The performance of sunflower under conservation agriculture

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Farmer-led transformation of agricultural production systems based on conservation agriculture principles is gathering momentum globally as a new trend for the 21st century. Worldwide, the area under no-till is currently estimated at 157 million hectares.

Since the 2008/09 season, conservation agriculture cropland has expanded at an average rate of 10 million hectares per year, which attests to the increased interest in this production method. The greatest rate of adoption has been observed in North and South America, Australia and Asia. More recently, an awareness of and support for conservation agriculture in Europe and Africa has increased.

Defining conservation agriculture

The principles of conservation agriculture include minimal soil disturbance (reduced tillage or no-till), retaining crop residues on the soil surface to produce a layer of mulch, as well as multiple cropping (such as crop rotation).

Several studies have shown that conservation agriculture practices may induce higher soil organic carbon (C) and nitrogen (N) levels when compared with conventional tillage practices. By emitting less carbon dioxide and capturing more carbon in the soil, conservation agriculture helps counter the effects of global warming. Conservation agriculture slows down runoff and soil erosion, improves water infiltration and restores soil quality. This, in turn, improves the efficiency of grain production while enhancing sustainability.

In South Africa, the Western Cape has the best adoption rate, with nearly 80% of producers owning no-till machinery. There is also a strong group of no-till producers in the Bergville and Winterton areas of KwaZulu-Natal. These areas lead the way in terms of conservation agriculture in the country.

Sunflower conservation agriculture

In North America, the no-till sunflower adoption rate varies. A 2011 survey showed that 100% of the sunflower area in South Dakota in the United States (US) was under no-till, with other states such as Vermont (88%) and Minnesota (78%) under conventional tillage. In the Canadian province of Manitoba, 100% of sunflower fields were conventionally tilled. There has been a positive trend during the past few years of more sunflower hectares being planted using no-till farming practices in the Great Plains region, which stretches across parts of the US and Canada.

In the Pampas region of Argentina, the relatively low adoption rate of no-till sunflower production is attributed to a lack of information on agronomic practices. Owing to a lack of experience and knowledge, South Africa also lags in the conversion to conservation agriculture systems, especially in terms of sunflower production. While producers are eager to adopt conservation agriculture, the lack of local guidelines and experience hinders the process.

Response to the no-till method

Several studies abroad have recorded how sunflower yield respond to conservation agriculture, particularly to no-till practices, and the results are contradicting. Higher no-till sunflower yields were recorded in two out of five years in Kansas in the US. In Spain, no-till only resulted in higher sunflower yields compared to conventionally tilled soil in dry years with less than 490mm of rain.

Several researchers reported a neutral effect on clay soil. In Texas, sunflower yield showed no difference between tillage and no-till in clay-loam soil. The same is true for clay soil in North Dakota. On vertic soil in Morocco, the choice of tillage method did not affect sunflower yield. Similar results were found in Brazil, and on clay-loam soil in Turkey, Iran and the Pampas region of Argentina.

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Reduced no-till sunflower yields are also reported. In Hyderabad in India, conventionally grown sunflower produced an 80% higher yield than no-till sunflower on a sandy clay-loam soil. Strip-tilled sunflower showed an 11% higher yield than no-till sunflower in Kansas in the US.

A South African trial

Researchers at the Grain Crops Institute (GCI) at the Agricultural Research Council (ARC) conducted a three-year field trial in Potchefstroom. The trial, which was planted on Avalon soil, showed that tillage system and/or nitrogen fertilisation influenced plant height, biomass, as well as the N, phosphorus, potassium and sulphur content of the biomass, at different growth stages. Calcium content was the only variable unaffected by either tillage system or nitrogen fertilisation.

During most seasons, either tillage system, nitrogen fertilisation or both affected the uptake of all elements, which is derived from the biomass and its elemental concentrations. This indicates that the uptake of nutrients is affected by an interaction between seasonal weather, especially rainfall, as well as tillage and nitrogen fertilisation. No differences in diseases, pests and weeds were observed among tillage systems or nitrogen fertilisation rates.

Tillage and sunflower seed yield

The mean sunflower seed yield under the no-till system was significantly lower (15%) than that of the tilled treatment in 2013/14. This difference declined to an insignificant 9% in 2014/15, followed by the no-till system's significant advantage of 34% over the yield of the tilled system.

