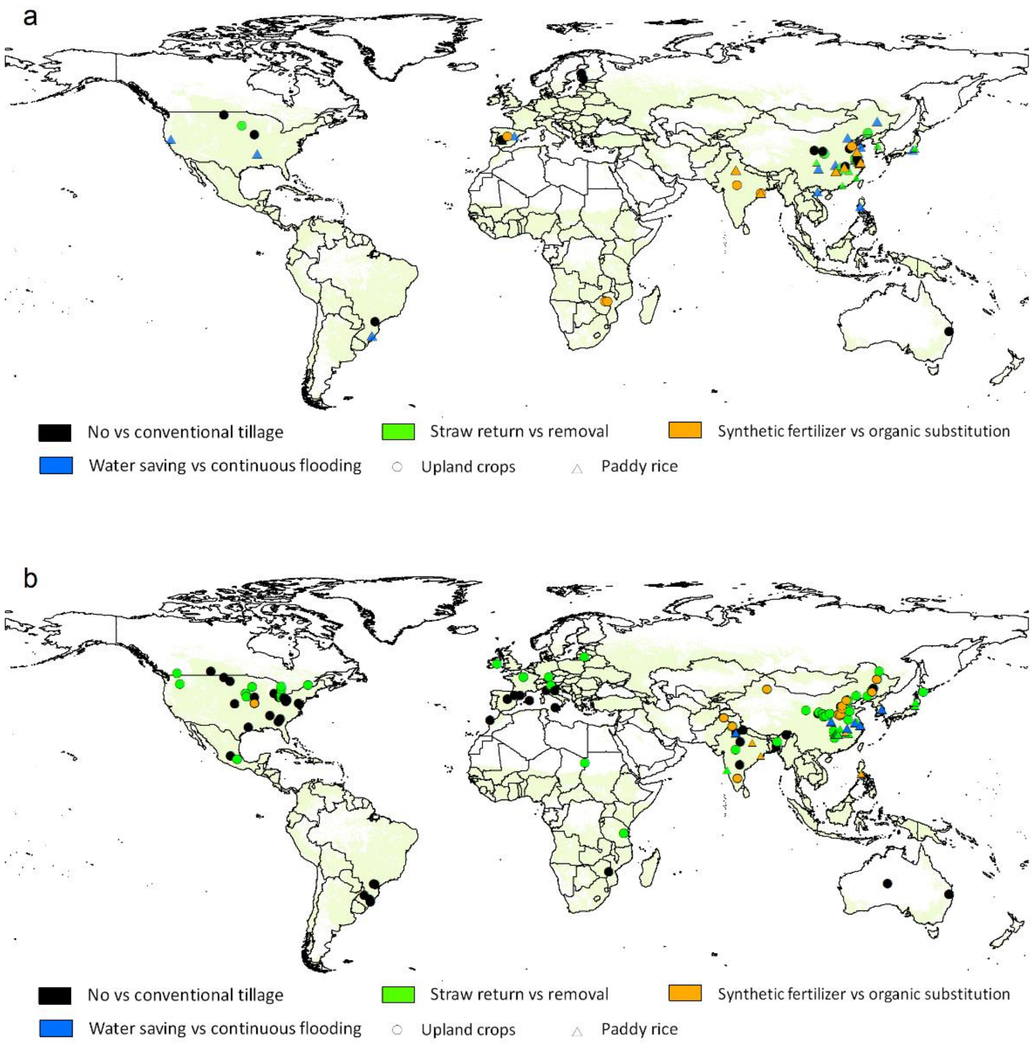

Figure S1. Map showing the locations of experimental sites for (a) non-CO_2 GHG (CH_4 and N_2O) emissions and crop yield and (b) SOC sequestration rate (SOCSR). The dataset contains 437 pairs of treatment and control observations of non-CO_2 GHG emissions and yield at 68 sites, and 412 pairs of SOCSR at 130 sites. Green area represents global croplands.

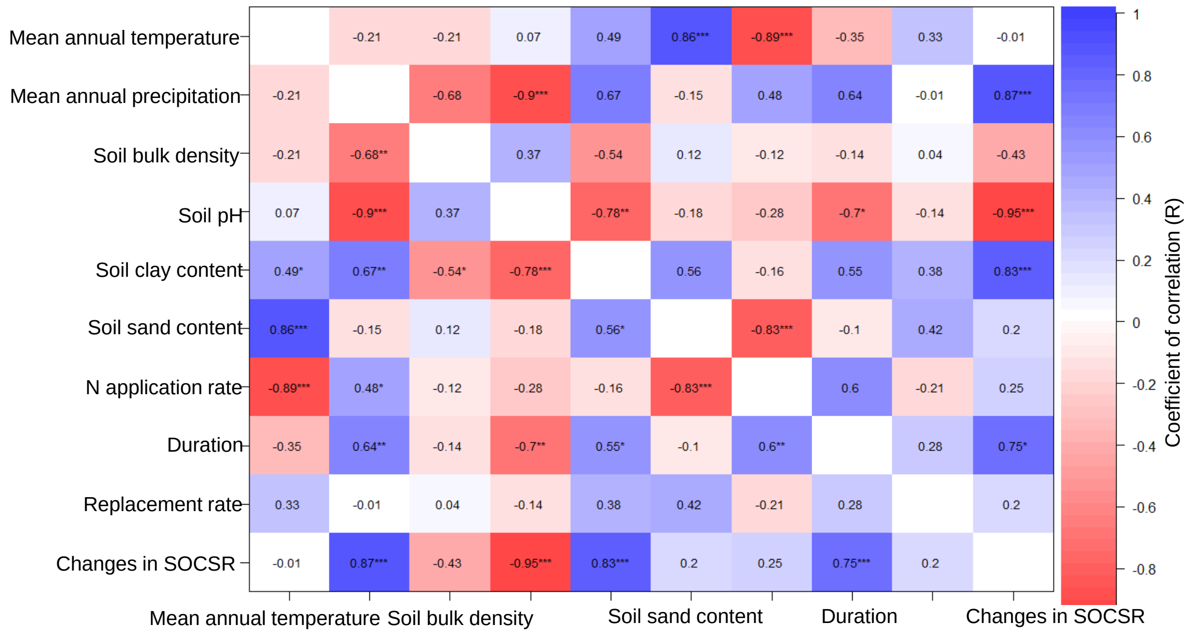

Figure S2. Correlation between variables for the replacement of synthetic fertilizer N with organic sources. Asterisks indicate significant differences from zero (***p< 0.001; **p < 0.01; *p<0.05)

