The relationship between conservation tillage practices and cover crops in the Sandveld

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Conservation tillage

Conservation tillage embraces crop production systems involving the management of surface residues. These practices and cover crop management have the potential to limit the degradation of soil and to maintain crop yields as well as ecosystem stability. The frequent cultivation of fields removes plant residues and organic matter, causing increased rates of soil mineralisation, resulting in losses of soil organic carbon. Tillage plays a major role in modification of soil structure as it influences the distribution of energy rich organic matter within the soil profile and thus impacts on the energy flow and the dynamics of soil geo-chemical functions.

Cover crops

Cover crops are plants that are grown primarily to:
- Improve and build soil fertility and quality: Cover crops can be good scavengers of soil N and can cycle significant amounts of recovered N to the follow-up crop.
- Manage soil erosion: The run-off from a field will be reduced and thus the cover crop will protect the waterways and downstream
ecosystems from excessive erosion. The roots also produce pores in the soil which allow for water to penetrate deep into the soil and thus help to conserve water in the soil.

- Suppress the growth and development of weeds and help to control diseases and pests: The occurrence of bacterial and fungal diseases in a soil will be reduced due to the break in disease cycles by the cover crops.
- It will positively improve the biodiversity of an area by increasing the variety of species.

Grasses or legumes are usually utilised as cover crops, but it can comprise other green plants or mixtures of plants.

Three tillage treatments are investigated:
- a conventional tillage treatment which includes a mouldboard plough to a depth of 350 mm combined with a rip treatment 600 mm deep between planting rows,
- a conservation rip treatment to a depth of 600 mm between planting rows and
- a paraplough treatment over two planting rows to a depth of 600 mm.

Three cover crop treatments were also investigated in combination with the three tillage treatments, the cover crops were:
- Black oats (C1),
- rye (C2) and
- rye+small grain (C3).

The cover crops were planted post potato harvest and in the rye+small grain treatment the rye was planted just after harvest and the small grain was planted the year before the establishment of the potato crop of the following cycle, coinciding with the first winter rains. The percentage cover (Figure. 2) of the cover crop treatments was determined by utilising the line-transect method in March of each year.

Cover offered by the cover crops

In the first season it was evident that the rye cover...
treatment resulted in the highest percentage cover with an average of 91% cover with the rip treatment, 89.5% with the conventional mouldboard treatment and 86.5% with the paraplough treatment. All values were high in the first year; the target percentage cover is at least 30% before commencement of planting by conservation farming standards. These percentages of cover will, however, decline as these values are for the first season after planting of cover crops and the potato planting will only commence after four years. The black oats paraplough treatment gave the lowest cover of 76%, but it is not statistically different from the treatments that gave up to 86.5% cover. The number of cover crop plants per square metre showed that the paraplough tillage treatments gave the highest number of plants per square metre with all cover crop treatments with 367.50, 356.25 and 301.25 plants/m² for the black oats, rye and rye+small grain treatments respectively in year one. Rye always provided a good cover as illustrated in Figure 3 with normal rainfall after establishment as in the first season with 124.4 mm in the period from August to December.

The data of the second season showed that the rye and rye+small grain cover crops resulted in the highest percentage cover ranging from 50-66%. The black oats treatments gave the lowest cover of 24-34% which was statistically lower than the other cover crop treatments. The number of cover crop plants per square metre showed that only the rye mouldboard treatment differed statistically from the black oats rip and black oats paraplough treatments. The rye mouldboard treatment resulted in 194.25 plants/m² whereas the latter had 148.25 and 146.25 plants/m² respectively. These obtained values were lower than that of the previous season, but this was due to adverse climatic conditions. Rye and rye+small grain cover crop treatments resulted in the highest percentage cover ranging from 37-43% in the third year of the trial. These values are acceptable because it is above the 30% norm which hopefully can be maintained up to the next potato cycle. The black oats resulted in 13-17% cover which were statistically lower than the other cover crop treatments and can therefore not be recommended as cover crop under the current conditions.

Figure 2: Percentage cover (means followed by the same letter did not differ significantly at the 5% level).
The overall cover percentage the third season was lower than the previous two seasons which can also be attributed to the serious drought conditions which prevailed earlier in the season, just after establishment of the cover crop with only 6.6 mm rain from August to December. The number of cover crop plants per square metre ranged from 210.5 plants/m² to 279.25 plants/m² for the black oats and rye respectively.

Due to the absence of sufficient follow-up rains, 73.9 mm in the period from August to December in the fourth season, the highest achievable cover was 24%, which was not sufficient to provide cover up to the next potato planting. The number of cover crop plants ranged from 64 up to 100.25 plants/m², which was lower than in the previous years. The lowest percentage cover achieved was 9.5% which will have a minimal effect on the follow up potato crop.

The interaction between tillage treatments and cover crop treatments

Over the period of four years (Figure 4), the highest total dry weight production was 653.25 g/m² in the conventional tillage regime with rye as cover crop. The results clearly indicated that the black oats cover crop treatment resulted in the lowest dry mass per square metre. The comparison of the three cover crop treatments per tillage regime shows that rye and rye+small grain cover crop treatments statistically outperformed the black oats cover crop.
oats treatment at this timeline of the trial with all three tillage treatments.

