Durum Wheat Yield And Quality In A No-Tillage Experiment

Michele Rinaldi[1], Antonio Troccoli[1], Angelo Pio De Santis[1], Salvatore Antonio Colecchia[1], Emanuele Barca[2]

[1]Council for Agricultural Research and Economics, Research Centre for Cereal and Industrial Crops (CREA-CI), S.S. 673, km 25,200, 71122 Foggia, Italy

[2]Water Research Institute of the Italian Research Council (IRSA-CNR), Bari, Italy

Introduction

Soil fertility, due to soil erosion and organic matter depletion, is the biggest sustainability challenge for conventional tillage in dryland agriculture of Southern Italy and the adoption of no tillage practices can address these issue (Troccoli et al., 2015). No tillage and residues management are widely considered the most important conservation agriculture practices as alternatives to conventional ploughing and tillage disturbance (Gristina et al., 2018).However, although direct seeding and residues surface disposal increase water holding capacity, crop yield resulted often limited in the transition period. Soil physical, chemical and microbiological changes, typically long term effects, occur in the 3-5 years range from the beginning of tillage management (Colecchia et al., 2015).

Aim of this work is to assess the response to two different soil tillage management in a Vertisol of Southern Italy of durum wheat grain yield and quality in a 4-year experiment.

Materials and Methods

The experiment was established in the fall 2013 at the Research Centre for Cereal and Industrial crops (Foggia, Italy; 41° 28'N, 15° 32'E; 75 m a.s.l.) on a clay-loam soil (Typic Chromoxerert). Main soil traits were 30% clay, 25% sand; pH 7.5; 12.5 g kg^{-1} total C. Mean long-term rainfall of the site is 479 mm. Mean air temperatures are 12.2 ºC in fall, 8.2 ºC in winter, and 17.6 ºC in spring.

The experiment was a randomized block design, replicated 5 times and elementary plots of about 1 ha size. Two soil management systems (SMS) were compared: direct seeding on no tillage soil (NT) and minimum tillage (MT).MT included wheat straw removal before the tillage operation, disk cultivator at 15 cm depth and chisel at 10 cm before sowing; NT included crop residues left on soil surface, use of glyphosate at a rate of 720 g of active ingredient $ha^{-1}$for weed control one week before sowing (Gaspardo NO-TILL).Common durum wheat management was followed: sowing at the beginning of December, cv. Sfinge, fertilization at the end of tillering with 400 kg ha^{-1} of ENTEC 25:15:0, chemical weed control at boot stage, harvest at the end of June.

Grain yield was recorded in 30 georeferenced sub-plots of 30 m^2 for each plot; on the grain sample test weight and protein content was measured with grain analyzer Foss Infratec 1241. A FAO-UNEP Aridity Index (AI = ΣRainfall/ΣET0) of the period March-May for each year, was also calculated.

A total of 1200 observations (30 subplots x 5 plots x 2 SMS x 4 Years) were tested for normality and variance homogeneity and submitted to a mixed model, considering "Year" as repeated factor and the subplot geographic coordinates.

Results

The grain yield data distribution resulted not Gaussian in the four years (Fig. 1) and for the two SMS. The means and standard deviations of the SMSxYear interaction are reported in Fig. 2. Since the distributions by years are not generally Gaussian, the (ordinary non-parametric) bootstrap procedure has been applied to estimate reliably the average difference between NT and MT values.

The difference between the averages are always significant and the tillage effect is dominant with except the year 2017, when NT produced more grain yield than MT treatment. The general grain yield level, low for the continuous wheat cropping, showed an inversion of tendency in the 4th year of experiment, and specifically from -4.9% (average of first 3 years) to +8.6% (about 0.21 t ha^{-1}) of NT respect to MT. This change can be due to the soil quality improvements and a steady-state condition of soil, after a period of some years from the start of SMS application.

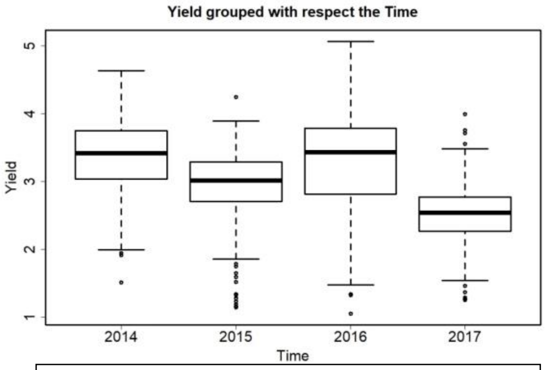

Fig. 1. Box plot of the data distribution in the 4 years of experiment.

