APPLICATION OF SOD SEEDING TECHNIQUES TO TEMPERATE RICE IN ITALY

APPLICAZIONE DI TECNICHE DI SEMINA SU SODO AL RISO TEMPERATO IN ITALIA

Eleonora Cordero[1*], Barbara Moretti[1], Luisella Celi[1], Cristina Lerda[1], Gianluca Beltarre[2], Daniele Tenni[2], Marco Romani[2], Dario Sacco[1]

[1]Dept. of Agricultural, Forest and Food Sciences, University of Turin, Grugliasco, Italy
[2]Rice Research Centre, Ente Nazionale Risi, Castello d'Agogna, Italy
*eleonora.cordero@unito.it

Abstract
Conservation agriculture (CA) can improve sustainable rice production. This work evaluated the effect of different CA practices on rice agronomic system. A four-year experiment (2013-2016) was carried out in Crescentino (VC), North-West Italy, comparing three tillage managements (sod dry seeding, sod wet seeding and ploughing), combined with three N fertilisation levels (0-110-160 kg N ha^{-1}) and two straw management (straw retained and removed). Yield and yield components were influenced by both tillage practices and N fertilisation, but not by straw management. Sod seeding reduced grain yield of about 16% with respect to ploughing, because of the lower panicle density and higher sterility. Rice responded to N fertilisation, but the higher sterility limited the positive effect at high N rates. Moreover, in sod seeding, high N supply increased Apparent Recovery (AR). Straw retention improved soil quality, increasing soil organic carbon concentration.

Keywords: conservation agriculture, sod seeding, nitrogen efficiency, soil organic matter
Parole chiave: agricoltura conservativa, semina su sodo, efficienza dell'azoto, sostanza organica del suolo

Introduction
Conservation agriculture (CA) is one of the best management practice for sustainable crop production (Zheng *et al.*, 2014). As for other cropping systems, CA techniques may be effective in rice cultivation, because of their potential benefit for labor saving and soil conservation. Many studies have been undertaken to investigate the effect of CA and nitrogen (N) fertilisation on rice yield and components (Huang *et al.,* 2015). However, environmental and management conditions largely influence final results. The purpose of this study was to analyze the rice cropping system, evaluating grain yield, yield components, N efficiency and soil C and N content related to the main CA practices, N rates of applications and straw managements.

Materials and Methods
A specific field experiment was carried out from 2013 to 2016 in Crescentino (VC), North-West Italy. The soil texture was silty-loam. The experiment compared three tillage managements: sod seeding based on dry seeding and delayed flooding (sod dry seeding), sod seeding based on water seeding (sod wet seeding) and conventional tillage based on water seeding (ploughing). These three different tillage practices were combined with three N fertilisation rates (0-110-160 kg N ha^{-1}) and two different straw managements (straw retained and straw removed). The treatments were laid out in a split split plot randomized complete block design, with tillage practices in the main plots, N fertilisation rates in the subplots and straw managements in the sub-subplots. Three blocks were established. The rice cultivar was CL 26, a long B grain variety, sown at a seed rate of 180 kg ha^{-1}.
Grain yield normalized to a moisture content of 14% was determined at harvest. Moreover, yield components (i.e. panicle density, number of spikelets per panicle, 1000-grain weight and sterility) were measured. Apparent Recovery (AR) was determined as the ratio between the difference of the amount of N taken up by the fertilised crop and the N uptake of the unfertilised treatment, divided by the N supplied. Finally, the effect of CA practices on soil C and N content and soil organic matter was evaluated.
Data were analyzed through a linear mixed effects model. If significant, differences between means were separated through Bonferroni post hoc test.

Results and discussion
Tillage practices and N fertilisation affected both yield and yield components. However, no interaction resulted to be significant except for spikelets number per panicle and sterility. Straw management had a negligible effect on the analysed parameters.
Both sod seeding techniques produced about 16% less grain than ploughing (*Figure 1*). Since the experiment was four-year old, and no interaction with year resulted to be significant, it could be hypothesized that this yield gap would not reduce over time.

