Supplemental Information 2: On-farm budgets for soybeans including net income after expenses

Balancing trade-offs in climate-smart agriculture: will selling carbon credits offset potential losses in the net yield income of small-scale soybean (*Glycine max* L.) producers in the mid-southern U.S.?

In this supplement, we provided detailed breakdowns of the expenses related to tillage actions (RT: reduced tillage and NT: no-tillage) and cover crop actions (NC: no cover, RY: rye cover, and RC: rye + clover cover). Action-specific expenses are considered income lost from yield income at the end of the growing season. We also provide a detailed breakdown of net yield income for each combination of tillage and cover crop action to support the results presented in the main work.

The budgets for tillage actions (Tables S2.1 and S2.2) were prepared using the Mississippi State University Extension annual budgets for soybean producers across Mississippi, U.S. (MSU-ES 2019). The budgets were adjusted to reflect the experimental conditions in our study for tillage treatments including potash fertilizer applied by air, three herbicide applications per year including water conditioners and surfactants, and rolling before planting. Expenses reflect different equipment used for RT and NT assuming producers already own all the required equipment.

The budgets for cover crop actions (Table 2.3) were prepared using the United States Department of Agriculture Cover Crop Mix, Seed Coat, and Seeding Rate Calculator for the Mid-South (USDA-NRCS 2021). Finally, the detailed breakdown of net yield income for each combination of actions (Table S2.4) was calculated by subtracting the action-specific expenses from the highest and lowest experimental yield value for the discrete yield categories where: low

yield ranges from 2070.46–2673.74 kg/acre and high yield ranges from 2770.04–3560.68 kg/acre. We converted yield from kg/ha to bushels/acre, calculated the price per bushel based on USD 8.75 per bushel, and then subtracted the action-specific expenses from the yield income.

Literature cited

MSU-ES (2019) *Soybeans 2019 planning budgets* (Mississippi State University Extension Services, Department of Agricultural Economics).

USDA-NRCS (2021) *Plant materials technical note 103: Cover crop mix, seed cost, and seeding rate calculator for field staff* (United States Department of Agriculture Natural Resources Conservation Services, Jamie L. Whitten Plant Materials Center, Coffeeville, Mississippi).

Table S2.1 Estimated total costs for reduced till field operations (USD) per acre soybeans, full-season, long-line, May planted, 12R 30" in the non-Delta are of Mississippi, U.S., in 2019. Costs modified from MUS-Extension (2019) to reflect experimental herbicide and fertilizer use, but all other expenses assumed for a general farm not using cover crops. Direct costs are calculated as operator input + fuel + equipment repairs and maintenance (r&m) + labour + interest on operator capital (int). Total income lost (i.e., utility lost) for reduced till is calculated as direct costs + fixed costs. Product names given in brackets.

operating input		budget							
item	**unit**	**input**	**fuel**	**r&m**	**labour**	**int**	**direct**	**fixed**	**total**
disk with roller	12R-30		1.88	1.1	0.84	0.03	3.85	4.71	8.56
disk (hipper, pass one)	12R-30		1.88	0.85	0.84	0.03	3.6	3.97	7.57
disk (hipper, pass two)	12R-30		1.88	0.85	0.84	0.03	3.6	3.97	7.57
field cultivator	32'		1.18	0.75	0.63	0.03	2.59	4.12	6.71
custom application									
applied by air	acre	6.5				0.07	6.57		6.57
potash (60% K2O)	cwt	20				0.7	20.7		20.7
broadcast one									
applied by spray	60'		0.72	0.36	0.89	0.07	2.04	1.34	3.38
herbicide (Gramoxone)	3 pt	7.2				0.25	7.45		7.45
water conditioner (AMS SuperMaxx)	pt	3.81*				0.05	3.86		3.86
surfactant (Scanner)	pt	1.44				0.05	1.49		1.49
broadcast one									
applied by spray	60'		0.72	0.36	0.89	0.07	2.04	1.34	3.38
herbicide (Makaze)	2 pt	12.80*				0.25	13.05		13.05
broadcast one									

applied by spray	60'		0.72	0.36	0.89	0.07	2.04	1.34	3.38
herbicide (Makaze)	2 pt	12.80*				0.25	13.05		13.05
herbicide (Dual Magnum)	1 pt	13.81				0.41	14.22		14.22
pre-folding	12R-30		1.72	2.32	2.44	0.19	6.67	6.7	13.37
seed drill	30'		1.89	1.87	1.41	0.19	5.36	5.78	11.14
soybean seed	lb	71				2.13	73.13		73.13
seed treatment (CruiserMaxx)	oz	6.85				0.21	7.06		7.06
herbicide (Gramoxone)	2 pt	4.8				0.25	7.45		7.45
water conditioner (AMS SuperMaxx)	pt	3.81**				0.05	3.86		3.86
surfactant (Scanner)	pt	1.44				0.05	1.49		1.49
herbicide (Dual Magnum)	1 pt	13.81				0.41	14.22		14.22
herbicide (Prowl)	2 pt	12.18				0.41	12.59		12.59
soil test	acre	3.33				0.02	3.35		3.35
soybean consultant	acre	6.5				0.2	6.7		6.7
header	25' flex		3.62	4.5	2.76	0.05	10.93	17	27.93
haul	bu	10.8				0.05	10.85		10.85
grain cart	700 bu		0.54	0.33	0.57	0.01	1.45	1.22	2.67
		-215.28	-16.75	-13.65	-13	-6.58	-265.26	-51.49	-316.75