This result is probably a reflection of the typical trend often found in soil that is in transition from an unstable tilled system to a stable no-till system, where the soil's physical, chemical and biological properties are at or close to its optimum. Additionally, the sunflower yield was higher under no-till conditions than under conventionally tilled soil during the 2015/16 season, which might be due to the drought. Similar results were noticed for the maize trials in North West.

Figure 1: Sunflower yield response to different tillage systems and levels of nitrogen fertilisation.

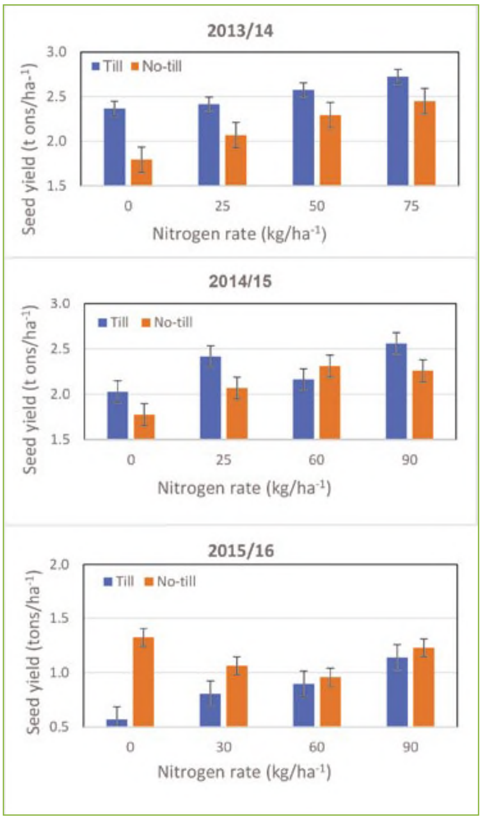

Table 1: Protein content (g/kg^{-1}) of sunflower seed as affected by soil tillage system and nitrogen fertilisation rates.

N-rate (kg/ha^{-1})	Till	No-till	N-rate (kg/ha^{-1})	Till	No-till	N-rate (kg/ha^{-1})	Till	No-till
2013/14			2014/15			2015/16		
0	142	144	0	144	139	0	178	177
25	145	147	30	150	163	30	177	190
50	156	145	60	187	184	60	192	209
75	157	157	90	186	196	90	197	210
Tillage	NS			NS			NS	
Nitrogen	**			**			*	
T x N	NS			NS			NS	

NS = Not significant, T = Tillage, N = Nitrogen
*Significant at the 0,05 probability level and **0,01 probability level

Table 2: Oil content (g/kg^{-1}) of sunflower as affected by soil tillage method and nitrogen fertilisation rates.

N-rate (kg/ha^{-1})	Till	No-till	N-rate (kg/ha^{-1})	Till	No-till	N-rate (kg/ha^{-1})	Till	No-till
2013/14			2014/15			2015/16		
0	428	437	0	472	476	0	456	449
25	423	433	30	467	463	30	447	430
50	428	427	60	449	454	60	440	404
75	432	423	90	449	450	90	446	417
Tillage	NS			NS			**	
Nitrogen	NS			**			*	
T x N	NS			NS			NS	

NS = Not significant, T = Tillage, N = Nitrogen
*Significant at the 0,05 probability level and **0,01 probability level

Nitrogen fertilisation

The results from the Potchefstroom field trial over three seasons indicated no significant interaction between tillage systems and nitrogen fertilisation rates. This indicates that the yield-to-nitrogen-rate response curves of the tillage systems are similar, implying that any further increase of nitrogen fertiliser from the recommended initial application does not result in an increased yield (*Figure 1*).

Sunflower oil and protein content

With increased nitrogen application rates, the seed protein content improved during all seasons, confirming previous results. Different tillage systems have no significant effect on seed protein (*Table 1*).

Tillage system and nitrogen fertilisation affected the seed oil content, but there was no interaction between the factors in one or more seasons, indicating that the effect of tillage systems and nitrogen fertilisation on the seed oil content is unpredictable (*Table 2*).

In conclusion

The mean seed yield of the no-till system was significantly lower than that of the tilled treatment in the first growing season. This difference declined to an insignificant discrepancy in the second season, followed by the no-till system's significant advantage of 34% over the tilled system's yield.

The seed protein content improved in all seasons with increased nitrogen application rates. Tillage system and nitrogen fertilisation affected seed oil content but showed no interaction. This lack of interaction shows that the effect of tillage systems and nitrogen fertilisation on the seed oil content is unpredictable.

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