Evaluating direct seeding on mulch on a field scale

Khaledian M.R., Ruelle P., Mailhol J.C., Delage L., Rosique P.

in

Arrue Ugarte J.L. (ed.), Cantero-Martínez C. (ed.).
Troisièmes rencontres méditerranéennes du semis direct

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 69

2006
pages 125-129

Evaluating direct seeding on mulch on a field scale

M.R. Khaledian*,, P. Ruelle***, J.C. Mailhol***, L. Delage*** and P. Rosique*****
*Ph.D student at Cemagref, Montpellier, France
**Guilan University, Iran
***Cemagref, BP 5095, 34196 Montpellier Cedex 05, France
email: mohammad.khaledian@cemagref.fr ; pierre.ruelle@cemagref.fr

SUMMARY – The impact of energy crisis on agriculture has brought an urgent need to reduce the energy consumption, as soil tillage is the most expensive element in crop production. Direct seeding on the mulch of previous crop residues is becoming increasingly attractive; however the impacts of this technique in France on agriculture and environment are less well known. An experiment was conducted from 2000 to 2005 in Montpellier in France, to compare the effects of direct seeding on mulch (DSM) and conventional tillage on yield and soil properties. The results indicate that DSM technique is an alternative and efficient technique for irrigated crops.

Keywords: Direct seeding, mulch, conventional tillage.

***RÉSUMÉ –** "Evolution du semis direct sur mulch au niveau du champ". L'impact de la crise énergétique sur l'agriculture rend plus que jamais nécessaire la réduction de la consommation d'énergie en s'intéressant en particulier au travail du sol qui représente le poste le plus important. Le semis direct sur couvert végétal (SCV) devient de plus en plus attractif ; cependant l'impact agronomique et environnemental du SCV en France est encore peu connu. Une expérimentation a été conduite de 2000 à 2005 à Montpellier (France), pour comparer les effets, sur le rendement et les propriétés du sol, du SCV et d'un système de travail du sol traditionnel. Les résultats montrent que la technique du SCV est une technique alternative intéressante et efficiente pour les cultures irriguées.*

***Mots-clés :** Semis direct, mulch, travail du sol conventionnel.*

Introduction

The direct seeding on mulch (DSM) technique is based on four essential farming practices as recommended by Séguy *et al.* (1996) for Brazil: (i) absence of soil tillage; (ii) maintenance of a crop residue mulch at all times; (iii) direct seeding with in crop residue; and (iv) use of suitable rotation crops. This method substantially reduces run-off and soil erosion, soil evaporation, and land preparation costs (Lal, 1989; Blevins and Frye, 1993), while improving soil structure and the long-term nutrient cycle (Fischer *et al.*, 2002). It can also moderate temperature fluctuation in the top soil (Bussière and Cellier, 1994) and improve some other soil properties, but DSM has also some negative impacts, such as lower soil temperature in winter, temporary nitrogen lockup and frequently lower yield for winter crops, greater risk of disease and weed problems (Fischer *et al.*, 2002), difficulties with weed control, poor seed emergence and greater risk of frost damage in the spring (Weill *et al.*, 1989). The adaptation of such a relatively complex technique by farmers is very slow (Erenstein, 1996).

Evaluating DSM and presenting the positive and negative effects of this method in a Mediterranean context is the aim of this study.

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 Mediterranean climate with 750 mm annual average rainfall, in the south of France. The site was divided into three plots: two plots with DSM [North direct seeding on mulch (NDSM) with 0.56 ha, and South direct seeding on mulch (SDSM) with 0.38 ha], and one plot of 1.7 ha with conventional tillage (CT). The crop rotation before the 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 and 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 poor emergence, wheat was destroyed and replaced by sorghum. For the 2004/2005 growing season, durum wheat (*Triticum turgidum* L. var. *durum*) was cultivated in the three plots.

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 not carried out. In April 2005, two levels of mulch (crop residue from previous years) were measured: 3.9 t/ha on NDSM and 1.5 t/ha, SDSM (after rainfed sorghum in 2004). Durum wheat (cv. Artimon) was sown on CT on 17 November 2004 (350 seed/m²) and with delay because of device availability on 30 November 2004 with a special sowing machine for direct seeding (SEMEATO) on DSM (450 seed/m², as recommended by Extension Service for DSM and delaying in seeding).

Table 1. The irrigation and nitrogen rates in the 2004/2005 growing season

Treatment	Irrigation (mm)		Nitrogen (kg/ha)		
	1	2	1	2	3
CT3N2I	27	43.7	54	67	30
CT3N1I	49.5	-	54	67	30
CT.R	-	-	54	67	30
NDSM	36.3	-*	54	61	-
NDSM.R	-	-	54	61	-
SDSM	19.9	-*	54	65	-

*No water application due to irrigation system failure.
CT: conventional tillage; R: rain fed; NDSM: north direct seeding on mulch; SDSM: south direct seeding on mulch; N: the number of nitrogen application; I: the number of irrigation.

Results and discussion

As shown in Table 2, total dry matter and grain yield are higher in CT3N2I treatment and highlight the positive effects of irrigation. In DSM treatments, yields are affected by water stress and low plant density, though the number of ears is satisfactory due to suckering; 1000 kernel weight and number of kernels are low in accordance with the low value of total dry matter.

Table 2. Yield and yield component of durum wheat

Treatment	Parameters				
	Grain yield (Mg/ha)	Total dry matter (Mg/ha)	1000 kernels weight (g)	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
CT.R	3.87	8.7	24.7	245	2.3
NDSM	3.06	7.2	22.9	158	2.2
NDSM.R	2.35	6.1	21.4	123	2.7
SDSM	3.35	8.9	21.9	206	2.1

CT: conventional tillage; N: the number of nitrogen application; I: the number of irrigation; R: rained, NDSM: north direct seeding on mulch; SDSM: south direct seeding on mulch.