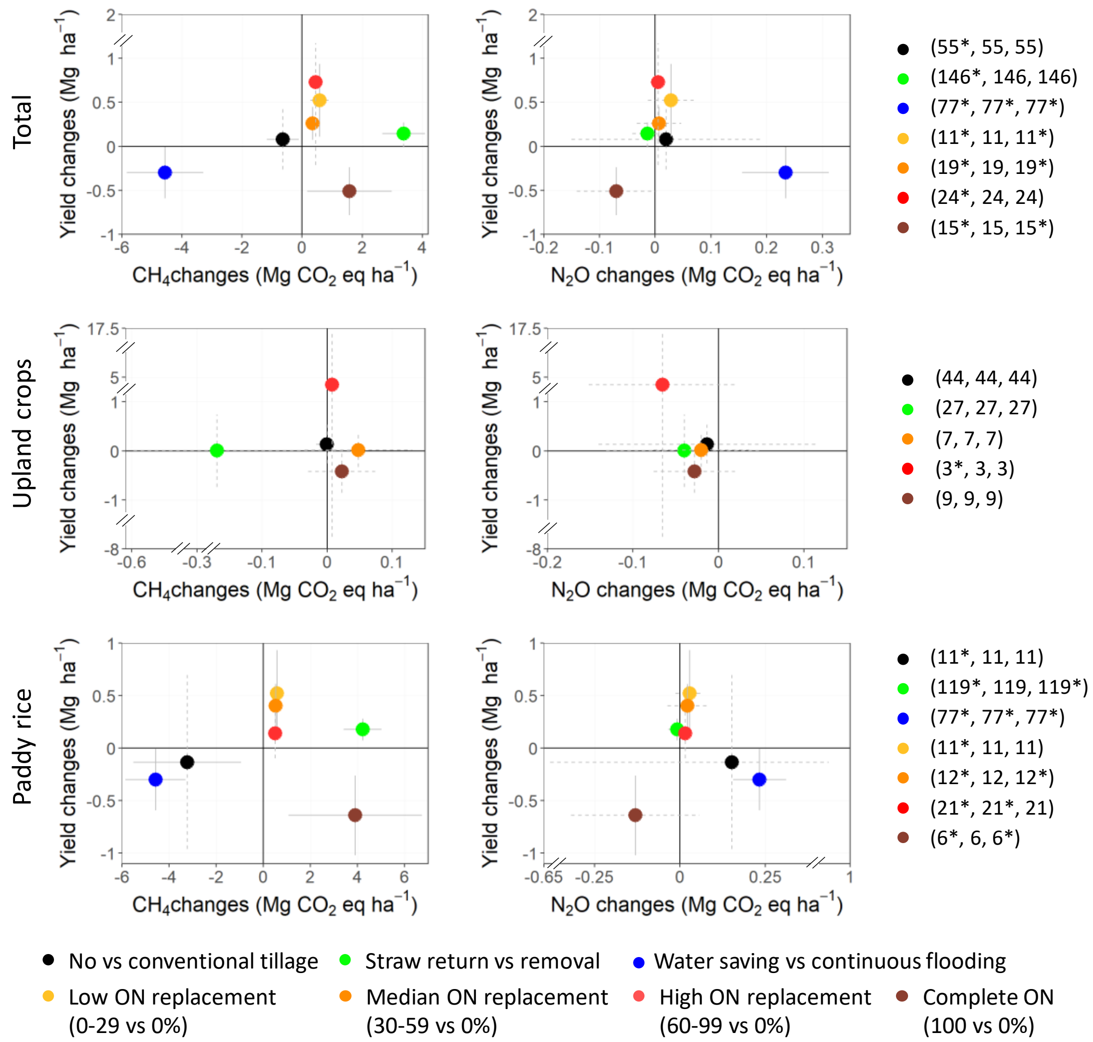

Figure S3. Overall effects of individual conversion of agricultural practices on CH_4 and N_2O emissions and crop yields. Data is presented as absolute mean difference between altered and conventional practices, with 95% confidence intervals (CIs) as error bars, and number of observations noted in parentheses, for CH_4 (left), N_2O (middle) and crop yields (right). The effects are significant when the 95% CIs do not overlap with zero. Asterisks and solid error bars represent significant, and dashed bars indicate the insignificances.

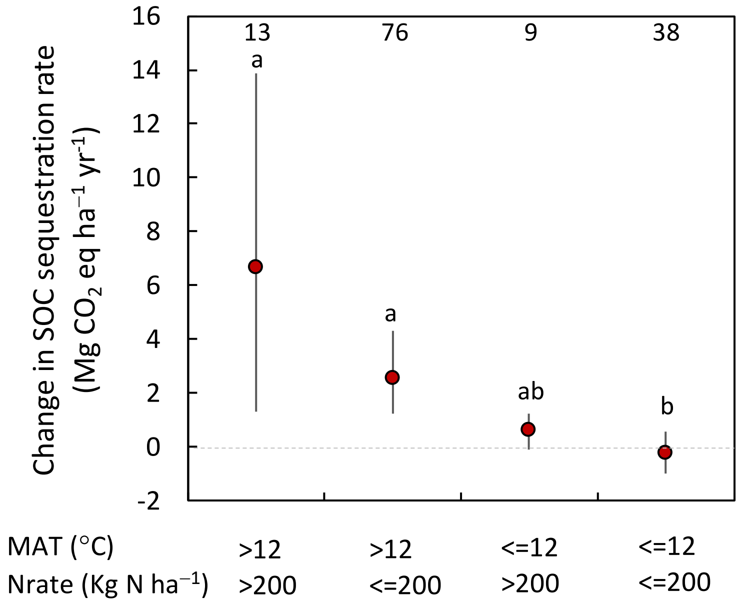

Figure S4. Response of the effect on SOC sequestration rate to mean annual air temperature (MAT) and fertilizer N application rate (Nrate), by no-tillage conversion from conventional tillage. Data is presented as absolute mean difference between altered and conventional practices, with 95% confidence intervals (CIs) as error bars, and number of observations at the top. Different letters indicate significant differences between groups of MAT and Nrate.

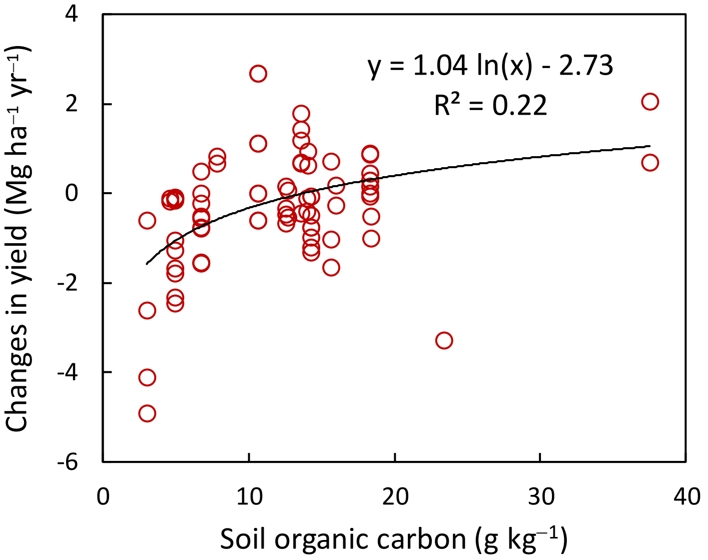

Figure S5. Relationship between soil organic carbon content and change in rice yield by conversion to water saving irrigation from continuous flooding.