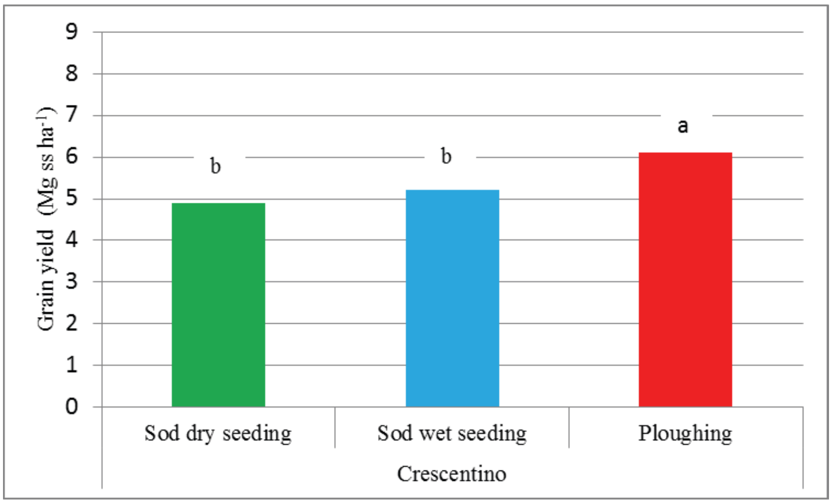

Fig. 1: Effect of different tillage management on grain yield. Different letters show significant differences according to Bonferroni post hoc test (P<0.05).
Fig. 1: Effetto di diverse tecniche di lavorazione sulla produzione di granella. Lettere differenti indicano differenze significative per il test post hoc di Bonferroni (P<0.05).

The main reason leading to yield gap in sod seeding treatments was the limited panicle density (*Table 1*), that induced a higher number of spikelets per panicle, especially in sod dry seeding. Unfortunately, the increased panicle length was combined with a higher sterility, compromising final grain yield.

Tab. 1: Effect of different tillage management on grain yield components. Different letters show significant differences according to Bonferroni post hoc test (P<0.05).
Tab. 1: Effetto di diverse tecniche di lavorazione sulle component della produzione. Lettere differenti indicano differenze significative per il test post hoc di Bonferroni (P<0.05).

Tillage management	Panicle density (Panicle m^{-2})	1000-grain weight (g)	Spikelets number per panicle (n°)	Sterility (%)
Ploughing	628 a	22.6	101 c	15.8 c
Sod dry seeding	520 c	22.6	131 a	23.4 a
Sod wet seeding	514 b	22.6	114 b	18.3 b

In this experiment, N fertilisation was studied in order to check the possibility of compensating yield losses in sod seeding with a higher N supply. The increased grain production obtained in the higher fertilisation rates was compromised by an increase in sterility percentage. Consequently, grain yield did not show any statistical differences between the two fertilised treatments (*Figure 2*).

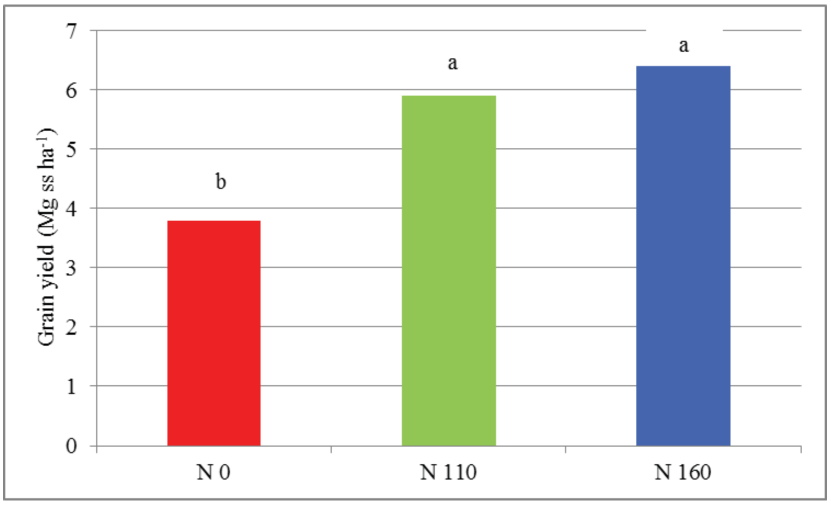

Fig. 2: Effect of different N rates on grain yield. Different letters show significant differences according to Bonferroni post hoc test (P<0.05).
Fig. 2: Effetto di diversi apporti di azoto sulla produzione di granella. Lettere differenti indicano differenze significative per il test post hoc di Bonferroni (P<0.05).

