Table 2. Farm energy inputs into soybean biodiesel production. Fertilizer application rates are 2002 and 2004 US annual averages (11, 12). Pesticide application rates are 2004 weighted averages of the top 11 soybean producing states (AR, IL, IN, IA, KS, MN, MO, NE, ND, OH, SD) (12).

	Application rate	Production energy		Per hectare energy use		Input energy in biodiesel production *	
	kg/ha	*MJ/kg*		*MJ/ha*		*MJ/L*	
Varietal seed	-	-		420	†	0.77	
Nitrogen	5.7	51.47 ‡	(2, 4, 5)	291		0.53	
Phosphorus	17.2	9.17	(3-5)	158		0.29	
Potash	30.1	5.96	(2-5)	179		0.33	
Lime	-	-		313	§	0.58	
Pesticide	1.2	475 ¶		605		1.11	
Fossil fuel	-	-		3,361 ‖		6.18	
Farm capital	-	-		769	(Table 3)	1.41	
Household	-	-		-		6.79	(Table 4)
Total						17.99	

* The 2000-2004 average yield of the 31 soybean producing states weighted by total production is 2,661 kg/ha (7, 8), and 4.89 kg of soybeans are crushed per liter of biodiesel produced.

† Given a weighted soybean yield of 2,661 kg/ha and a national average seeding rate of 76.1 kg/ha (13), 2.86% of one year's crop can be used to plant the same acreage the next year. We assume that growing, processing, packaging, and transporting soybean seed for planting requires 150% of the energy used to grow soybeans used for feed or industrial purposes (14). We therefore estimate the energy to produce the soybeans needed to plant 1 ha of land as 4.29% the energy to produce 1 ha of soybeans for direct use for feed and fuel (9,791 MJ/ha).

‡ Fertilizer production energy is the same as in corn production.

§ Because we assume corn and soybeans are grown in rotation, we divide the liming energy input between corn and soybeans equally.

¶ In 2004, glyphosate, which requires approximately 475 MJ/kg to produce and distribute (15), accounted for 81% of all pesticide use (12). We assume that the energy to produce glyphosate is similar in all pesticides used in soybean farming; however, this is likely a slight overestimate as glyphosate tends to be more costly in energy terms to produce than other pesticides (2).

‖ Estimates of farm fossil fuel use for truck and tractor use, irrigation, and drying were taken from 2002 ERS-USDA survey data (16) and weighted by average state production. Energy content and average usage rates are as follows: diesel (36.6 MJ/L and 38.4 L/ha), gasoline (32.05 MJ/L and 12.2 L/ha), electricity (3.6 MJ/kWh and 69.4 kWh/ha), natural gas (37.3 MJ/m^3 and 3.7 m^3/ha), and LP gas (25.5 MJ/L and 3.7 L/ha). We also estimate custom work diesel use of 6.6 L/ha (14), and farm-related transportation and personal commute energy use equal to those of corn farming.