Table S1. Variable descriptions of cropland GHG emissions and yield collected.

Category	Variable	Type	Unit
Emissions	CH_4 emissions	Continuous	Mg CH_4 ha^{-1}
	N_2O emissions	Continuous	Mg N_2O ha^{-1}
	Soil organic carbon sequestration rate (SOCSR)	Continuous	Mg C ha^{-1}
Yield	Crop yield	Continuous	Mg ha^{-1}
Climatic factors	Mean annual temperature (MAT)	Continuous	°C
	Mean annual precipitation (MAP)	Continuous	mm
Soil attributes	pH	Continuous	-
	Bulk density	Continuous	g cm^{-3}
	Clay content	Continuous	%
	Sand content	Continuous	%
Managements	Crop type	Categorical	-
	Practice type	Categorical	-
	Fertilizer type	Categorical	-
	N fertilizer application rate	Continuous	kg N ha^{-1}
	Duration	Continuous	Days/years

Table S2. Collected references for cropland GHG emissions, yield and conversions of agricultural practices. Each row presents an observation under a certain management practice. X denotes observation available by corresponding reference. + represents paired management practice.

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Fan et al., 2018	China	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	2 years	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	2 years	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	2 years	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	2 years	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	2 years	2 years
Fan et al., 2018	China	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	2 years	2 years
Jin et al., 2017	US	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	4 years	1 year
Jin et al., 2017	US	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	4 years	1 year
Jin et al., 2017	US	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	4 years	1 year
Jin et al., 2017	US	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	4 years	1 year
Jin et al., 2017	US	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	4 years	1 year
Piva et al., 2012	Brazil	Upland crops	Maize	X	X	X	X	X	-	-	-	-	-	-	3.5 years	1 year
Sainju et al., 2014	US	Upland crops	Barley	X	X	X	X	X	-	-	-	-	-	-	6 years	3 years
Sainju et al., 2014	US	Upland crops	Barley	X	X	X	X	X	-	-	-	-	-	-	6 years	3 years
Sainju et al., 2014	US	Upland crops	Barley	X	X	X	X	X	-	-	-	-	-	-	6 years	3 years
Sainju et al., 2014	US	Upland crops	Barley	X	X	X	X	X	-	-	-	-	-	-	6 years	3 years
Tellez-Rio et al., 2017	Spain	Upland crops	Wheat	X	X	X	X	X	-	-	-	-	-	-	2 years	1 year
Tellez-Rio et al., 2017	Spain	Upland crops	Wheat	X	X	X	X	X	-	-	-	-	-	-	2 years	1 year
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	X	X	X	-	-	-	-	-	-	3 years	3 years
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	X	X	X	-	-	-	-	-	-	3 years	3 years
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	X	X	X	-	-	-	-	-	-	3 years	3 years