The highest total dry cover crop mass in the second year was 150.0 g/m² in the conventional tillage regime with rye+small grain. Rye and rye+small grain combinations only showed significant differences between the rye+small grain mouldboard and the rye+small grain paraplough treatments which showed a difference of 35 g/m² dry mass. The results indicate that the black oats cover crop treatment resulted in the lowest mass of dry matter per square metre when compared to the other cover crop treatments. It is evident from the results, from the first to fourth year, that when black oats was used as cover crop in any of the tillage regimes it had the lowest dry mass production throughout the first four year cycle of the trial. The black oats combinations had significantly lower bio-mass when compared to any of the treatment combinations, encircled in red in Figure 4. The dry mass per square meter production of the other treatments resulted in no statistical difference between any of them in the third year and only in the fourth year of the cycle the rip rye treatment outperformed the rip rye+small grain treatment. The comparison of the three cover crop treatments per tillage regime showed that the cover crop treatment rye and rye+small grain statistically outperformed the black oats treatment in all four seasons. During the second cycle of potato production it is now recommended that fodder barley as cover crop should be planted in place of black oats to achieve higher cover crop outputs. Figure 5 shows clearly how the black oats were outperformed by the other cover crop combinations. The higher dry matter production experienced in the first year was due to good follow up rains that followed the establishment of the cover crop after the potatoes were harvested. The three seasons thereafter did not produce the high optimum dry matter production as was experienced in the first year due to drier conditions after the establishment of the cover crops.

Weed control

During the first four years of the trial weeds were not problematic. White Goosefoot (Chenopodium album), Withondebossie, numbers ranged from 4.5 to 21.0 plants/m² over all treatment combinations in the first season. The paraplough treatment with rye as cover crop treatment showed the lowest number of White Goosefoot, but it only differed significantly from the rip black oats and conventional black oats treatment. Sowthistle (Sonchus oleraceas), Sydissel, only showed significant differences between the lowest paraplough rye treatment of 8 plants/m² and the highest rip rye+small grain treatment of 19 plants/m². The total dry mass of all weeds showed that the paraplough treatments with cover crop combinations rye+small grain and rye resulted in the lowest dry matter mass of weeds i.e. 10.36 and 7.2 g/m² respectively (Fig. 6) which indicates that the minimum tillage produced by the paraplough did not lead to increased weed infestation. When only cover crop is considered it is evident that the black oats cover crop treatment resulted in the highest dry mass of weeds per square metre which was 76.71 g/m² for the conventional treatment, 83.56 and 31.45 g/m² for the rip and paraplough treatments respectively. These results are due to the lack of performance by the black oats as sufficient cover crop. The cover crop treatment eventually recommended will have to suppress weed development and contain the spread thereof. No significant differences were found when cover crop treatments inside tillage regimes were compared.

The pivot location in the second year of the trial was relatively weed free and therefore resulted in low numbers of weeds. The total dry mass of all weeds showed that the mouldboard treatments with cover crop combinations black oats and rye resulted in the highest dry matter mass of weeds i.e. 7.55 and 0.32 g/m² respectively. White Goosefoot (Chenopodium album) numbers were 0.5 plants/m² with the black oats and rye mouldboard treatment combinations. The other treatments showed no White Goosefoot (Chenopodium album) infestations. Sowthistle (Sonchus oleraceas) was only present in the black oats mouldboard treatment at 1.0 plants/m² which did not pose a risk. The other cover crop treatments inside tillage regimes showed no recorded presence of weeds.

The total dry mass of weeds, in the third season, ranged from 0.49 to 2.28 g/m² which were very low, due to very low rainfall of only 6.6 mm from August to December. White Goosefoot (Chenopodium album) numbers ranged from 1.5 to 4.75 plants/m². White
Goosefoot was the only weed that was present in all treatments, but it was present in such low numbers that it posed no problems for production purposes.

During the fourth year, once again, very low weed numbers were encountered and ranged from 0 to 3 plants/m² with a dry matter mass ranging between 0 and 8.4 g/m² with no significant differences between treatments. Stinkkruid (Oncosiphon grandiflorum) was the only weed present in all tillage regimes with a maximum number of 3 plants/m². White Goosefoot (Chenopodium album) was only present in the mouldboard treatment ranging from 0 to 1 plants/m².

The results thus far on the prevalence of weeds showed no negative effects as a result of the paraplough treatment compared to the conventional tillage practices. Should the data follow the same trends in the future, it is evident that the weeds prevalent in the Sandveld would not be an inhibitive factor in the process to convert to conservation tillage practices.

The results after the first cycle are very positive regarding conservation tillage and cover crops, it will be of great significance if these outcomes are to be repeated in the forthcoming growth cycles, when potatoes are established again, as this could set new standards for potato production due to the fact that it will not only conserve the soil dynamics but will eventually regenerate it over time. Black oats will be replaced by fodder barley due to its lack of performance, possibly due to the low rainfall which was encountered after establishment of the cover crops from August to December for all years except the first year, in order to achieve higher cover percentages which could suppress the development of weeds.

I wish to thank Albert de Villiers and his team for their valuable contribution to the success of this trial.

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