

# How does maize-cowpea intercropping maximize land use and economic return? - A field trial in Bangladesh

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## Supporting information

Number of pages - 11

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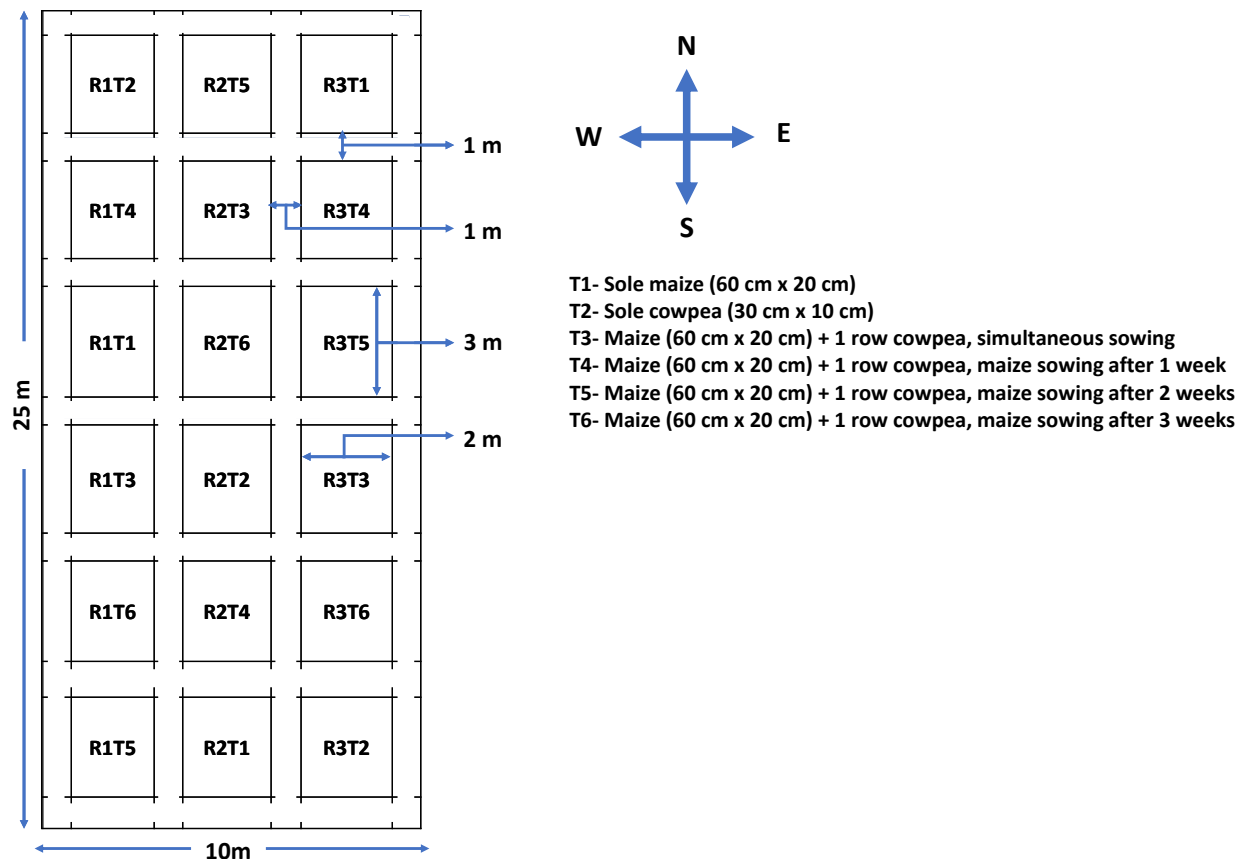


