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Efficiency of Crop–Livestock Production Systems Under Conservation Agriculture: Scope for Sustainable System Transformation in Rain-Fed Drylands of Tunisia

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Background

- The improvement of the food security of smallholders limited to rain-fed practices requires sustainable cropping systems that must limit degradation and conserve natural resources.
- Given the problems of land degradation and the decline in fertility of the soil which have led to a reduction in yields, Conservation Agriculture (CA) represents an alternative for farmers.
- (CA) can reverse soil degradation, improve agricultural production, and improve the socio-economic condition.

Background

- The adoption of CA main benefits are the improved farm economics, the diversification, the increased yields and greater yield stability, the soil protection and the better water saving in arid areas.
- In Tunisia, farmers are aware about soil and water issues. Several farmers have adopted the idea to test conservation agriculture techniques. However, the full adoption in their own plots is a more complicated process.

El Rhahla Site, Siliana

Associations Fourragères pour l'Amélioration de la rotation agronomique de la production Fourragère
El Rhahla Site, Siliana (2021)

Background

Objective

- To evaluate the technical efficiency of farmers engaged in mixed (CLCA) in Tunisian rainfed areas.
- To understand if the adoption of CLCA is more technically efficient than conventional system.
- To identify the key factors that influence the adoption of CA by farmers in Tunisian rainfed areas?

Data collection and sampling procedures

The study area: Kef, Siliana, Zaghouan and Kairouan

Characteristics:

- Tunisian semi-arid areas
- The same agroecological system characterized by the mixed crop-livestock farming.
- Facing a deep erosion problem,
- Agriculture represents the main activity and income source

The sample:

- 118 farmers
- 50% of the interviewed farmers are adopting the conservation practices

Methodological framework and data analysis

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Empirical model

The stochastic frontier production function model is expressed by the equation:

$$Y_i = f(x_i, \beta) + V_i - U_i$$

- Yi output level of ith production unit with i ranging from 1, 2, …, N;
- f(xi ; β) is a function given the vector of inputs x;
- β is a vector of parameters to be estimated;
- V is the symmetric error term accounting for random variations in output;
- U represents the error-term associated to technical inefficiency relative to the stochastic frontier, which assumes only positive values.

Empirical model

The technical inefficiency model:

$$TI_i = \delta_0 + \sum_{j=1}^{5} \delta_j Z_{ji} + \sum_{k=1}^{4} \delta_k D_{kj}$$

- TIi is technical inefficiency of the (i) farmer.
- δ are unknown parameters to be estimated to explain the inefficiencies of production of the farm output activities.
- Dkj represents the four input variables (the labor, the land, the crop capital and the livestock capital).
- Zji represents the five socio-economic variables(Inefficiency variables: the age, the education, the dependency ratio, share of off-farm income, the credit access, and the extension access).

Empirical findings and discussions

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Socio economic characteristics of samples households: Non-adopters

Variable	Mean	Max	Min	SD
Outputs				
Cereals[(a)]	698.7	2580	118	507.62
Legumes	654	1056	336	369.64
Forage crops[(b)]	453.31	1800	160	304.66
Livestock 1 (Cattle)	744.35	4400	200	952.65
Livestock 2 (Small ruminants)	6715.83	23900	1878	5323.59
Inputs				
Labour (Man-dDay per year)	1.90	3.75	0.51	0.83
Land (Hectares)	6.92	12	4	2.64
Crop capital (TND) [(c)]	978.46	2319.81	313.09	455.36
Livestock capital (TND) [(d)]	3717.51	17622	670	3288.91
Inefficiency variables				
Age of household (Years)	53.32	87	27	14.40
Education (Yes=1, No=0)	0.67	1	0	0.48
Dependency ratio	0.97	6	0.25	0.96
Share of off-farm income (%)	55.68	99.62	7.58	21.48
Credit access (Yes=1, No=0)	0.02	1	0	0.13
Extension access (Yes=1, No=0)	0.17	1	0	0.38

Empirical findings and discussions

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Socio economic characteristics of samples households: Adopters