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	X	X	X	-	-	-	-	-	-	3 years	3 years
Bayer et al., 2014	Brazil	Paddy rice	Paddy rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Bayer et al., 2014	Brazil	Paddy rice	Paddy rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Bayer et al., 2014	Brazil	Paddy rice	Paddy rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Fangueiro et al., 2017	Spain	Paddy rice	Paddy rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Fangueiro et al., 2017	Spain	Paddy rice	Paddy rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Fangueiro et al., 2017	Spain	Paddy rice	Paddy rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Fangueiro et al., 2017	Spain	Upland crops	Aerobic rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Fangueiro et al., 2017	Spain	Upland crops	Aerobic rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Fangueiro et al., 2017	Spain	Upland crops	Aerobic rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
García-Marco et al., 2016	Spain	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
García-Marco et al., 2016	Spain	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Harada et al., 2007	Japan	Paddy rice	Paddy rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Regina and Alakukku 2010	Finland	Upland crops	Barley	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Regina and Alakukku 2010	Finland	Upland crops	Barley	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Regina and Alakukku 2010	Finland	Upland crops	Barley	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Tian et al., 2012	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Tian et al., 2012	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Tian et al., 2013	China	Upland crops	Wheat-maize	X	X	-	X	X	-	-	-	-	-	-	-	1 year
Tian et al., 2013	China	Upland crops	Wheat-maize	X	X	-	X	X	-	-	-	-	-	-	-	1 year
Yao et al., 2013	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Yao et al., 2013	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Yeboah et al., 2016	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Yeboah et al., 2016	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Zhang et al., 2015a	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Zhang et al., 2015a	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Zhang et al., 2015a	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Zhang et al., 2015a	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Zhang et al., 2015c	China	Paddy rice	Paddy rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Zhang et al., 2015c	China	Paddy rice	Paddy rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Zhang et al., 2015c	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Zhang et al., 2015c	China	Upland crops	Wheat	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Zhang et al., 2016c	China	Paddy rice	Paddy rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season
Zhang et al., 2016c	China	Paddy rice	Paddy rice	X	X	-	X	X	-	-	-	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
A′ lvaro-Fuentes et al., 2009	Spain	Upland crops	Barley	-	-	X	-	X	-	-	-	-	-	-	16 years	-
A′ lvaro-Fuentes et al., 2009	Spain	Upland crops	Barley	-	-	X	-	X	-	-	-	-	-	-	16 years	-
A′ lvaro-Fuentes et al., 2012	Spain	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	13 years	-
A′ lvaro-Fuentes et al., 2012	Spain	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	13 years	-
A′ lvaro-Fuentes et al., 2012	Spain	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Barbera et al., 2012	Italy	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	19 years	-
Bayer et al., 2006	Brazil	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	18 years	-
Bayer et al., 2006	Brazil	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	18 years	-
Bayer et al., 2006	Brazil	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	9 years	-
Bayer et al., 2006	Brazil	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	9 years	-
Bayer et al., 2006	Brazil	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Bayer et al., 2006	Brazil	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Ben-Hur Costa et al., 2011	Brazil	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	19 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Ben-Hur Costa et al., 2011	Brazil	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	19 years	-
Bhattacharyya et al., 2008	India	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	4 years	-
Bhattacharyya et al., 2013a	India	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	9 years	-
Buyanovsky et al., 1998	US	Upland crops	Corn	-	-	X	-	X	-	-	-	-	-	-	26 years	-
Campbell et al., 1995	Canada	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	12 years	-
Campbell et al., 1995	Canada	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	12 years	-
Campbell et al., 1996a	Canada	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Campbell et al., 1996a	Canada	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	9 years	-
Campbell et al., 1996b	Canada	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Campbell et al., 1996b	Canada	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	9 years	-
Cavigelli et al., 2018	US	Upland crops	Wheat-corn-legume	-	-	X	-	X	-	-	-	-	-	-	11 years	-
Cavigelli et al., 2018	US	Upland crops	Wheat-corn-legume	-	-	X	-	X	-	-	-	-	-	-	16 years	-
Chen et al., 2015	China	Paddy rice	Paddy rice	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Chen et al., 2015	China	Paddy rice	Paddy rice	-	-	X	-	X	-	-	-	-	-	-	7 years	-
Choudhary et al., 2013	India	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	2 years	-
Choudhary et al., 2013	India	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	2 years	-
Clapp et al., 2000	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Clapp et al., 2000	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Clapp et al., 2000	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Clapp et al., 2000	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	13 years	-
Dendooven et al., 2012	Mexico	Upland crops	Corn-wheat	-	-	X	-	X	-	-	-	-	-	-	19 years	-
Dendooven et al., 2012	Mexico	Upland crops	Corn-wheat	-	-	X	-	X	-	-	-	-	-	-	19 years	-
Dikgwatlhe et al., 2014	China	Upland crops	Wheat-maize	-	-	X	-	X	-	-	-	-	-	-	4 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Dikgwatlhe et al., 2014	China	Upland crops	Wheat-maize	-	-	X	-	X	-	-	-	-	-	-	12 years	-
Dimassi et al., 2014	France	Upland crops	Wheat-maize	-	-	X	-	X	-	-	-	-	-	-	42 years	-
Dimassi et al., 2014	France	Upland crops	Wheat-maize	-	-	X	-	X	-	-	-	-	-	-	42 years	-
Dimassi et al., 2014	France	Upland crops	Wheat-maize	-	-	X	-	X	-	-	-	-	-	-	42 years	-
Dimassi et al., 2014	France	Upland crops	Wheat-maize	-	-	X	-	X	-	-	-	-	-	-	42 years	-
Dixit et al., 2019	India	Upland crops	Soybean-maize	-	-	X	-	X	-	-	-	-	-	-	6 years	-
Dong et al., 2009	China	Upland crops	Wheat–corn	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Dong et al., 2009	China	Upland crops	Wheat–corn	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Farina et al., 2011	Italy	Upland crops	Maize-wheat	-	-	X	-	X	-	-	-	-	-	-	2 years	-
Follett et al., 2005	Mexico	Upland crops	Wheat-corn	-	-	X	-	X	-	-	-	-	-	-	6 years	-
Follett et al., 2005	Mexico	Upland crops	Wheat-corn	-	-	X	-	X	-	-	-	-	-	-	6 years	-
Follett et al., 2005	Mexico	Upland crops	Wheat-corn	-	-	X	-	X	-	-	-	-	-	-	6 years	-
Follett et al., 2005	Mexico	Upland crops	Wheat-legume	-	-	X	-	X	-	-	-	-	-	-	6 years	-
Follett et al., 2005	Mexico	Upland crops	Wheat-legume	-	-	X	-	X	-	-	-	-	-	-	6 years	-
Follett et al., 2005	Mexico	Upland crops	Wheat-legume	-	-	X	-	X	-	-	-	-	-	-	6 years	-
Franzluebbers and Stuedemann	US	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	1 year	-
Franzluebbers and Stuedemann	US	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	2 years	-
Franzluebbers and Stuedemann	US	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Franzluebbers et al., 1995a	US	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	9 years	-
Franzluebbers et al., 1995a	US	Upland crops	Legume	-	-	X	-	X	-	-	-	-	-	-	9 years	-
Franzluebbers et al., 1995b	US	Upland crops	Sorghum-wheat/soybean	-	-	X	-	X	-	-	-	-	-	-	9 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Franzluebbers et al., 1995b	US	Upland crops	Sorghum-wheat/soybean	-	-	X	-	X	-	-	-	-	-	-	9 years	-
Franzluebbers et al., 1995b	US	Upland crops	Wheat/soybean	-	-	X	-	X	-	-	-	-	-	-	9 years	-
Grandy et al., 2006	US	Upland crops	Maize-wheat-soybean	-	-	X	-	X	-	-	-	-	-	-	12 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Gwenzi et al., 2009	Zimbabwe	Upland crops	Wheat-cotton	-	-	X	-	X	-	-	-	-	-	-	6 years	-
Halpern et al., 2010	Canada	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	16 years	-
Halpern et al., 2010	Canada	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	16 years	-
He et al., 2019	China	Upland crops	Unkown	-	-	X	-	X	-	-	-	-	-	-	10 years	-
Hernanz et al., 2009	Spain	Upland crops	Winter wheat-legume	-	-	X	-	X	-	-	-	-	-	-	20 years	-
Ji et al., 2010	China	Paddy rice	Unkown	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Ji et al., 2010	China	Paddy rice	Unkown	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Lo′ pez-Fando and Pardo 2011	Spain	Upland crops	Barley/legume	-	-	X	-	X	-	-	-	-	-	-	16 years	-
Maas et al., 2017	US	Upland crops	Corn-soybean	-	-	X	-	X	-	-	-	-	-	-	44 years	-
Maas et al., 2017	US	Upland crops	Corn-soybean	-	-	X	-	X	-	-	-	-	-	-	37 years	-
Maillard et al., 2018	Canada	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	29 years	-
Mazzoncini et al., 2016	Italy	Upland crops	Wheat-soybean	-	-	X	-	X	-	-	-	-	-	-	30 years	-
Mikha et al., 2018	US	Upland crops	Wheat-sorghum	-	-	X	-	X	-	-	-	-	-	-	50 years	-
Mikha et al., 2018	US	Upland crops	Wheat-sorghum	-	-	X	-	X	-	-	-	-	-	-	50 years	-
Mikha et al., 2018	US	Upland crops	Wheat-sorghum	-	-	X	-	X	-	-	-	-	-	-	50 years	-
Mrabet et al., 2001	Morocco	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	11 years	-
Page et al., 2013	Australia	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	27 years	-
Page et al., 2013	Australia	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	27 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
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		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Page et al., 2013	Australia	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	27 years	-
Page et al., 2013	Australia	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	27 years	-
Page et al., 2013	Australia	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Page et al., 2013	Australia	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	26 years	-
Peterson et al., 1998	US	Upland crops	Wheat	-	-	X	-	X	-	-	-	-	-	-	8 years	-
Peterson et al., 1998	US	Upland crops	Wheat-sunflower	-	-	X	-	X	-	-	-	-	-	-	8 years	-
Pratibh et al., 2016	India	Upland crops	Legume	-	-	X	-	X	-	-	-	-	-	-	4 years	-
Pratibh et al., 2016	India	Upland crops	Legume	-	-	X	-	X	-	-	-	-	-	-	4 years	-
Pratibh et al., 2016	India	Upland crops	Legume	-	-	X	-	X	-	-	-	-	-	-	4 years	-
Qi et al., 2018	China	Paddy rice	Paddy rice	-	-	X	-	X	-	-	-	-	-	-	10 years	-
Qi et al., 2018	China	Paddy rice	Paddy rice	-	-	X	-	X	-	-	-	-	-	-	10 years	-
Sa et al., 2001	Brazil	Upland crops	Wheat-legume	-	-	X	-	X	-	-	-	-	-	-	22 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2002	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Sainju et al., 2006	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	3 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Sainju et al., 2006	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Sainju et al., 2006	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Sainju et al., 2006	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Sainju et al., 2006	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Sainju et al., 2006	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Sainju et al., 2006	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Sainju et al., 2006	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Sainju et al., 2008	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	10 years	-
Sainju et al., 2008	US	Upland crops	Mix	-	-	X	-	X	-	-	-	-	-	-	10 years	-
Shrestha et al., 2009	US	Upland crops	Grass–legume	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Shrestha et al., 2009	US	Upland crops	Grass–legume	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Shrestha et al., 2009	US	Upland crops	Grass–legume	-	-	X	-	X	-	-	-	-	-	-	5 years	-
Tian et al., 2016	China	Upland crops	Wheat-maize	-	-	X	-	X	-	-	-	-	-	-	10 years	-
Tian et al., 2016	China	Upland crops	Wheat-maize	-	-	X	-	X	-	-	-	-	-	-	10 years	-
Veloso et al., 2018	Brazil	Upland crops	Oat/maize	-	-	X	-	X	-	-	-	-	-	-	29 years	-
Veloso et al., 2018	Brazil	Upland crops	Vetch/maize	-	-	X	-	X	-	-	-	-	-	-	29 years	-
Veloso et al., 2018	Brazil	Upland crops	Oat-vetch/maize-cowpea	-	-	X	-	X	-	-	-	-	-	-	29 years	-
Veloso et al., 2018	Brazil	Upland crops	Oat/maize	-	-	X	-	X	-	-	-	-	-	-	29 years	-
Veloso et al., 2018	Brazil	Upland crops	Vetch/maize	-	-	X	-	X	-	-	-	-	-	-	29 years	-
Veloso et al., 2018	Brazil	Upland crops	Oat-vetch/maize-cowpea	-	-	X	-	X	-	-	-	-	-	-	29 years	-
Wang et al., 2018a	China	Upland crops	Wheat-maize	-	-	X	-	X	-	-	-	-	-	-	8 years	-
Yadav et al., 2017	India	Upland crops	Maize	-	-	X	-	X	-	-	-	-	-	-	6 years	-
Yadav et al., 2019	India	Paddy rice	Paddy rice	-	-	X	-	X	-	-	-	-	-	-	3 years	-
Yadav et al., 2019	India	Upland crops	Aerobic rice	-	-	X	-	X	-	-	-	-	-	-	3 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Zhang et al., 2019	China	Upland crops	Maize–soybean	-	-	X	-	X	-	-	-	-	-	-	12 years	-
Zhang et al., 2019	China	Upland crops	Maize–soybean	-	-	X	-	X	-	-	-	-	-	-	12 years	-
Zhao et al., 2013	China	Upland crops	Maize-wheat	-	-	X	-	X	-	-	-	-	-	-	8 years	-
Zhao et al., 2013	China	Upland crops	Maize-wheat	-	-	X	-	X	-	-	-	-	-	-	8 years	-
Zhao et al., 2013	China	Upland crops	Maize-wheat	-	-	X	-	X	-	-	-	-	-	-	8 years	-
Zhao et al., 2013	China	Upland crops	Maize-wheat	-	-	X	-	X	-	-	-	-	-	-	8 years	-
Zhao et al., 2013	China	Upland crops	Maize-wheat	-	-	X	-	X	-	-	-	-	-	-	4 years	-
Jiang et al., 2017	China	Upland crops	Maize	X	X	X	X	-	X	-	-	-	-	-	5 years	1 growing season
Jiang et al., 2017	China	Upland crops	Maize	X	X	X	X	-	X	-	-	-	-	-	5 years	1 growing season
Liu et al., 2016a	China	Paddy rice	Paddy rice	X	X	X	X	-	X	-	-	-	-	-	3 years	1 growing season
Liu et al., 2016a	China	Paddy rice	Paddy rice	X	X	X	X	-	X	-	-	-	-	-	3 years	1 growing season
Liu et al., 2016b	China	Paddy rice	Paddy rice	X	X	X	X	-	X	-	-	-	-	-	1 year	3 years
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	X	X	-	X	-	-	-	-	-	3 years	3 years
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	X	X	-	X	-	-	-	-	-	3 years	3 years
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	X	X	-	X	-	-	-	-	-	3 years	3 years
Zhang et al., 2017	China	Upland crops	Wheat-maize	X	X	X	X	-	X	-	-	-	-	-	2 years	2 years
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	X	X	-	X	-	-	-	-	-	3 years	3 years
Bhatia et al., 2005	India	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Cui et al., 2017	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	X	-	-	-	-	-	-	1 year