In this short transition period, changes in soil compaction has been also observed, with a reduced penetration resistance at the 4th year of SMS application in NT (Rinaldi et al., 2018). Furthermore, a climatic effect can also be considered, because the 2017 experienced as a very dry cropping season, with a large evapotranspirative demand and an AI of 0.37.

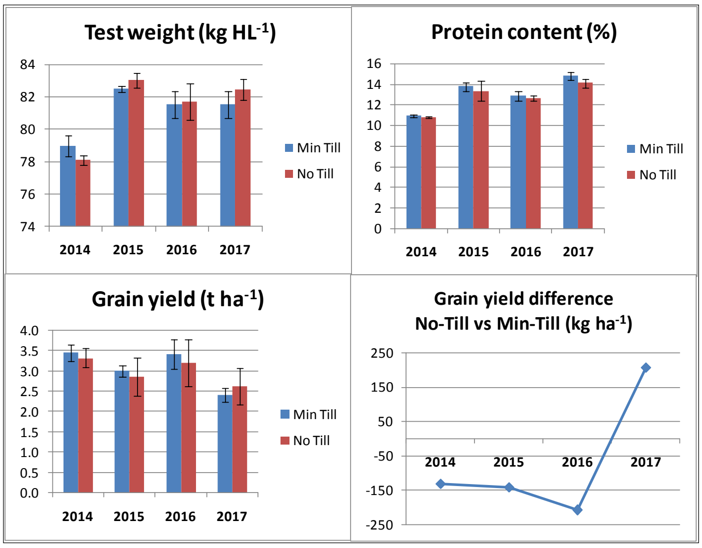

Fig. 2. Means and std of SMSxYear interaction of the 3 examined characters; in the last graph the grain yield difference (NT - MT) has been reported.

The statistical analysis showed significant differences in the SMSxYear interaction for test weight, showing a superiority of NT respect to MT only in the 2nd and in the 4th year of treatment application: these years both resulted "semi-arid" for the AI values. This can be explained by soil moisture at grain filling stage, wetter in NT than in MT for crop residues mulch effect (Rinaldi et al., 2015).The grain protein content resulted greater in MT (+0.4%) than in NT, following, in general, an inverse correlation with grain yield.

Conclusions

Even if preliminarily, the experiment confirms a minimum length period of 3 years as time-frame for reaching a new steady-state in no-tillage management, characterized by an enhanced soil quality and a stabilized production levels. In semi-arid environment in Southern Italy, no tillage and residues application can improve soil moisture at grain filling stage, soil characteristics and, finally, grain yield, after some years of transition period, especially in dry years. Further in-depth analysis is, however, necessary, especially about soil chemical and microbiological aspects.

Acknowledgments

The work is supported by the “STRATEGA”, project funded by Regione Puglia - DipartimentoAgricoltura, Sviluppo Rurale ed Ambientale, CUP: B36J14001230007.

References

Colecchia et al., 2015. Effects of tillage systems in durum wheat under rainfed Mediterranean conditions. Cereal Research Communications, 43, 704–716.

Gristina et al., 2018. No-till durum wheat yield success probability in semi arid climate: A methodological framework.Soil and Tillage Research, 181, 29-36.

Rinaldi et al., 2015. Valutazione del compattamento e dell'umidità del suolo in frumento duro gestito in modo conservativo e convenzionale. Atti del XLIV Convegno SIA, 14-16 Settembre, Bologna, ISBN 9788890849923

Rinaldi et al., 2018. Conversion to No Tillage Consisted in Reduced Soil Penetration Resistance Below Tillage Depth After 3 Years in a Vertisol. Proceedings SIA 2018.

Troccoli et al., 2015. Is it appropriate to support the farmers for adopting Conservation Agriculture? Economic and environmental impact assessment. It. J. of Agron., 10:169-177.

Società Italiana di Agronomia

Proceedings of the XLVII Conference of the Italian Society for Agronomy

University of Palermo

Dipartimento di Scienze Agrarie, Alimentari e Forestali

Complesso Monumentale di San Pietro

Marsala (TP)

12-14 September 2018

Società Italiana di Agronomia

A cura di
Edit by

Giovanna Seddaiu
Marcella Giuliani
Claudio Leto

Comitato Scientifico
Scientific Committee

Società Italiana di Agronomia
www.siagr.it

ISBN 978-88-904387-4-5