Variable	Mean	Max	Min	SD
Outputs				
Cereals[(a)]	1806.1	3936	560	812.53
Legumes[(b)]	1216.4	2900	440	584.91
Forage crops[(c)]	1247.1	2750	450	720.30
Livestock 1 (Cattle)	17516.7	69600	2700	25842.48
Livestock 2 (Small ruminants)	47618.3	190500	5000	52403.11
Inputs				
Labour (Man-day per year)	27.2	188	2	38.60
Land (Hectares)	81.4	400	4	87.26
Crop capital (TND) [(d)]	2040.1	4425	214	1102.26
Livestock capital (TND) [(e)]	14722.2	51000	3000	11836.92
Inefficiency variables				
Age of household head (Years)	51.4	70	34	9.9
Education (Yes=1, No=0)	0.9	1	0	0.3
Dependency ratio	0.6	1	0.11	0.2
Share of off-farm income (%)	90.5	100	36.12	28.14
Credit access (Yes=1, No=0)	0.08	1	0	0.22
Extension access (Yes=1, No=0)	0.95	1	0	0.0

Empirical findings and discussions

Determinants of technical inefficiency model, with- and without CA adoption

Variable	CA Non-Adopters farmers		CA Adopters Farmers	
Constant	-0.215	(-0.951)	0.845	(1.316)
Labor	0.637	(0.458)	-0.061	(0.842)
Land	-2.244*	(1.454)	0.460	(2.458)
Crop capital	3.202***	(0.864)	-0.410	(0.988)
Livestock capital	-0.011	(0.627)	0.318*	(0.206)
Labor*Land	-0.317***	(0.098)	-0.136	(0.555)
Labor*Crop capital	-0.407	(0.588)	0.013	(0.421)
Labor*livestock capital	0.039	(0.860)	0.030	(0.027)
Land*Crop capital	3.664***	(1.212)	0.228	(0.930)
Land*Livestock capital	0.127	(0.299)	-0.110	(0.145)
Crop capital*Livestock capital	-1.015	(0.815)	0.009	(0.099)

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Determinants of technical inefficiency model, with and without CA adoption

Variable	CA Non-Adopters farmers		CA Adopters Farmers	
Crop capital*Livestock capital	-1.015	(0.815)	0.009	(0.099)
Inefficiency effects model				
Constant	0.198*	(0.129)	0.828	(0.955)
Age	-0.001	(0.001)	-0.019***	(0.006)
Education	-0.117*	(0.065)	-0.354*	(0.244)
Dependency ratio	0.002	(0.029)	-0.300	(0.470)
Share of off-farm income	0.054	(0.141)	0.230	(1.457)
Credit access	-0.520	(0.569)	-0.214	(0.395)
Extension access	-0.051	(0.048)	0.089	(0.839)
σ^2	0.006***	(0.001)	0.051**	(0.020)
γ	0.448*	(0.261)	0.999***	(0.002)
log likelihood function =	68.075		77.71	
LR test of the one-sided error	15.322		67.42	

*Notes: *, ** and *** are statistically significant at 10 per cent, 5 per cent and 1 per cent levels, respectively*
Values given in parentheses are standard errors

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Technical efficiency levels between CA Adopters and Non-Adopters farmers

Item	CA Adopter Farmers	CA Non-Adopter Farmers	Difference
Mean	0.909 (0.012)	0.905 (0.006)	0.004
Minimum	0.433	0.779	
Maximum	0.999	0.993	
Farm frequency (TE < 60%)	1	0	
Farm frequency (60% < TE < 80%)	5	2	
Farm frequency (TE > 80%)	53	57	