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	X	-	-	-	-	-	-	2 years
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	X	-	-	-	-	-	-	2 years
Gupta et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Gupta et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Hang et al., 2014	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Hang et al., 2014	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Hang et al., 2014	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Hang et al., 2014	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Hang et al., 2014	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Hang et al., 2014	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Htun et al., 2017	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Htun et al., 2017	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Hu et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Hu et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Hu et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Hu et al., 2016	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Hu et al., 2016	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season

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								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Hu et al., 2016	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Jiang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Kim et al., 2014	South Korea	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Kim et al., 2014	South Korea	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Koyama et al., 2015	Japan	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Lehman et al., 2016	US	Upland crops	Maize	X	X	-	X	-	X	-	-	-	-	-	-	4 years
Liu et al., 2016b	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
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		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Ma et al., 2009	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Ma et al., 2009	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Ma et al., 2009	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Ma et al., 2009	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Ma et al., 2009	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Ma et al., 2009	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Qin et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Qin et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Qin et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Qin et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Qin et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Qin et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Qin et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Qin et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Qin et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Samoy-Pascual et al., 2019	Philippines	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Shen et al., 2014	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Shen et al., 2014	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Shen et al., 2014	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Shen et al., 2014	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Wang et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Wang et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Wang et al., 2017	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Wang et al., 2018d	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Wang et al., 2018d	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Wang et al., 2018d	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Xiong et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Xiong et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Xiong et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Xiong et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Xiong et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Xiong et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Xu et al., 2017a	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Xu et al., 2017a	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Xu et al., 2017b	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Xu et al., 2017b	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2017b	China	Upland crops	Maize	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2017b	China	Upland crops	Maize	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Yang et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 year
Yao et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yao et al., 2013	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yao et al., 2013	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yeboah et al., 2016	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Yeboah et al., 2016	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015a	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015a	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015a	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015a	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015a	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015a	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Zhang et al., 2015a	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015a	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015b	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015b	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015b	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015c	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015c	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015c	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Zhang et al., 2015c	China	Upland crops	Wheat	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Wang et al., 2017	China	Paddy rice	Paddy rice	X	X	-	X	-	X	-	-	-	-	-	-	1 growing season
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Allmaras et al., 2004	US	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Aulakh et al., 2001	India	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Aulakh et al., 2001	India	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Aulakh et al., 2001	India	Upland crops	Wheat	-	-	X	-	-	X	-	-	-	-	-	4 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Bhattacharyya et al., 2012	India	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	6 years	-
Bista et al., 2016	US	Upland crops	Wheat	-	-	X	-	-	X	-	-	-	-	-	80 years	-
Campbell et al., 1998	Canada	Upland crops	Wheat	-	-	X	-	-	X	-	-	-	-	-	10 years	-
Cassman et al., 1996	Philippines	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	11 years	-
Cassman et al., 1996	Philippines	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	9.5 years	-
Chen et al., 2015	China	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Chen et al., 2015	China	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	7 years	-
Cheng et al., 2017	China	Paddy rice	Unkown	-	-	X	-	-	X	-	-	-	-	-	31 years	-
Clapp et al., 2000	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Clapp et al., 2000	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Clapp et al., 2000	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Clapp et al., 2000	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Cong et al., 2014	China	Upland crops	Corn-wheat	-	-	X	-	-	X	-	-	-	-	-	16 years	-
Cong et al., 2014	China	Upland crops	Corn-wheat	-	-	X	-	-	X	-	-	-	-	-	20 years	-
Cong et al., 2014	China	Upland crops	Corn-wheat	-	-	X	-	-	X	-	-	-	-	-	20 years	-
Dendooven et al., 2012	Mexico	Upland crops	Corn-wheat	-	-	X	-	-	X	-	-	-	-	-	19 years	-
Dendooven et al., 2012	Mexico	Upland crops	Corn-wheat	-	-	X	-	-	X	-	-	-	-	-	19 years	-
Dikgwatlhe et al., 2014	China	Upland crops	Wheat-maize	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Dikgwatlhe et al., 2014	China	Upland crops	Wheat-maize	-	-	X	-	-	X	-	-	-	-	-	12 years	-
Dimassi et al., 2014	France	Upland crops	Wheat-maize	-	-	X	-	-	X	-	-	-	-	-	42 years	-
Dimassi et al., 2014	France	Upland crops	Wheat-maize	-	-	X	-	-	X	-	-	-	-	-	42 years	-
Dimassi et al., 2014	France	Upland crops	Wheat-maize	-	-	X	-	-	X	-	-	-	-	-	42 years	-
Dimassi et al., 2014	France	Upland crops	Wheat-maize	-	-	X	-	-	X	-	-	-	-	-	42 years	-
Dong et al., 2009	China	Upland crops	Wheat–corn	-	-	X	-	-	X	-	-	-	-	-	5 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Dou et al., 2016	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	25 years	-
Fan et al., 2008	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	26 years	-
Fan et al., 2018	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	2 years	-
Fan et al., 2018	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	2 years	-
Feiziene et al., 2018	Lithuania	Upland crops	Wheat-barley	-	-	X	-	-	X	-	-	-	-	-	17 years	-
Feiziene et al., 2018	Lithuania	Upland crops	Wheat-barley	-	-	X	-	-	X	-	-	-	-	-	17 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Guzman and Al-Kaisi 2014	US	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Halpern et al., 2010	Canada	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	16 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Halpern et al., 2010	Canada	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	16 years	-
Heitkamp et al., 2012	Germany	Upland crops	Maize-wheat-barley	-	-	X	-	-	X	-	-	-	-	-	21 years	-
Heitkamp et al., 2012	Germany	Upland crops	Maize-wheat-barley	-	-	X	-	-	X	-	-	-	-	-	21 years	-
Heitkamp et al., 2012	Germany	Upland crops	Maize-wheat-barley	-	-	X	-	-	X	-	-	-	-	-	21 years	-
Heitkamp et al., 2012	Germany	Upland crops	Maize-wheat-barley	-	-	X	-	-	X	-	-	-	-	-	21 years	-
Heitkamp et al., 2012	Germany	Upland crops	Maize-wheat-barley	-	-	X	-	-	X	-	-	-	-	-	21 years	-
Heitkamp et al., 2012	Germany	Upland crops	Maize-wheat-barley	-	-	X	-	-	X	-	-	-	-	-	21 years	-
Hua et al., 2014	China	Upland crops	Wheat-soybean	-	-	X	-	-	X	-	-	-	-	-	29 years	-
Huang et al., 2013	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	6 years	-
Huang et al., 2013	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	6 years	-
Huang et al., 2013	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	6 years	-
Huang et al., 2018	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	7 years	-
Huang et al., 2018	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	7 years	-
Huang et al., 2018	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	7 years	-
Jacinthe and Lal 2003	US	Upland crops	Wheat	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Jacinthe and Lal 2003	US	Upland crops	Wheat	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Jacinthe and Lal 2003	US	Upland crops	Wheat	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Jacinthe and Lal 2003	US	Upland crops	Wheat	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Ji et al., 2010	China	Paddy rice	Unkown	-	-	X	-	-	X	-	-	-	-	-	28 years	-
Ji et al., 2010	China	Paddy rice	Unkown	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Ji et al., 2010	China	Paddy rice	Unkown	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Kaur et al., 2008	India	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	14 years	-
Kaur et al., 2008	India	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	14 years	-
Koga and Tsuji 2009	Japan	Upland crops	Mix-legume	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Liu et al., 2014	China	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	11 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Liu et al., 2014	China	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	21 years	-
Liu et al., 2014	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	11 years	-
Liu et al., 2014	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	11 years	-
Liu et al., 2019	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	14 years	-
Liu et al., 2019	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	14 years	-
Liu et al., 2019	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	14 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	5 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	5 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	5 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	5 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	5 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	5 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	5 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	5 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	5 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	10 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	10 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	10 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	10 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	10 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	10 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	10 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	10 years	-
Lou et al., 2011	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	10 years	-
Meena et al., 2019	India	Upland crops	Maize-chickpea	-	-	X	-	-	X	-	-	-	-	-	5 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Poeplau et al., 2017	Italy	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	40 years	-
Poeplau et al., 2017	Italy	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	40 years	-
Poeplau et al., 2017	Italy	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	40 years	-
Poeplau et al., 2017	Italy	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	40 years	-
Poeplau et al., 2017	Italy	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	40 years	-
Qi et al., 2018	China	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	10 years	-
Ramdas et al., 2016	India	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	5 years	-
Saha and Ghosh	India	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Shirato et al., 2011	Japan	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	37 years	-
Srinivasarao et al., 2012b	India	Upland crops	Soybean-safflower	-	-	X	-	-	X	-	-	-	-	-	15 years	-