In NDSM and SDSM, total dry matter per plant has the same order of magnitude as CT treatments values (4.5 and 4.9 g/plant versus 4.2 and 5.0 g/plant, respectively) but the 1000 kernel weight is lower. So without irrigation system failure, an acceptable yield could have been obtained in DSM treatments though plant density was low.

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 soil but high to medium soil water content in the surface layer is unfavourable to obtain satisfactory 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 were not closed. As contact between soils and seed was not satisfactory, a lot of seed did not germinate in good conditions and died or even were picked by birds.

These results can be compared to those obtained for summer irrigated crops during the last three years (Table 3). For a corn crop, as well as for sorghum, grain yields were not significantly different under CT and DSM treatments. For winter crops some studies indicated that yield in DSM treatment is lower.

Table 3. Grain yield (Mg/ha) of previous campaigns

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.
CT: conventional tillage; DSM: direct seeding on mulch.

To analyse the effect of CT and DSM on soil properties, some soil data are presented in Figs 1 and 2. As plant density is different, soil water content values for 0-15 cm layer can be compared during two periods: at the beginning of the cropping season when plant water uptake was very low and when LAI was higher than 3 as water consumption is no longer influenced by plant density.

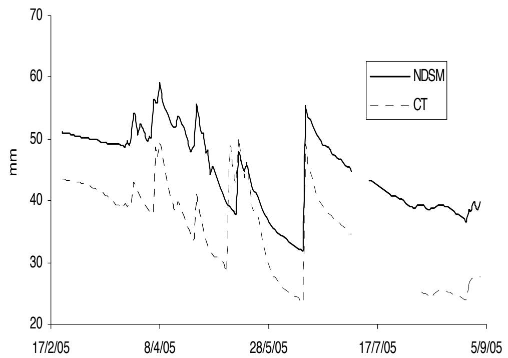

Fig. 1. Soil water content under NDSM and CT in 0-15 cm layer.

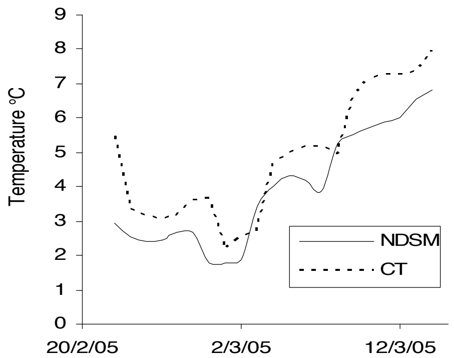

Fig. 2. Daily soil temperature (at 8:00 a.m.) under CT and NDSM at 6 cm depth.

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 concluded 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 an impact of DSM on conserving soil moisture (Lal, 1976; 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. At the Lavalette fields in 2005, tillage treatments showed considerable differences in soil bulk density at the top 30 cm soil profile after harvest (Table 4). In the first layer (0-5 cm) there is no real difference due to the treatment. 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.

Table 4. Soil bulk density in different subplots after harvesting

Depth (cm)	Subplots						
	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	-

CT: conventional tillage; R: rain fed; NDSM: north direct seeding on mulch; SDSM: south direct seeding on mulch.

The observations in DSM can be explained by settling of soil particles, which increased bulk density to a great extent under zero tillage system (Cassel and Nelson, 1985). Really, what is the effect of such a situation on rooting under Mediterranean climate? Root profiles were observed at harvest down to a depth of 1.5 m. Root development had the same order in the upper layers for the two treatments and a little difference in deeper layers was observed between CT and DSM treatments.

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. Under DSM, bulk density for the upper 25 cm is partially increased, but root development seems acceptable in comparing with CT for the upper layers.

References

Blevins, R.L., and Frye, W.W. (1993). Conservation tillage: An ecological approach to soil management. *Adv. Agron.*, 51: 33-76.
Bussière, F. and Cellier, P. (1994). Modification of the soil temperature and water content regimes by a crop residue mulch: Experiment and modelling. *Agric. For. Meteorol.*, 68: 1-28.

Cassel, D.K. and Nelson, L.A. (1985). Spatial and temporal variability of soil physical properties of Norfolk loamy sand as affected by tillage. *Soil Tillage Res.*, 5: 5-17.
Erenstein, O., (1996). *Evaluating the potential of conservation tillage in maize-based farming systems in the Mexican tropics*. NRG Reprint Series: 96-01. CIMMYT, Mexico, D.F., Mexico.
Fischer, R.A., Santiveri, F. and Vidal, I.R. (2002). Crop rotation, tillage and crop residue management for wheat and maize in the sub-humid tropical highlands: I. Wheat and legume performance. *Field Crops Res.*, 79: 107-122.
Fortin, M.C. (1993). Soil temperature, soil water, and no-till corn development following in-row residue removal. *Agron. J.*, 85: 571-576.
Lal, R. (1976). No-tillage effects on soil properties under different crops in western Nigeria. *Soil Sci. Soc. Am. J.*, 40: 762-768.
Lal, R. (1989). Conservation tillage for sustainable agriculture: Tropics versus temperate environments. *Adv. Agron.*, 42: 85-197.
Séguy, L., Bouzinac, S., Trentini, A. and Côrtes, N.A. (1996). L’agriculture brésilienne des fronts pionniers. *Agric. Dév.*, 12: 1-61.
Weill, A.N., McKyes, E. and Mehuys, G.R. (1989). Agronomic and economic feasibility of growing corn with different levels of tillage and dairy manure in Quebec. *Soil Tillage Res.*, 14: 311-325.