* from Forestry Distributing (forestrydistributing.com)
**2020 price (2019 not available)

Table S2.2 Estimated total costs for no tillage field operations (USD) per acre soybeans, full-season, long-line, May planted, 12R 30" in the non-Delta are of Mississippi, U.S., in 2019. Costs modified from MUS-Extension (2019) to reflect experimental herbicide and fertilizer use, but all other expenses assumed for a general farm not using cover crops. Direct costs are calculated as operator input + fuel + equipment repairs and maintenance (r&m) + labour + interest on operator capital (int). Total income lost (i.e., utility lost) for no tillage is calculated as direct costs + fixed costs. Product names given in brackets.

operating input		budget							
item	**unit**	**input**	**fuel**	**r&m**	**labour**	**int**	**direct**	**fixed**	**total**
roller	30'		1.13	0.45	0.667	0.03	2.28	1.92	4.2
custom application									
applied by air	acre	6.5				0.07	6.57		6.57
potash (60% K2O)	cwt	20				0.7	20.7		20.7
broadcast one									
applied by spray	60'		0.72	0.36	0.89	0.07	2.04	1.34	3.38
herbicide (Gramoxone)	3 pt	7.2				0.25	7.45		7.45
water conditioner (AMS SuperMaxx)	pt	3.81*				0.05	3.86		3.86
surfactant (Scanner)	pt	1.44				0.05	1.49		1.49
broadcast one									
applied by spray	60'		0.72	0.36	0.89	0.07	2.04	1.34	3.38
herbicide (Makaze)	2 pt	12.80*				0.25	13.05		13.05
broadcast one									
applied by sprak	60'		0.72	0.36	0.89	0.07	2.04	1.34	3.38
herbicide (Makaze)	2 pt	12.80*				0.25	13.05		13.05
herbicide (Dual Magnum)	1 pt	13.81				0.41	14.22		14.22

seed drill (no till)	30'		1.97	2.64	1.47	0.19	6.27	8.06	14.33
soybean seed	lb	71				2.13	73.13		73.13
seed treatment (CruiserMaxx)	oz	6.85				0.21	7.06		7.06
herbicide (Gramoxone)	2 pt	4.8				0.25	7.45		7.45
water conditioner (AMS SuperMaxx)	pt	3.81**				0.05	3.86		3.86
surfactant (Scanner)	pt	1.44				0.05	1.49		1.49
herbicide (Dual Magnum)	1 pt	13.81				0.41	14.22		14.22
herbicide (Prowl)	2 pt	12.18				0.41	12.59		12.59
soil test	acre	3.33				0.02	3.35		3.35
soybean consultant	acre	6.5				0.2	6.7		6.7
header	25' flex		3.62	4.5	2.76	0.05	10.93	17	27.93
haul	bu	10.8				0.05	10.85		10.85
grain cart	700 bu		0.54	0.33	0.57	0.01	1.45	1.22	2.67
		-215.28	-9.42	-9	-8.14	-6.3	-248.14	-32.33	-280.36

* from Forestry Distributing (forestrydistributing.com)
**2020 price (2019 not available)

Table S2.3 Estimated costs for cover crops (USD) per acre, planted end-season of the previous year in the non-Delta area of Mississippi, U.S., in 2019. Planting rates (lbs/acre) and seed costs are from USDA (2021).

actions				costs
cover crops		tillage		
mix	lbs/acre	type	seed	income lost
none	0	reduced	0	0
		no	0	0
rye	100	reduced	26	-26
		no	26	-26
rye	50	reduced	13	-25
clover	7.5		12	
		none	13	-25
			12	

Table S2.4 Yield income and net yield income (i.e., utility) for different combinations of tillage and cover crop actions. For each yield range (discrete categories), yield income is calculated as the experimental yield income returned minus expenses (income lost) for the lowest (i.e., low) and highest (i.e., high) values. Yield (kg/ha) was converted into bushels (bu/acre) and then to USD based on the 2019 estimated value of soybeans (USD 8.75). Net yield income is calculated as yield income minus action-specific expenses.

	yield income			net yield income	
yield range	(kg/ha)	(bu/acre)	USD	reduced till	no till
low	2070.46	30.85	269.94	-46.81	-10.42
	2673.74	39.84	348.59	31.84	68.23
high	2770.04	41.27	361.14	44.39	80.78
	3560.68	53.05	464.22	147.47	183.86
low	2070.46	30.85	269.94	-83.95	-47.88
	2673.74	39.84	348.59	-5.3	30.77
high	2770.04	41.27	361.14	7.25	43.32
	3560.68	53.05	464.22	110.33	146.4
low	2070.46	30.85	269.94	-82.95	-46.88
	2673.74	39.84	348.59	-4.3	31.77
high	2770.04	41.27	361.14	8.25	44.32
	3560.68	53.05	464.22	111.33	147.4