Figure S1: Schematic diagram of experimental design

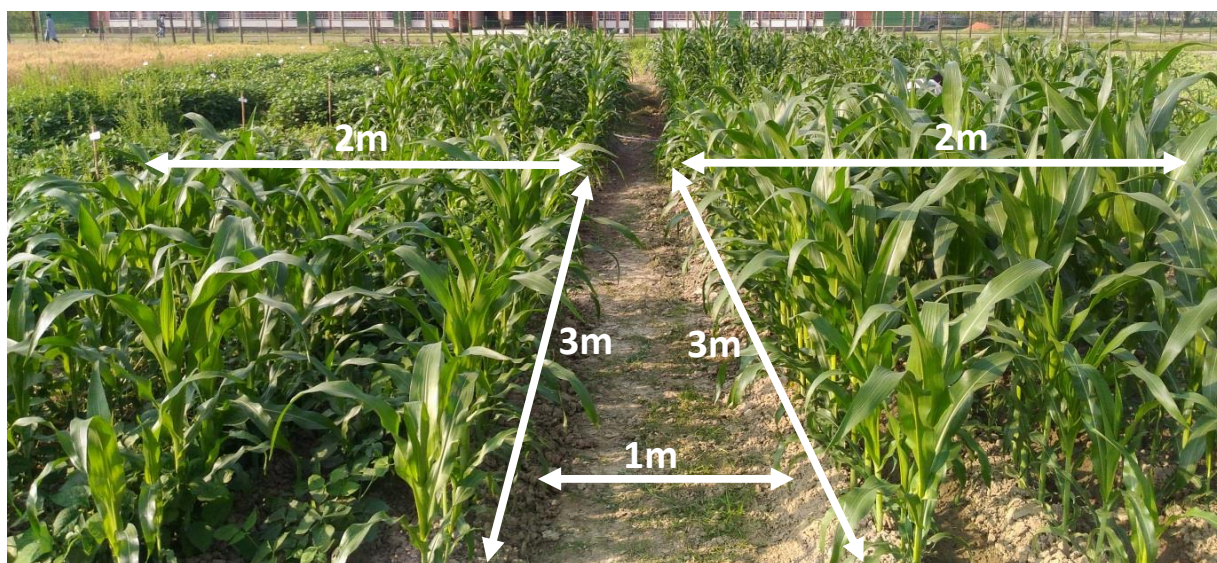


Figure S2: A photograph of field trial

**Table S1: Monthly average air temperature, humidity and total rainfall, cloud and sunshine of the experimental site during the period from December, 2018 to May, 2019**

Month	Temperature (°C)			Rainfall (mm)	Humidity (%)	Cloud (%)	Sunshine (hrs.)
	Max	Min	Mean				
December	28	19	24	2.1	54	11	353
January	30	20	25	0	44	2	372
February	31	22	27	18.7	54	9	332
March	33	24	29	15.1	59	11	372
April	35	27	32	8.6	66	21	356
May	36	29	33	23.5	71	31	358

**Table S2: Sowing dates and duration between maize and cowpea**

Treatment	Date of sowing		Duration between maize and cowpea (Days)
	Cowpea	Maize	
T <sub>1</sub>	-	18-12-2018	-
T <sub>2</sub>	18-12-2018	-	-
T <sub>3</sub>	18-12-2018	18-12-2018	0
T <sub>4</sub>	18-12-2018	25-12-2018	7
T <sub>5</sub>	18-12-2018	01-01-2019	14
T <sub>6</sub>	18-12-2018	08-01-2019	21

#### **Description of the cowpea variety**

Cowpea (*Vigna unguiculata* L. Walp.) is legume grown particularly in dry areas. In Bangladesh has been introduced possibly in 1991 while it is known yet whether it has been grown as wild land race. The cultivar used in this experiment has been collected from the farmers and therefore, the variety is not known to the community. However, the general characteristics of the variety has been listed in the table below-

**Table S3: General morphological indicators and the growth habit of cowpea**

Days after sowing	Morphological indicator
10-15	Seedling emergence
24-28	Three-leaf stage
33-35	Strat to branching
38-43	Three-branch stage
48-53	Start of flowering
60-65	50% flowering
75-80	Pod formation
95-115	Pod Maturity