Srinivasarao et al., 2012b	India	Upland crops	Soybean-safflower	-	-	X	-	-	X	-	-	-	-	-	15 years	-
Sugihara et al., 2012	Tanzania	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Sugihara et al., 2012	Tanzania	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Sugihara et al., 2012	Tanzania	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Sugihara et al., 2012	Tanzania	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	3 years	-
Tong et al., 2014	China	Upland crops	Wheat-maize	-	-	X	-	-	X	-	-	-	-	-	17 years	-
van Groenigen et al., 2011	Ireland	Upland crops	Wheat	-	-	X	-	-	X	-	-	-	-	-	9 years	-
van Groenigen et al., 2011	Ireland	Upland crops	Wheat	-	-	X	-	-	X	-	-	-	-	-	9 years	-
Wang et al., 2018a	China	Upland crops	Wheat-maize	-	-	X	-	-	X	-	-	-	-	-	8 years	-
Wang et al., 2018b	China	Upland crops	Wheat/soybean	-	-	X	-	-	X	-	-	-	-	-	33 years	-
Wang et al., 2018b	China	Upland crops	Wheat/maize/soybean	-	-	X	-	-	X	-	-	-	-	-	21 years	-
Wang et al., 2018b	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	18 years	-
Yao et al., 2018	China	Upland crops	Legume	-	-	X	-	-	X	-	-	-	-	-	4 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Zhang et al., 2010	China	Upland crops	Maize	-	-	X	-	-	X	-	-	-	-	-	15 years	-
Zhang et al., 2010	China	Upland crops	Wheat/maize	-	-	X	-	-	X	-	-	-	-	-	15 years	-
Zhang et al., 2010	China	Upland crops	Wheat/maize	-	-	X	-	-	X	-	-	-	-	-	15 years	-
Zhang et al., 2012	China	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	26 years	-
Zhang et al., 2012	China	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	26 years	-
Zhang et al., 2012	China	Paddy rice	Paddy rice	-	-	X	-	-	X	-	-	-	-	-	26 years	-
Zhang et al., 2015b	China	Upland crops	Corn–millet–corn–millet	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Zhang et al., 2015b	China	Upland crops	Corn–millet–corn–millet	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Zhang et al., 2015b	China	Upland crops	Corn–millet–corn–millet	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	8 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	8 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	8 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	8 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	13 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	18 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	18 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	18 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	18 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	22 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	22 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	22 years	-
Zhang et al., 2016b	China	Upland crops	Unkown	-	-	X	-	-	X	-	-	-	-	-	22 years	-
Zhao et al., 2013	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	4 years	-
Zhao et al., 2013	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	24 years	-
Zhao et al., 2013	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	24 years	-
Zhao et al., 2018	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	7 years	-
Zhao et al., 2018	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	7 years	-
Zhao et al., 2018	China	Upland crops	Maize-wheat	-	-	X	-	-	X	-	-	-	-	-	7 years	-
Camargo et al., 2018	Brazil	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Camargo et al., 2018	Brazil	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Dong et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Dong et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Dong et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Dong et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Dong et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Dong et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Dong et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Dong et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Gupta et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Gupta et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kreye et al., 2007	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kreye et al., 2007	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kreye et al., 2007	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kreye et al., 2007	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kumar et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kumar et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kumar et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kumar et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kumar et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kumar et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kumar et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kumar et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kumar et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Kumar et al., 2016	India	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
LaHue et al., 2016	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
LaHue et al., 2016	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
LaHue et al., 2016	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
LaHue et al., 2016	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
LaHue et al., 2016	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 year
LaHue et al., 2016	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 year
LaHue et al., 2016	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 year
LaHue et al., 2016	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 year
Li et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Li et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Li et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Li et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Li et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Li et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Linquist et al., 2015	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Linquist et al., 2015	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Linquist et al., 2015	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Linquist et al., 2015	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Linquist et al., 2015	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Linquist et al., 2015	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Linquist et al., 2015	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Linquist et al., 2015	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Linquist et al., 2015	US	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Maris et al., 2016	Spain	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Pandey et al., 2014	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Pandey et al., 2014	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Pandey et al., 2014	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Pandey et al., 2014	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Samoy-Pascual et al., 2019	Philippines	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Samoy-Pascual et al., 2019	Philippines	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Su et al., 2017	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Su et al., 2017	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Su et al., 2017	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Wang et al., 2017	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Wang et al., 2017	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Wang et al., 2018c	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Wang et al., 2018c	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Win et al., 2015	Japan	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Win et al., 2015	Japan	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Xu et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Xu et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Xu et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Xu et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Xu et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Xu et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Xu et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Xu et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Yang et al., 2019	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Yang et al., 2019	China	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Zschornack et al., 2016	Brazil	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Zschornack et al., 2016	Brazil	Paddy rice	Paddy rice	X	X	-	X	-	-	X	-	-	-	-	-	1 growing season
Fangueiro et al., 2017	China	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	2 years	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Haque et al, 2017	South Korea	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Haque et al, 2017	South Korea	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Haque et al, 2017	South Korea	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Haque et al, 2017	South Korea	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Li et al., 2016	China	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Li et al., 2016	China	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Li et al., 2016	China	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Qu et al., 2012	China	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	7 years	-
Qu et al., 2012	China	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	7 years	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Xu et al., 2013	China	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	1 year	-
Xu et al., 2017c	China	Paddy rice	Paddy rice	-	-	X	-	-	-	X	-	-	-	-	3 years	-
Bhattacharyya et al., 2012	India	Paddy rice	Paddy rice	X	X	X	X	-	-	-	X	-	-	-	4 years	3 years
Bhattacharyya et al., 2012	India	Paddy rice	Paddy rice	X	X	X	X	-	-	-	X	-	-	-	4 years	3 years
Bhatia et al., 2005	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Bhatia et al., 2005	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Bhatia et al., 2005	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Das and Adhya 2014	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Das and Adhya 2014	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Das and Adhya 2014	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Dash et al., 2017	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Dash et al., 2017	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Dash et al., 2017	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Dash et al., 2017	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Dash et al., 2017	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Dash et al., 2017	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Dash et al., 2017	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Dash et al., 2017	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Guardia et al., 2017	Spain	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 year
Guardia et al., 2017	Spain	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 year
Lenka et al., 2017	India	Upland crops	Wheat	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Lenka et al., 2017	India	Upland crops	Wheat	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Liang et al., 2013	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mohanty et al., 2017	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mohanty et al., 2017	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mohanty et al., 2017	India	Upland crops	Aerobic rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Mohanty et al., 2017	India	Upland crops	Aerobic rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Shi et al., 2014	China	Upland crops	Maize	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Sun et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Sun et al., 2018	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Tang et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Tang et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Tang et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Tang et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Tang et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Tang et al., 2016	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Zhang et al., 2016c	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Zhang et al., 2016c	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Zhang et al., 2016c	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Zhang et al., 2016c	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Zhao et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Zhao et al., 2015	China	Paddy rice	Paddy rice	X	X	-	X	-	-	-	X	-	-	-	-	1 growing season
Brar et al.,2015	India	Upland crops	Wheat-maize	-	-	X	-	-	-	-	X	-	-	-	36 years	-
Buyanovsky et al., 1998	US	Upland crops	Wheat	-	-	X	-	-	-	-	X	-	-	-	26 years	-
Buyanovsky et al., 1998	US	Upland crops	Corn	-	-	X	-	-	-	-	X	-	-	-	26 years	-
Cai and Qin 2006	China	Upland crops	Wheat-maize	-	-	X	-	-	-	-	X	-	-	-	15 years	-
Cai and Qin 2006	China	Upland crops	Wheat-maize	-	-	X	-	-	-	-	X	-	-	-	15 years	-
Cassman et al., 1996	Philippines	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	11 years	-
Cassman et al., 1996	Philippines	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	9.5 years	-
Chen et al., 2017	China	Upland crops	Maize	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Chen et al., 2017	China	Upland crops	Maize	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Chen et al., 2017	China	Upland crops	Maize	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Chen et al., 2017	China	Upland crops	Maize	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Fan et al., 2014	China	Upland crops	Maize-wheat	-	-	X	-	-	-	-	X	-	-	-	20 years	-
Fan et al., 2014	China	Upland crops	Maize-wheat	-	-	X	-	-	-	-	X	-	-	-	20 years	-
Prasad et al., 2016	India	Upland crops	Millet-legume	-	-	X	-	-	-	-	X	-	-	-	10 years	-
Prasad et al., 2016	India	Upland crops	Millet-legume	-	-	X	-	-	-	-	X	-	-	-	10 years	-
Shahzad et al., 2017	Pakistan	Upland crops	Maize	-	-	X	-	-	-	-	X	-	-	-	1 year	-