N fertilisation rates affected grain and total N concentration and consequently N uptake. The interaction between tillage and fertilisation was significant (*Figure 3)* and highlighted by the steeper increase in sod seeding treatments than in ploughing.

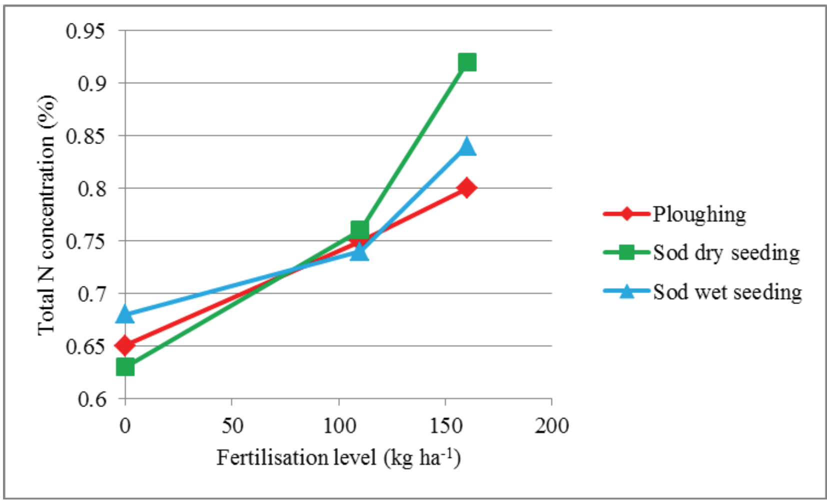

Fig. 3:Relationship between N fertilisation and total N concentration.
Fig. 3:Relazione tra apporti di N e concentrazione di N nella pianta intera.

Consequently, sod seeding treatments showed a higher AR in the higher N rate. Conversely, in ploughing treatment the increase in N fertilisation lead to a lower AR (*Figure 4*).Therefore, it is possible to improve nitrogen use efficiency in sod seeding treatments by increasing N supply up to 160 kg N ha^{-1}.

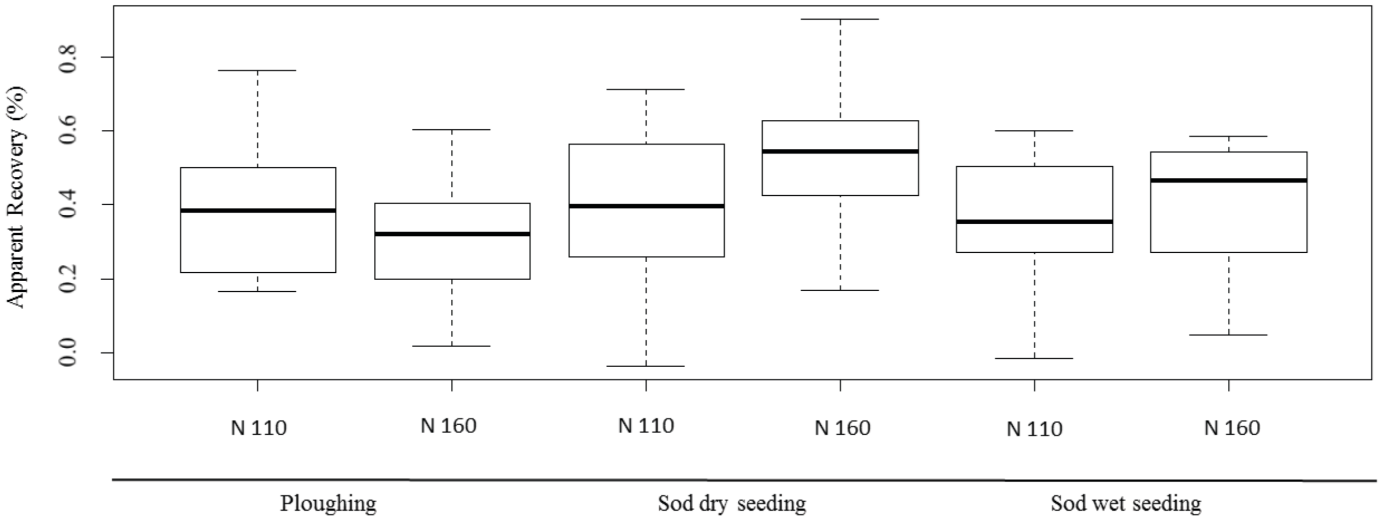

Fig. 4: Influence of tillage practices and N fertilisation on Apparent Recovery.
Fig. 4: Influenza di tecniche di lavorazione e apporti di azoto sull'Apparent Recovery.