**Table S4: Age of cowpea and maize in measurement of LAI, light interception, Canopy coverage and architecture**

Treatment	LAI and light interception measurement		Canopy coverage and architecture measurement	
	Age of cowpea (DAS)	Age of maize (DAS)	Age of cowpea (DAS)	Age of maize (DAS)
T <sub>1</sub>	-	75	-	85
T <sub>2</sub>	75	-	85	-
T <sub>3</sub>	75	75	85	85
T <sub>4</sub>	75	68	85	78
T <sub>5</sub>	75	61	85	71
T <sub>6</sub>	75	54	85	64

**Table S5: ANOVA of yield and yield contributing characters of maize**

Variable	Source	Nparm	DF	DFDen	F Ratio	Prob > F
Plant height	Treatment	4	4	8	0.6927	0.6175
Cob plants <sup>-1</sup>	Treatment	4	4	8	0.6667	0.6328
Cob length	Treatment	4	4	8	36.179	<0.01
Cob circumference	Treatment	4	4	8	12.648	0.0015
Grain cob <sup>-1</sup>	Treatment	4	4	8	5.9349	0.0161
1000 Grain Wt.	Treatment	4	4	8	4.8661	0.0676
Harvest Index	Treatment	4	4	8	1.2691	0.3576
Stover yield	Treatment	4	4	8	42.904	<0.01
SPAD value	Treatment	4	4	8	133.05	<0.01
Seed yield	Treatment	4	4	8	5.5101	0.0198
Biological yield	Treatment	4	4	8	14.2922	0.01
GDD	Treatment	4	4	8	68.7985	<0.01
Days to flowering	Treatment	4	4	8	8.2097	0.0062

**Table S6: ANOVA of yield and yield contributing characters of cowpea**

Variable	Source	Nparm	DF	DFDen	F Ratio	Prob > F
Plant height	Treatment	4	4	8	0.7912	0.5625
No. of branch Plant <sup>-1</sup>	Treatment	4	4	8	1.4308	0.3081
Pod plant <sup>-1</sup>	Treatment	4	4	8	96.8957	<0.01
Seed pod <sup>-1</sup>	Treatment	4	4	8	3.4223	0.0652
Pod Length	Treatment	4	4	8	1.0902	0.4231
Seeds/Plant	Treatment	4	4	8	47.7106	<0.01
SPAD meter value	Treatment	4	4	8	7.1489	0.0094
Nodules plant <sup>-1</sup>	Treatment	4	4	8	8.1701	0.0063

Yield	Treatment	4	4	8	53.8776	<0.01
Pod wt./1m <sup>2</sup> area(g)	Treatment	4	4	8	69.1755	<0.01
1000 Grain wt. (gm)	Treatment	4	4	8	90.3472	<0.01
Stover yield	Treatment	4	4	8	123.81	<0.01
Biological yield	Treatment	4	4	8	172.2723	<0.01
Harvest index	Treatment	4	4	8	5.385	0.02

**Table S7: ANOVA of Intercropping effects on the above-ground competition**

Variable	Source	Nparm	DF	DFDen	F Ratio	Prob > F
2g-r-b	Treatment	5	5	10	0.6643	0.6591
VARI	Treatment	5	5	10	1.455	0.2865
Below canopy PAR (Line to line)	Treatment	5	5	10	4.6613	0.0186
Below canopy PAR (Row to row)	Treatment	5	5	10	6.7678	0.0053
LAI (Line to line)	Treatment	5	5	10	4.6613	0.0186
LAI (Row to row)	Treatment	5	5	10	6.7678	0.0053