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Shahzad et al., 2017	Pakistan	Upland crops	Maize	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Shahzad et al., 2017	Pakistan	Upland crops	Maize	-	-	X	-	-	-	-	X	-	-	-	2 years	-
Shahzad et al., 2017	Pakistan	Upland crops	Maize	-	-	X	-	-	-	-	X	-	-	-	2 years	-
Srinivasarao et al., 2012a	India	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	21 years	-
Srinivasarao et al., 2012a	India	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	21 years	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Tripathy and Singh 2004	India	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	1 year	-
Zhang et al., 2010	China	Upland crops	Maize	-	-	X	-	-	-	-	X	-	-	-	15 years	-
Zhang et al., 2010	China	Upland crops	Wheat/maize	-	-	X	-	-	-	-	X	-	-	-	15 years	-
Zhang et al., 2010	China	Upland crops	Wheat/maize	-	-	X	-	-	-	-	X	-	-	-	15 years	-
Zhang et al., 2010	China	Upland crops	Wheat/maize	-	-	X	-	-	-	-	X	-	-	-	15 years	-
Zhang et al., 2012	China	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	24 years	-
Zhang et al., 2012	China	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	24 years	-
Zhang et al., 2012	China	Paddy rice	Paddy rice	-	-	X	-	-	-	-	X	-	-	-	24 years	-
Zhang et al., 2016a	China	Upland crops	Maize-wheat	-	-	X	-	-	-	-	X	-	-	-	15 years	-
Zhang et al., 2016a	China	Upland crops	Maize-wheat	-	-	X	-	-	-	-	X	-	-	-	15 years	-
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	-	X	-	1 year

