Table 3. Validation results (pixel counts) for remotely sensed classes of cropping patterns compared to the collective pool of all field datasets. Overall accuracy was 85.6%.

Remotely sensed classes	Field data			Row total	User's accuracy
	Single cropping	Double cropping	Noncropland		
Single cropping	47	16	50	113	41.6%
Double cropping	26	163	4	193	84.5%
Not row crop	0	4	383	387	99.0%
Column total	73	183	437	693	
Producer's accuracy	64.4%	89.1%	87.7%		

for corn as a secondary crop is 34.3 kg N ha^{-1} (Broch and Pedroso 2008; Broch and Pedroso 2009; Cerri et al. 2007; Cruz et al. 2005; Edgar 2007; de Carvalho et al. 2008; Galford 2010; Mar et al. 2003; Souza and Sorrato 2006). For this work, we used the average fertilizer rate (34 kg N ha^{-1}) for second crops and included a high (75 kg N ha^{-1}) and low range (0 kg N ha^{-1}) in our sensitivity analysis. We then used the area in single and double crops to estimate greenhouse gas emissions (in CO_2-e) associated with fertilizer N_2O losses (GHG_{N2O}),

$$GHG_{N2O} = 0.03 \text{ Fertilizer Area } (44 \text{ g } N_2O/28 \text{ g N}) \text{ GWP}_{N2O}, \quad (2)$$

where 3% of the applied N fertilizer is lost as N_2O (Crutzen et al. 2008; Scanlon and Kiely 2003), fertilizer is the N fertilizer dose in g N ha^{-1} (10 000 g N ha^{-1} for single crop and 34 000 g ha^{-1} for double crop), area is the land area (ha) being fertilized, and GWP_{N2O} is the 100-yr GWP of nitrous oxide (300; Forster et al. 2007).

3. Results

3.1. Remote sensing accuracy

We assessed our accuracy in remote sensing analyses with the comparison of field data using overall accuracy, producer's and user's accuracy, and KAPPA K_{hat} metrics (Table 3). We find that our overall accuracy is 86%. Further accuracy assessments were conducted to better represent the nature of the dataset. The producer's accuracy is a measure of omission by using column totals, and the user's accuracy is a measure of commission using row totals. The KAPPA K_{hat} statistic assesses accuracy while accounting for the off-trace elements from the error matrix. A K_{hat} value close to one is much better than a random classification, zero is random, and negative numbers are worse than random (Jenson 2005). Croplands were detected with producer's accuracy of 98% and user's accuracy of 82%. The K_{hat} for the cropland and noncropland classes was 0.82. For the detection of mechanized agriculture single- and double-cropping land use, producer's and user's accuracies were 64% and 42% for single crops and 89% and 84% for double crops, respectively. The K_{hat} statistic for noncroplands and single- and double-crop classes was 0.74. The field data underrepresent single crops (Table 3), because many of the field sites had no recorded single crops and were not representative of the region, so this may be a bias that causes the validation to suggest that the remote sensing may systematically underestimate the presence of single crops.