**Table S8: ANOVA of intercropping systems on the economic analysis**

Variable	Source	Nparm	DF	DFDen	F Ratio	Prob > F
Relative yield maize	Treatment	5	5	10	77.1271	<0.01
Relative yield of cowpea	Treatment	5	5	10	167.2843	<0.01
LER	Treatment	5	5	10	35.2627	<0.01
Maize equivalent yield	Treatment	5	5	10	65.0788	<0.01
Maize gross return	Treatment	5	5	10	80.5804	<0.01
Cowpea gross return	Treatment	5	5	10	150.0085	<0.01
Gross return total	Treatment	5	5	10	44.3353	<0.01
Net Return	Treatment	5	5	10	23.0453	<0.01
BCR	Treatment	5	5	10	14.3465	0.0003

**Table S9: REML variance component estimates of maize**

Variable	Random Effect	Var Ratio	Var Component	Std Error	Wald p-Value	Pct of Total
Plant height	Block	-0.009398	-0.013333	0.305356	0.9652	0.000
	Residual		1.4186667	0.7093333		100.000
	Total		1.4186667	0.7093333		100.000
Cob plant <sup>-1</sup>	Block	-0.111111	-0.000667	0.0008028	0.4063	0.000
	Residual		0.006	0.003		100.000
	Total		0.006	0.003		100.000

Cob length	Block	0.0376399	0.0061667	0.04224	0.8839	3.627
	Residual		0.1638333	0.0819167		96.373
	Total		0.17	0.0762261		100.000
Cob circumference	Block	0.0228013	0.0023333	0.0249912	0.9256	2.229
	Residual		0.1023333	0.0511667		97.771
	Total		0.1046667	0.0468549		100.000
Grain cob <sup>-1</sup>	Block	-0.195323	-165.9167	85.037705	0.0510	0.000
	Residual		849.44844	424.72422		100.000
	Total		849.44844	424.72422		100.000
1000 Grain Wt.	Block	-0.0388	-0.299028	1.4620078	0.8379	0.000
	Residual		7.7070017	3.8535008		100.000
	Total		7.7070017	3.8535008		100.000
Harvest index	Block	-0.048978	-2.171e-5	0.0000803	0.7868	0.000
	Residual		0.0004433	0.0002216		100.000
	Total		0.0004433	0.0002216		100.000
Stover yield	Block	1.3661852	0.0270144	0.0310322	0.3840	57.738
	Residual		0.0197736	0.0098868		42.262
	Total		0.046788	0.0319632		100.000
SPAD Value	Block	0.9405222	0.3241667	0.3946081	0.4114	48.467
	Residual		0.3446667	0.1723333		51.533
	Total		0.6688333	0.4165751		100.000
Yield	Block	-0.118672	-0.031792	0.0345307	0.3572	0.000
	Residual		0.2678962	0.1339481		100.000
	Total		0.2678962	0.1339481		100.000
Biological yield	Block	-0.051053	-0.016091	0.0565453	0.7760	0.000
	Residual		0.3151877	0.1575939		100.000
	Total		0.3151877	0.1575939		100.000
GDD	Block	0.174189	0.00454	0.010095	0.6529	14.835
	Residual		0.026063	0.013032		85.165
	Total		0.030603	0.014276		100
Days to flowering	Block	0.16129	0.666667	1.54948	0.667	13.889
	Residual		4.133333	2.066667		86.111
	Total		4.8	2.227904		100

**Table S10: REML variance component estimates of cowpea**

Variable	Random Effect	Var Ratio	Var Component	Std Error	Wald p-Value	Pct of Total
Plant height	Block	0.1470929	202.32467	496.84186	0.6838	12.823
	Residual		1375.4887	687.74433		87.177
	Total		1577.8133	728.45535		100.000