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	-	X	-	1 year
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	-	X	-	1 year
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	-	X	-	1 year
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	-	X	-	3 years
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	-	X	-	3 years
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	-	X	-	3 years
Wang et al., 2011	Austrilia	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	-	X	-	3 years
Sainju et al., 2014	US	Upland crops	Barley	X	X	-	X	-	-	-	-	-	-	X	-	1 year
Sainju et al., 2014	US	Upland crops	Barley	X	X	-	X	-	-	-	-	-	-	X	-	1 year
Sainju et al., 2014	US	Upland crops	Barley	X	X	-	X	-	-	-	-	-	-	X	-	3 years
Sainju et al., 2014	US	Upland crops	Barley	X	X	-	X	-	-	-	-	-	-	X	-	3 years
Sainju et al., 2014	US	Upland crops	Barley	X	X	-	X	-	-	-	-	-	-	X	-	1 year
Sainju et al., 2014	US	Upland crops	Barley	X	X	-	X	-	-	-	-	-	-	X	-	1 year
Sainju et al., 2014	US	Upland crops	Barley	X	X	-	X	-	-	-	-	-	-	X	-	3 years
Sainju et al., 2014	US	Upland crops	Barley	X	X	-	X	-	-	-	-	-	-	X	-	3 years
Yeboah et al., 2016	China	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	X	-	-	1 growing season
Yeboah et al., 2016	China	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	X	-	-	1 growing season
Yeboah et al., 2016	China	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	X	-	-	1 growing season
Yeboah et al., 2016	China	Upland crops	Wheat	X	X	-	X	-	-	-	-	-	X	-	-	1 growing season
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	1 year

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	1 year
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	2 years
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	2 years
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	2 years
Fan et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	-	X	-	-	2 years
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Mapanda et al., 2011	Zimbabwe	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 growing season
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Bhattacharyya et al., 2013b	India	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Barton et al., 2016	Australia	Upland crops	Barley	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Barton et al., 2016	Australia	Upland crops	Barley	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Barton et al., 2016	Australia	Upland crops	Barley	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Barton et al., 2016	Australia	Upland crops	Barley	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Mukumbuta et al., 2017	Japan	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year

Reference	Country	Crop		Variables				Management practices							Durations	
								Individual				Paired				
		Category	Type	CH_4	N_2O	SOCSR	Yield	No-tillage	Straw return	Intermittent irrigation	SN replacements by ON	SN +ON	No-tillage +straw return	No-tillage +SN	SOCSR	Non-CO2 GHG&yield
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Trinh et al., 2017	Vietnam	Paddy rice	Paddy rice	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year
Afreh et al., 2018	China	Upland crops	Maize	X	X	-	X	-	-	-	-	X	-	-	-	1 year

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