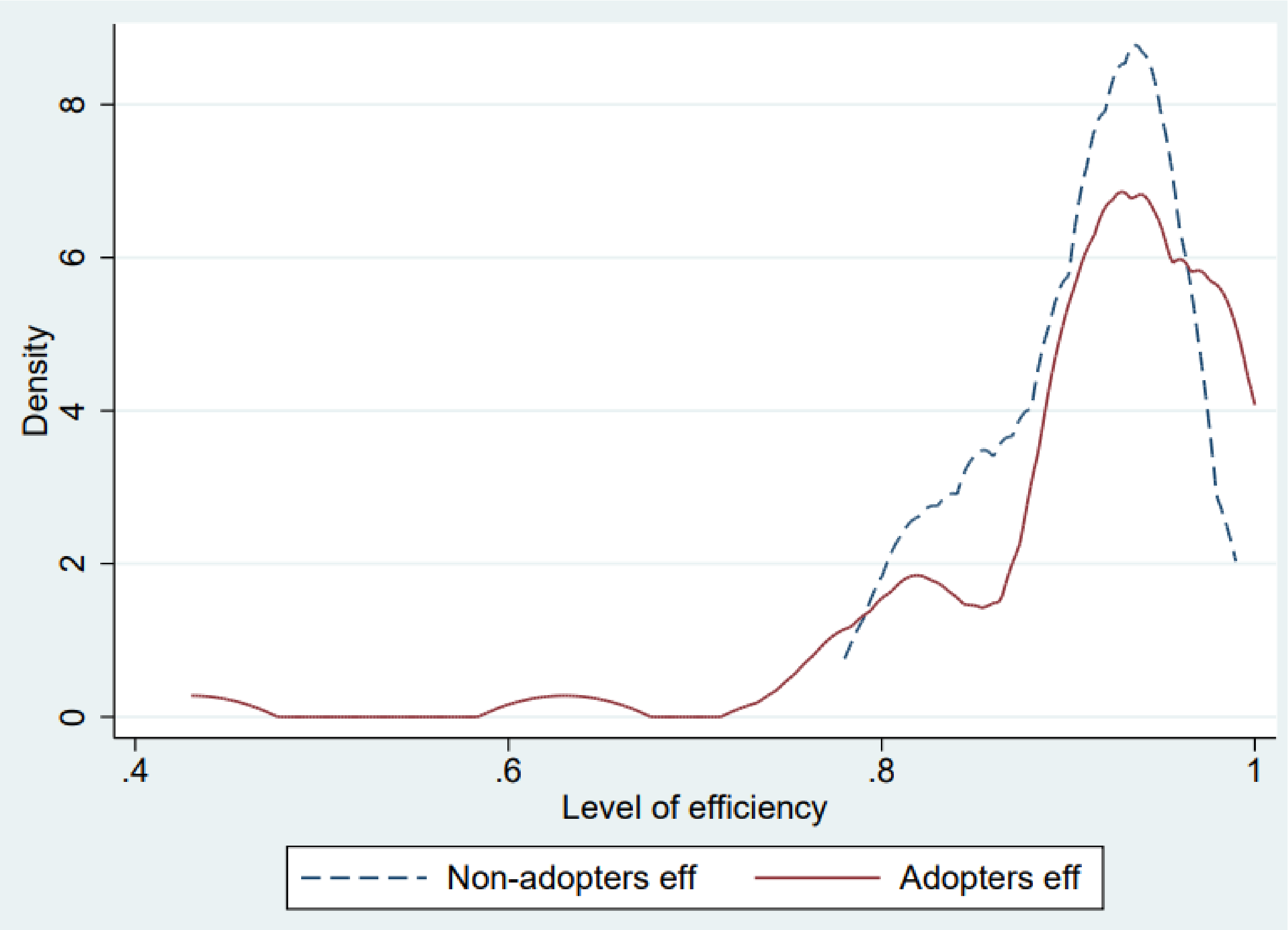
The mean value of technical efficiency of adopter and non adopter farmers indicated that they could improve their efficiency respectively by 9.1% and 9.5%

Technical efficiency levels between CA Adopters and Non-Adopters farmers

The percentage of adopter farmers having a technical efficiency level higher than the mean value was 72.8 per cent.

Only 61.1% of non-adopter farmers had levels of technical efficiency higher than the mean level.

This implies that, in general, CA adopter farmers were more technically efficient than those not adopting the CA.



Distribution of TE level of CA adopter and non-adopter

Concluding remarks and policy implications

- Farmers in the integrated crop-livestock system have a high technical efficiency. For both CA adopter and non-adopter farmers, they could increase their production by almost 10 per cent through more efficient use of production inputs, mainly the land and the capital.

- In the CLI system, all farmers who are not adopting CA need to improve the interaction between land and crop capital to be more technically efficient.

- The key driving forces that significantly improved technical efficiency were farmer’s age and education

Concluding remarks and policy implications

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Policy implications

- The design of strategies for enhancing the production taking account of the heterogeneity of farmers is more useful for policymakers.
- Researchers, extensionists, and policymakers need to adapt, respectively, scientific research, extension methods, and policies to the specific contexts of farmers and farming systems.
- The fragmentation of CA technology on different packages (SWC techniques, legumes crop integration, and livestock feeding improvement) could make easier the establishment and dissemination of agroecological practices.
- The implementation of trainings and field school programs with a strong extension network for a wider dissemination of CA technology particularly for young farmers should enhance farmers efficiency.

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