No. of branch plant <sup>-1</sup>	Block	0.0271508	0.0553333	0.505808	0.9129	2.643
	Residual		2.038	1.019		97.357
	Total		2.0933333	0.9374744		100.000
Pod plant <sup>-1</sup>	Block	2.1780822	0.3445	0.3764657	0.3601	68.534
	Residual		0.1581667	0.0790833		31.466
	Total		0.5026667	0.381417		100.000
Seed pod <sup>-1</sup>	Block	-0.084806	-0.064	0.11512	0.5783	0.000
	Residual		0.7546667	0.3773333		100.000
	Total		0.7546667	0.3773333		100.000
Pod length	Block	-0.057894	-0.038987	0.1170168	0.7390	0.000
	Residual		0.67342	0.33671		100.000
	Total		0.67342	0.33671		100.000
Seeds plant <sup>-1</sup>	Block	1.1559084	130.62364	153.64083	0.3952	53.616
	Residual		113.00519	56.502593		46.384
	Total		243.62883	159.75303		100.000
Nodules plant <sup>-1</sup>	Block	-0.153527	-0.086333	0.0620092	0.1638	0.000
	Residual		0.5623333	0.2811667		100.000
	Total		0.5623333	0.2811667		100.000
Yield	Block	0.9207635	0.008936	0.0109202	0.4132	47.937
	Residual		0.009705	0.0048525		52.063
	Total		0.018641	0.011549		100.000
SPAD meter value	Block	-0.17074	-0.811292	0.4950855	0.1013	0.000
	Residual		4.751625	2.3758125		100.000
	Total		4.751625	2.3758125		100.000
Pod wt./1m <sup>2</sup> plot(g)	Block	-0.132582	-4.116667	3.7447389	0.2716	0.000
	Residual		31.05	15.525		100.000
	Total		31.05	15.525		100.000
1000 Grain wt. (gm)	Block	0.1089113	0.2038	0.6075826	0.7373	9.821
	Residual		1.8712467	0.9356233		90.179
	Total		2.0750467	0.9457226		100.000
Stover yield	Block	3.5531915	0.00167	0.0017646	0.3440	78.037
	Residual		0.00047	0.000235		21.963
	Total		0.00214	0.001774		100.000
Biological yield	Block	0.3992435	0.0047749	0.007266	0.5111	28.533
	Residual		0.01196	0.00598		71.467
	Total		0.0167349	0.0086169		100.000
Harvest index	Block	0.1874539	0.0001508	0.0003219	0.6395	15.786
	Residual		0.0008043	0.0004022		84.214
	Total		0.0009551	0.0004479		100.000

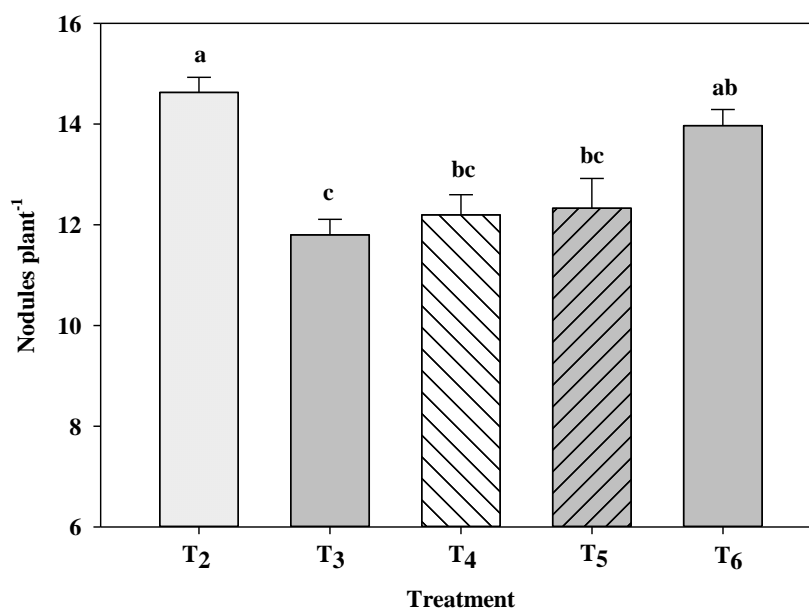
**Table S11: REML variance component estimates of intercropping analysis**

