Sustainability Of Direct Seeding Versus Conventional Tillage

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Abstract- Direct seeding durability on the mulch of crop residues (DSM) is questionable for irrigated crop in Mediterranean condition, so conventional tillage (CT) and DSM techniques were implemented in an experimental site in Montpellier in south of France since 2000. Durum wheat was planted with different irrigation and nitrogen treatments. CT and DSM effects on soil and crop parameters were investigated. An increase of soil bulk density was observed in DSM. Root depth decreased slightly in DSM; however LAI development and total dry matter were approximately equivalent, but CT yield was higher due to water shortage in DSM. These results demonstrate that DSM technique is an efficient technique with limited impact on yield; however planting problems and weed control in DSM are not negligible so choosing planting technique and rotation of crops are very important.
Keywords: direct seeding, yield, durum wheat, soil properties

Résumé- Pour analyser la durabilité du semis direct sur mulch (SDM) dans les conditions méditerranéennes, une comparaison culture traditionnelle (CT) et SDM a été réalisée sur un site expérimental à Montpellier, dans le sud de la France depuis 2000. Un blé dur a été mis en place avec différents traitements d'irrigation et d'apports d'azote en 2004. Différents paramètres du sol et de la culture ont été mesurés. En particulier, la densité du sol est légèrement accrue sous SDM et le développement racinaire, un peu moins important ; le LAI et le rendement en matière sèche totale sont pratiquement équivalents à ceux de CT. Ces résultats confortent des observations antérieures sur l'efficience du SDM qui a un impact limité sur le rendement ; cependant la maîtrise du semis et des adventices ont un rôle important qui doit s'appuyer sur des choix techniques adéquats et la rotation des cultures.
Mots-clés: semis direct, rendement, blé dur, propriétés du sol.

INTRODUCTION

Direst seeding on mulch (DSM) substantially reduces run-off and soil erosion, soil evaporation, land preparation costs (lal, 1989; Blevins and Frye, 1993), improving soil structure and long-term nutrient cycling (Fischer et al., 2002). It can also moderate the temperature fluctuation in the top soil (Bussière et al., 1994) and improve some other soil properties, but there are some negative impacts for DSM too, like: lower soil temperature in winter, temporary nitrogen lockup and frequently lower yield for winter crop, greater risk of diseases and weed problems (Fischer et al., 2002), difficulties with weed control, poor seed emergence and a greater risk of frost damage in the spring (Weill et al., 1989). Experience has shown that the adaptation of DSM by farmers is very slow (Erenstein, 1996).

MATERIALS AND METHODS

The study has been carried out on Lavalette farms in Montpellier (43° 40' N, 3° 50' E, altitude 30m), under Mediterranean climate with 750 mm annual average rainfall, in the south of France. Two fields (North (NDSM) with 0.56 ha and South (SDSM) with 0.38 ha) and one field (CT with 1.7 ha) were under DSM and conventional tillage (CT), respectively. The crop rotation before 2004/2005 growing season on these fields was: oat-corn (2000/2001); oat-corn in CT and NDSM plots and oat-sunflower in SDSM plot (2001/2002); wheat-sorghum (2002/2003); oat &

vetch -sorghum (2003/2004). For all these cropping seasons, the first crop was destroyed in April using glyphosate, before planting the main crop; in December 2003, due to flooding in NDSM and CT and a poor emergence, wheat was destroyed and replaced by sorghum. For 2004/2005 growing season, durum wheat was cultivated in three plots.

Table1. The irrigation and nitrogen rates in 2004/2005 growing season

Treatment	Irrigation (mm)		Nitrogen ($kg.ha^{-1}$)		
	1	2	1	2	3
CT3N2I	27	43.7	54	67	30
CT3N1I	49.5	-	54	67	30
CTR (rainfed)	-	-	54	67	30
NDSM	36.3	-*	54	61	-
NDSMR (rainfed)	-	-	54	61	-
SDSM	19.9	-*	54	65	-

* No water application due to irrigation system failure

The nitrogen (N) and irrigation (I) treatments are summarized in table 1. Due to irrigation failure, only one irrigation was applied on DSM treatments, nitrogen requirement were lowered and the third nitrogen application was suppressed.

