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THE IMPACTS OF NO-TILLAGE ON GRAIN YIELD OF DURUM WHEAT AND ENERGY REQUIREMENT IN THE MEDITERRANEAN CLIMATE

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1. Introduction

A key principle of no-tillage (NT) system is the retention of crop residues on the soil surface to preserve soil water for crop growth. In response to the negative impact of soil degradation processes under conventional tillage (CT) systems that are based on soil tillage, NT system without tillage practice and with protective cover of crop residue are being developed in many parts of the world. Apart from the positive effects on soil conservation and sustained land productivity, another major impact of NT is decreasing labor costs, generallyleading to a higher income and a better standard of living for the farmers.

However NT is a successful system especially in the South of America, but the impacts of this system in the Mediterranean climate especially in the south of France is less well known; so that this study has been carried out within the scope of a European project.

2. Materials and methods

The study has been carried out on Lavalette experimental site in Montpellier (43°40'N, 3°50'E, altitude 30 m), under a Mediterranean climate w ith 750 mm annual average rainfall, in the south of France. Field experiments and measurements were curried out in 2004, 2005 and 2006. Durum wheat was sown for two seasons under two tillage treatments i.e. CT and NT. Two plots were cultivated under DSM (1 ha) and CT (1.7 ha). Time requirement, fuel consumption and yield were measured in these two systems.

The energy requirement for each tillage system was determined by measuring the tractor fuel consumption applying volumetric system. Energy equivalent of 38.7 MJ.L-1 was taken for energy calculation (Cervinka (1980)). Statistical assessment of this experiment was performed by the analysis of variance (ANOVA). The Duncan's test was employed to compare the mean results, after a significant variation had been highlighted by ANOVA. The differences had been considered as significant if $P<0.05$.

3. Results

- The amount of wheat grain yield and response to the tillage systems varied depending on the season.
  - In the first growing season, grain yield was significantly higher in CT while no significant difference of grain yield was evident in both NT1 and NT2.
  - In the second season, grain yield was lower in all treatments as compared with the first one. In CT, grain yield was significantly higher (Table 1). Similar to the first year of the experiment, no significant impact of soil texture was found in NT treatments.
- The emerged plant number was significantly higher in CT than NT. The unfavorable effects of residues prevent proper seed placement and emergence. Better plant emergence in CT translated into higher grain yield. Lower yield under NT may have been associated with the development of cereal leaf beetle (Oulema melanopus L.); this pest can cause senescence during grain filling stage.
- Table 2 shows fuel consumption, energy requirement, and the work duration of machinery used for crop establishment in each treatment. CT system was the greatest fuel and energy consumer. The greatest part of the energy, almost 45% or 696.6 MJ.ha^{-1} spent to plow, while NT system required only 270.9 MJ.ha^{-1}. In comparing these data to other sources, wide variations can be expected due to soil types, field conditions, working depth, etc. NT involved time saving of 87% for crop establishment, as compared to CT. The time required per hectare was reduced from 7.55 h to 1 h. Work rate was better in NT system. That parameter can be interesting when we have not lots of time to prepare the soil for sowing or in some cases one or more tractors and one or more workers can be saved.
- In table 3 total energy and total work duration in both tillage systems over the season were shown. CT system was the greatest fuel and energy consumer. CT required 2631.6 and 2476.8 MJ.ha^{-1} for the first and second season, respectively. The maximum energy requirement in NT is 1431.9 MJ.ha^{-1} enabling thus saving 46% of energy. NT can reduce work duration too. Substitution of CT with NT enables us to save approximately 64% of work duration over the season.
- To prepare the soil for sowing in CT, we need 233 and 261 MJ to produce 1 Mg of grain yield in the first and second season, respectively (Figure 1). While the maximum energy requirement in NT is just 100 MJ.
- The results of this study indicated that grain yield of durum wheat was higher in CT system. Lower yield under NT may have been associated with the development of cereal leaf beetle and lower emerged plant number. While, NT provided a considerable saving in work duration, fuel consumption and energy required for either crop production or seed bed preparation.

Table 1. Soil physical and chemical properties at the Lavalette Agricultural Research Station, Montpellier, France

Plot	Clay (%)	Silt (%)	Sand (%)	Texture (USDA) (0-120 cm)	Organic matter (%)	Organic carbon (%)	N total (%)	C/N
CT	18	47	35	loam	1.55	0.91	0.07	12.3
NT1	17	39	44	loam	1.76	1.02	0.09	11.4
NT2	25	44	31	sandy clay loam	2.05	1.19	0.11	11.2

Table 2. Monthly rainfall, Penman evapotranspiration, and mean air temperature for two season compared with a 13-year average at Lavalette.

Month	Rainfall (mm)			Penman Evapotranspiration (mm)			Mean air temperature °C		
	2004-2005	2005-2006	13-year average	2004-2005	2005-2006	13-year average	2004-2005	2005-2006	13-year average
November	14	41	92	17	19	18	10	10	10
December	58	4	103	12	8	9	8	4	8
January	2	194	72	18	11	12	6	6	7
February	20	5	46	32	25	27	5	6	8
March	14	23	36	57	58	57	9	10	11
April	31	6	65	92	97	86	13	14	13
May	43	16	51	134	137	122	17	18	17
June	55	21	36	168	169	153	23	21	21
Total	236	311	501	530	524	476			
S. D.*	-265	-190		54	48				

*** Deviation from 13-year average**

Table 3. Average durum wheat yield of two growing seasons

Tillage system	Durum wheat 2004/2005 Mg.ha^{-1}	Durum wheat 2005/2006 Mg.ha^{-1}
Conventional tillage (CT)	6.65a	5.94a
No-tillage plot 1 (NT1)	3.06b	2.72b
No-tillage plot 2 (NT2)	3.44b	2.75b

Data within the same column followed by the same letter are not significantly different at the probability level $P<0.05$.

Table 4. Energy and time requirement of two tillage methods to prepare the soil for sowing durum wheat

Tillage	Fuel consumption L.ha^{-1}	Energy requirement MJ.ha^{-1}	Work duration h
2004/2005 season			
Conventional tillage (CT)	68	2631.6	9.75
No-tillage plot 1 (NT1)	35	1354.5	3.2
No-tillage plot 2 (NT2)	37	1431.9	3.4
2005/2006 season			
Conventional tillage (CT)	64	2476.8	9.35
No-tillage plot 1 (NT1)	37	1431.9	3.14
No-tillage plot 2 (NT2)	37	1431.9	3.14

Table 5. Total energy and total time requirement of two tillage methods to crop production of durum wheat.

Tillage	Fuel consumption L.ha^{-1}	Energy requirement MJ.ha^{-1}	Work duration h
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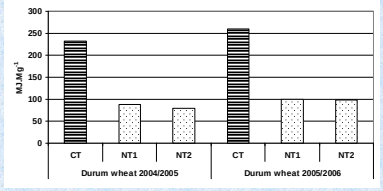

Figure 1: Energy requirement of two soil tillage methods to prepare the soil for sowing durum wheat with respect to energy requirement to obtain grain yield

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