Variable	Random Effect	Var Ratio	Var Component	Std Error	Wald p-Value	Pct of Total
Relative Yield maize	Block	0.1536037	0.000784	0.0016785	0.6404	13.315
	Residual		0.0051043	0.0022827		86.685
	Total		0.0058884	0.0025082		100.000
Relative yield of cowpea	Block	-0.086996	-0.000207	0.0002597	0.4252	0.000
	Residual		0.0023799	0.0010643		100.000
	Total		0.0023799	0.0010643		100.000
LER	Block	0.2720841	0.0018216	0.0029795	0.5410	21.389
	Residual		0.006695	0.0029941		78.611
	Total		0.0085166	0.0038541		100.000
Maize equivalent yield	Block	-0.106932	-0.022723	0.0202978	0.2629	0.000
	Residual		0.2125018	0.0950337		100.000
	Total		0.2125018	0.0950337		100.000
Maize Gross Return	Block	-0.097246	-4768785	4994882.1	0.3397	0.000
	Residual		49038345	21930615		100.000
	Total		49038345	21930615		100.000
Cowpea Gross Return	Block	0.6220573	3723328.5	4741946.4	0.4323	38.350
	Residual		5985507.6	2676800.4		61.650
	Total		9708836.1	5221388.3		100.000
Gross Return Total	Block	-0.067549	-3341297	6134460.6	0.5860	0.000
	Residual		49465099	22121465		100.000
	Total		49465099	22121465		100.000
Net Return	Block	-0.067549	-3341297	6134460.6	0.5860	0.000
	Residual		49465099	22121465		100.000
	Total		49465099	22121465		100.000
BCR	Block	-0.037647	-0.000765	0.0030289	0.8005	0.000
	Residual		0.0203276	0.0090908		100.000
	Total		0.0203276	0.0090908		100.000

**Table S12: REML variance component estimates of above-ground competition**

Variable	Random Effect	Var Ratio	Var Component	Std Error	Wald p-Value	Pct of Total
2g-r-b	Block	0.0266432	4.9422e-5	0.0003843	0.8977	2.595

	Residual		0.001855	0.0008296		97.405
	Total		0.0019044	0.0007788		100.000
VARI	Block	0.9124135	0.0027735	0.003288	0.3989	47.710
	Residual		0.0030398	0.0013594		52.290
	Total		0.0058133	0.0034703		100.000
Below canopy PAR (Line to line)	Block	-0.104204	-194.1493	181.18956	0.2839	0.000
	Residual		1863.1701	833.23502		100.000
	Total		1863.1701	833.23502		100.000
Below canopy PAR (Row to row)	Block	-0.052078	-108.7	285.32202	0.7032	0.000
	Residual		2087.2556	933.44906		100.000
	Total		2087.2556	933.44906		100.000
LAI (Line to line)	Block	-0.104204	-0.006758	0.0063072	0.2839	0.000
	Residual		0.064857	0.0290049		100.000
	Total		0.064857	0.0290049		100.000
LAI (Row to row)	Block	-0.052078	-0.002104	0.0055238	0.7032	0.000
	Residual		0.0404093	0.0180716		100.000
	Total		0.0404093	0.0180716		100.000



**Figure S3:** Nodules plant<sup>-1</sup> of cowpea grown under different intercropping practices. The treatments are: T<sub>2</sub>—sole cowpea, T<sub>3</sub>—maize + cowpea intercropping, simultaneous sowing, T<sub>4</sub>—maize + cowpea intercropping, maize sown after 1 wk, T<sub>5</sub>—maize + cowpea intercropping, maize sown after 2 wk, and T<sub>6</sub>—maize + cowpea intercropping, maize sown after 3 wk. Different letters above the bars indicate statistically significant differences at Tukey's HSD ( $\alpha=5\%$ ). Error bars represent the standard error of means, N=3.