In April 2005, two levels of mulch (crop residues from previous years) were measured 3.9 $t.ha^{-1}$ on NDSM and 1.5 $t.ha^{-1}$, SDSM (after a rainfed sorghum in 2004). Durum wheat (cv. Artimon) was sown on CT on 17 November 2004 (350 $seed.m^{-2}$) and on 30 November 2004 with a special sower for direct seeding (SEMEATO) on DSM (450 $seed.m^{-2}$). During the growing season and after harvest classical plant and soil characteristics (LAI, yield components, water and nitrogen content, soil bulk density…) were measured.

RESULTS AND DISCUSSION

As shown in table 2, total dry matter and grain yield are higher in CT3N2I treatment and point out the effect of irrigation. In DSM treatments, yields are affected by water stress and low plant density, though the number of ears are acceptable due to suckering, the 1000 kernel weight and number of kernels are low in accordance with the low value of total dry matter.

Table 2. Yield composition and yield component of durum wheat

Treatment	Parameters				
	Grain yield ($Mg.ha^{-1}$)	Total dry matter ($Mg.ha^{-1}$)	1000 kernels weight (gr)	Plant density at emergence ($plant.m^{-2}$)	Ear suckering at harvest
CT3N2I	7.22	13.3	33.5	264	2.1
CT3N1I	6.30	11	26.8	264	2.1
CTR	3.87	8.7	24.7	245	2.3
NDSM	3.06	7.2	22.9	158	2.2
NDSMR	2.35	6.1	21.4	123	2.7
SDSM	3.35	8.9	21.9	206	2.1

In NDSM and SDSM, total dry matter per plant is of the same order of magnitude as CT treatments values (4.5 and 4.9 $gr.plant^{-1}$ versus 4.2 and 5.0 $gr.plant^{-1}$, respectively) but the 1000 kernel weight is lower. So without irrigation system failure, an acceptable yield could be obtained in DSM treatments though plant density was low.

This last point must be analysed. Durum wheat was sown during a rainy period in November and the characteristics of the seed bed were influenced by soil water content. Direct planting seeders as SEMEATO are well adapted to dry soils but high to medium soil water content in soil surface layer is unfavourable to obtain an efficient seeding. It was observed that surface soil particles were pulled away from part to part by the discs of the sowing machine and most of the seed lines weren't closed. As contact between soil and wheat seed wasn't satisfactory, a lot of seed didn't germinate in good conditions and died . These results can be compared to those obtained for summer irrigated crops during the last three years (table 3).

Table 3. Grain Yield ($Mg.ha^{-1}$) comparison for previous campaigns with limited irrigation

Year	2002	2003	2004
Crop	Corn	Sorghum	Sorghum
CT treatment	10.4	6.7	7.7
DSM treatment	11.4	7.2	7.2*

*For a 2nd sowing after soil insects attacks

For a corn crop, as well as for sorghum, grain yields were not significantly different under CT and DSM treatments. For winter crops some papers indicated that the yield in DSM treatment are lower. To analyse the impacts of CT and DSM on soil properties, some soil data are presented in figures 1 and 2. As plant density is different, values for 0-15 cm layer can be compared during two periods: at the beginning of the cropping season when water plant uptake was very low and when LAI is higher than 3, when water consumption is no longer influenced by plant density.