C concentration and C/N ratio did not vary between the different treatments. However, straw retention increased C and C/N parameter in the labile organic fractions (FPOM). Focusing on this labile C, the distribution along the soil profile was more homogeneous in the ploughed treatments, as no differences emerged between 0-12.5 cm and 12.5-25 cm layer (*Figure 5*). Conversely, in sod seeding it was evident the accumulation of FPOM in the upper layer.

F. Ventura, G. Seddaiu, G. Cola (a cura di), Atti del XX Convegno AIAM e XLVI Convegno SIA.
Milano, 12-14 settembre 2017.
DOI 10.6092/unibo/amsacta/5692

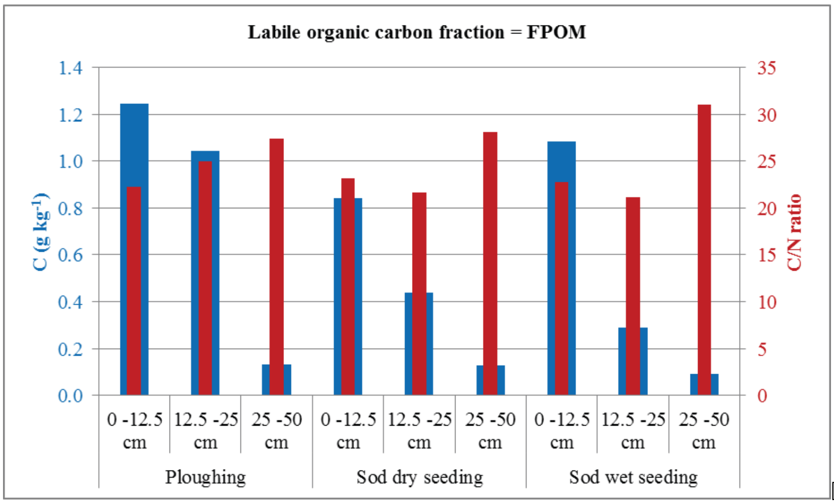

Fig. 5: C concentration and C/N ratio of the labile organic matter (FPOM) in the soil profile.
Fig. 5: Concentrazione di C e rapporto C/N della frazione labile di sostanza organica (FPOM) lungo il profilo del suolo.

In ploughed treatments, FPOM degradation decreased whit depth, as shown by the higher C/N ratio. Instead, sod seeding treatments showed a faster degradation in the 12.5-25 cm, as demonstrated by a lower C/N. This fact can be explained considering that less labile organic matter reaches this layers, but this amount remains here longer, having then more time for degradation.

Conclusions

Sod seeding techniques applied to rice compromised rice grain yield, as a result of low panicle density and high sterility. Rice varieties more adapted to CA, able to compensate the lower panicle density by increasing yield components, could probably limit the yield reduction. Alternatively, seeding rate in sod seeding treatments could be increased in order to compensate the yield gap.
The increase of N supply up to 160 kg N ha^{-1}in sod seeding treatments seems also an efficient solution to reduce grain yield losses as it does not imply any reduction in N use efficiency, but sterility must be controlled.
Finally, straw return has to be promoted as an efficient tool for soil quality improvement. However, it could limit plant emergence, so its adoption is recommended to be coupled with the use of row cleaners and/or straw spreaders.

References

Huang M., Zhou x., Cao F., Xia B., Zou Y., 2015. No-tillage effect on rice yield in China: a meta-analysis. Field Crops Research 183:126-137.
Zheng C., Jiang Y., Chen C., Sun Y., Feng J., Deng A., Song Z., Zhang W., 2014. The impacts of conservation agriculture on crop yield in China depend on specific practices, crops and cropping regions. The Crop Journal 2:289-296.

DOI 10.6092/unibo/amsacta/5692