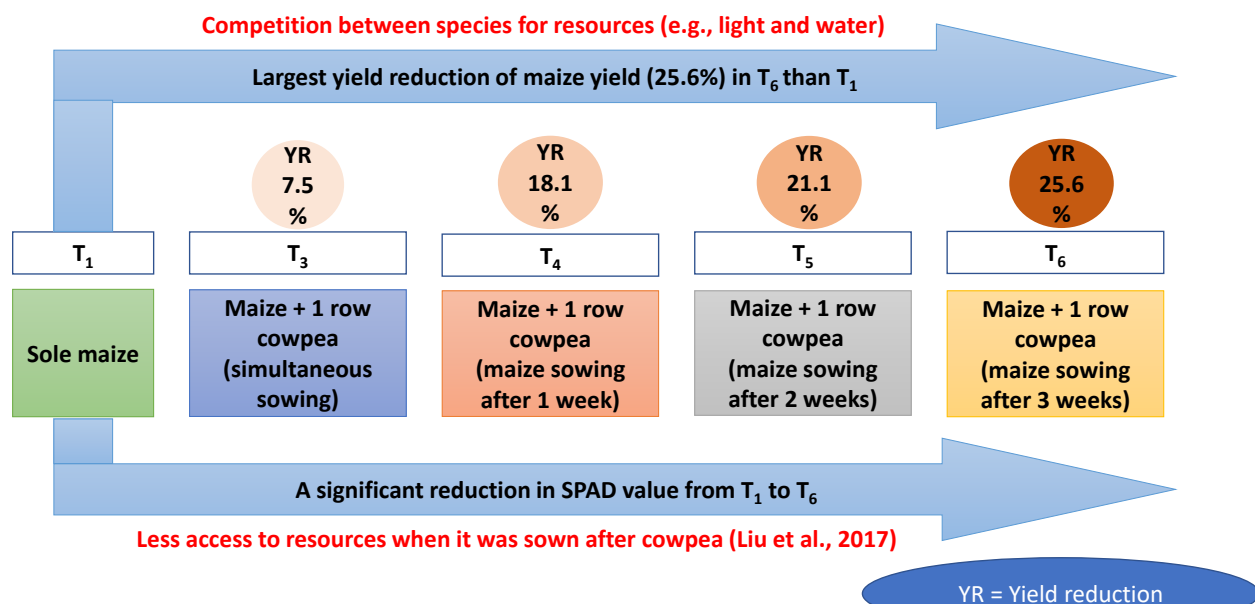


Figure S4. Changes in the performance maize due to its cultivation under difference practices.