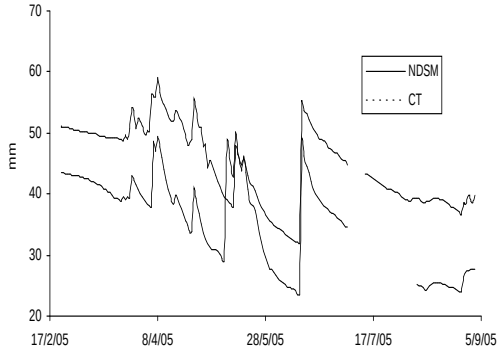

Fig. 1. Soil water content under NDSM and CT in 0-15 cm layer

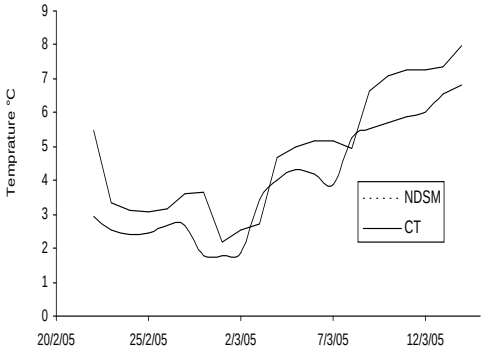

Fig. 2. Daily Soil temperature (at 8:00 a.m.) under CT and NDSM at 6 cm depth.

During the first period, in February, soil water content is about 10 mm higher under NDSM than under CT; observations after flooding showed the same saturation value for the two sites, so it can be conclude that the upper layer is really wetter under DSM. For the second period, data after the 10 May pointed out that DSM keeps 8 to 10 mm more than CT after irrigation and rainfall. The results suggest that there is a impact of DSM on conserving soil moisture as said Lal (1976) and Fortin (1993), especially if DSM is in a long established system, such as in this case. This phenomenon is important for mineralization and N plant uptake, but it also decreases soil temperature. Figure 2 shows that DSM soil temperature at 6 cm was one degree lower than under CT in February and March, except for some days. This suggests that CT has little impact on improving soil temperature under cool weather conditions. The differences in plant density value between DMS and CT could have been increased by the effect of soil temperature differences.

Bulk density also can be used as an indicator to evaluate tillage effect on soil physical properties. Tillage treatments showed considerable difference in soil bulk density at the top 30

cm soil profile after harvest (Table 2). In the first layer (0-5 cm) there is no real difference due to the treatments. This can be related to the high level of biological activity observed near the surface in DSM. For next 10 cm, a slight increase (mean value: 0.1) was recorded in DSM. This evolution is enlarged for 15-25 cm, but the bulk density is much variable probably due to the presence of a plough pan. The observations under DSM can be explained by settling of soil particles, which increased bulk density to a great extent under DSM (Cassel and Nelson, 1985). Really, what is the effect of such a situation on rooting under Mediterranean climate? Root profiles were observed after harvest down to a depth of 1.5 m and little differences were observed between CT and DSM treatments.

Table 2. Soil bulk density in different subplots after harvesting

Depth	Subplots						
(cm)	CT1	CTR	CT2	NDSM1	NDSMR	NDSM2	SDSM
0-5	1.49	1.39	1.48	1.41	1.49	1.48	1.54
5-10	1.55	1.49	1.52	1.68	1.61	1.67	1.64
10-15	1.67	1.60	1.65	1.86	1.71	1.78	1.76
15-20	1.69	1.63	1.66	1.98	1.77	1.83	1.96
20-25	1.73	1.90	1.61	2.04	1.86	1.83	-

CONCLUSIONS

Direct seeding on mulch (DSM) results in acceptable yield in comparing with conventional tillage in Mediterranean context. This result proved for summer irrigated crops, but it has to be confirmed for winter crops. This experiment showed that DSM has some difficulties in autumn on wet soil and this affect emergence, however satisfactory plant development overrides this unfavourable effect. The presence of mulch limits soil evaporation and maintains an extra soil water content which is suitable for mineralization and nitrogen plant uptake during the dry periods. DSM moderates soil temperature fluctuation in the top soil layer, but increases time necessary for plant emergence in cold conditions. Bulk density for the upper 25 cm is partially increased, but root profile under DSM seems acceptable in comparing with CT.

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