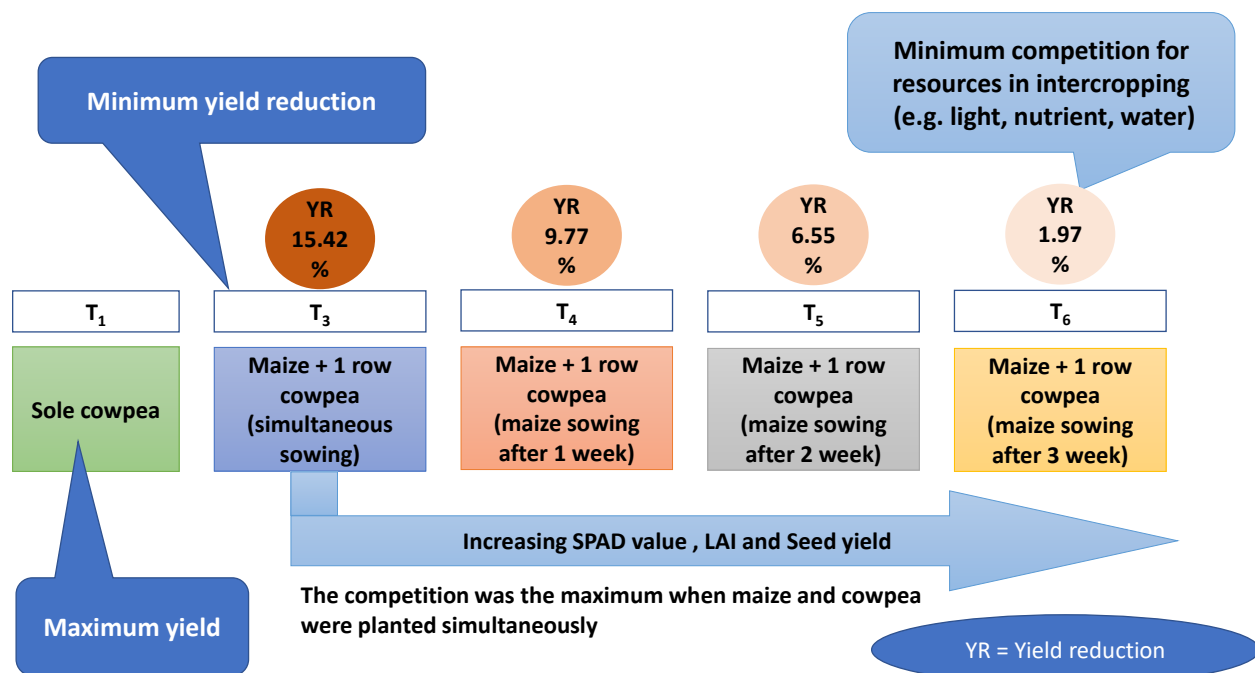


Figure S5. Changes in cowpea yield as influenced by different cultivation practices

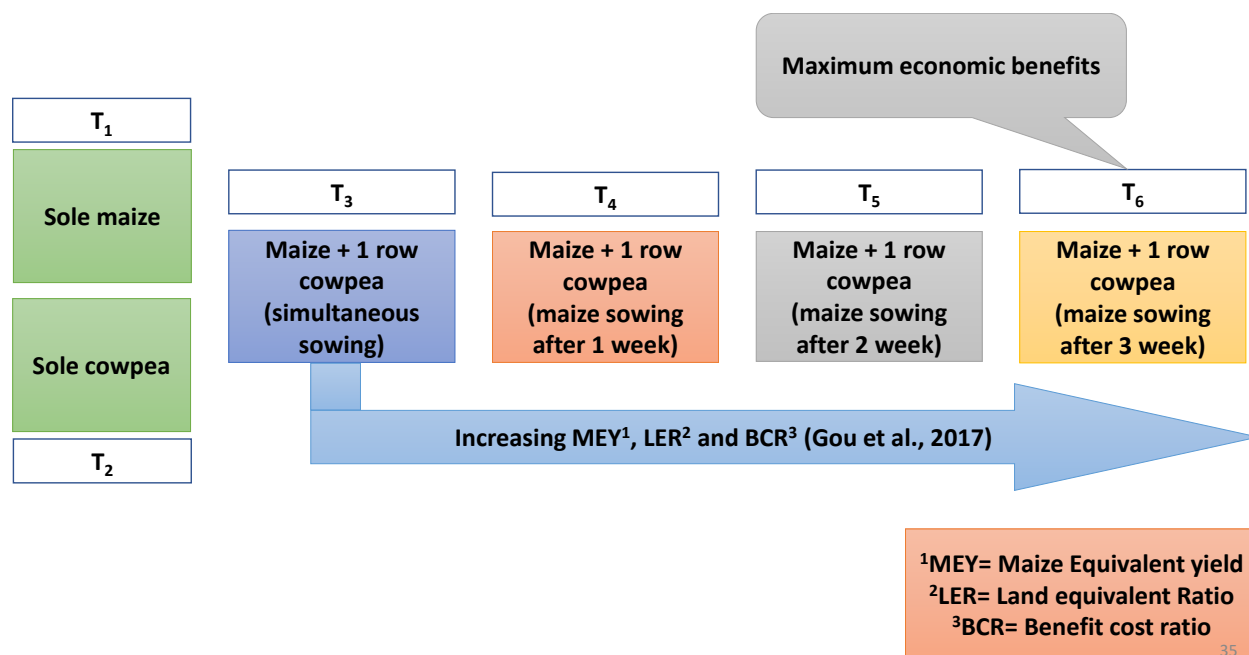


Figure S6. Yield advantage and economic benefits of intercropping