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FINAL REPORT 2024

Winetech Number: P04000236

1. PROGRAMME & PROJECT LEADER INFORMATION

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2. PROJECT INFORMATION

Project title	Effect of mechanical pruning on grapevine trunk diseases
Short title	Mechanical pruning and vine diseases

Fruit kind(s)	wine grapes		
Start date (mm/yyyy)	2019-04	**End date** (mm/yyyy)	2023-03

Keywords	mechanical pruning, trunk diseases, prune wound infections

	CFPA	RAISIN SA	HORTGRO	SATI	WINETECH	ARC	OTHER
TOTALS All years	R 0	R 0	R 0	R 0	R 952278	R 564413	R 0

Total cost of the entire project	R 1516691

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3. EXECUTIVE SUMMARY

Objectives and Rationale
The study aimed to determine the effect of mechanical pruning (MP) on the occurrence of grapevine trunk disease pathogens compared to conventional hand pruning (HP).

Methods
During the dormant seasons of 2019, 2020, 2021 and 2022, selected vineyards in Robertson, Goudini / Aan de Doorns, Vredendal and Upington were hand or mechanically pruned. From the mechanically pruned vines (MP), 10 pruning stubs plus at least 4-5 years older growth were removed (as one intact piece). In the hand-pruned vineyard (HP), the distal spur, together with ~10cm of the cordon were removed. Fungal isolations were conducted from samples, and the pathogen incidences and severities were determined.

Key Results
In general, HP vines had significantly higher incidences and severities of aggressive canker and dieback pathogens, especially wood-rotting Basidiomycetes, Botryosphaeriaceae, Togniniaceae, and Diatrypaceae (only in 2019). Very few basidiomycetes were observed in the mechanically pruned vines; however, they were abundant in the HP vineyards.

Key Conclusion of Discussion
Mechanical pruning is a viable option to limit the effect of trunk pathogens and increase the lifespan of the vineyards. The explanation for the higher incidence in hand-pruned vines could be two-fold, firstly, the hand-pruned vines had larger wounds. This is likely due to the technique of conventional hand pruning, which generally cuts back to two-bud spurs, resulting in "severe" cutback of spurs to prevent the build-up of old wood, creating larger wounds. Secondly, the length of the two-bud spur is significantly shorter in hand-pruned vines, and the pathogen only has a short distance to colonise before it reaches the older wood of the spur and cordon, where it can colonise and kill the wood. Even though mechanically pruned vines have more wounds since there is a larger number of shoots and wounds can be uneven and jagged, the wounds are smaller, further from the older wood, and the longer canes give the vine more opportunity to compensate when infection occurs.

Take Home Message for Industry
Mechanical pruning could increase the lifespan of vineyards to complement other benefits of MP, like reduced labour costs, increased yield and acceptable or increased wine quality. However, mechanical pruning is a good alternative to hand pruning if vines have sufficient vigour and are trained on the correct trellis system. The larger crop load and expanded growth above ground require more water and fertiliser to apply mechanical pruning sustainably. Additionally, mechanically pruned vines must be mechanically harvested. For these reasons, hand-pruned vineyards should not be converted to mechanically pruned vineyards. Preparation is key. Before considering mechanical pruning, ensure that you have the correct trellis system, row spacing, rootstock-scion combination, etc. and consult experts in the field.

4. PROBLEM IDENTIFICATION AND MOTIVATION

Problem Identification

"Effect of mechanical pruning on vine diseases" has been identified as a priority in the "Research strategy for SA Wine Industry – 2018", Theme 2 "Health of Vitis species", "Grapevine Fungi & Bacteria Protection", 2.2.2.2. "Effect of pruning practices specifically on dieback". No research has been done in South Africa to study the effect of mechanical pruning (MP) on vine diseases. The project aims to study the effect of (MP) on the incidence and severity of grapevine trunk diseases compared to conventional pruning. Besides an altered canopy

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structure, MP results in a changed microclimate within the canopy, which may favour the development of certain diseases. Depending on the type of MP, a significant increase in the number of pruning wounds can occur (Van Rensburg, 2016), as well as wounds with larger surface areas. Trunk pathogens infect susceptible wounds. A build-up of old wood also occurs, and even if renewal pruning is practised on a 3-year rotational basis as prescribed, pathogen fruiting bodies are able to form and release spores that can infect new pruning wounds. Due to greater production and increased pruning wounds, the life span of MP vineyards is also lower (Van Rensburg, 2015).

Motivation

Growth responses, grape composition and morphology, wine quality and labour costs associated with mechanical pruning (MP) have been investigated locally (Archer and Van Schalkwyk, 2007), but the effect on the incidence and severity of trunk diseases, especially the long-term effect in terms of sustainable production, is unknown. The study aims to provide the local grapevine industry with new information on the risks and benefits associated with MP and to make recommendations to prevent inoculum build-up and wound infections to increase the lifespan of such vineyards in order to complement other benefits of MP, like reduced labour costs, increased production and acceptable or increased wine quality.

5. ACCUMULATED PROGRESS TABLE

Objectives	**Milestones (Significant event or stage in a project)**	**Date Achieved**
To compare the incidence and severity of pruning wound infections and inoculum (fungal fruiting bodies) in MP vs. hand-pruned vines in selected vineyards in the Robertson area.	Identify mechanical pruned vineyards that are suitable for comparison studies (i.e. correct areas, cultivars, type of mechanical pruning, etc.). Determine the incidence and severity of pruning wound infections and inoculum (fungal fruiting bodies) in MP vs. hand-pruned vines.	2020-03-21
To compare the incidence and severity of pruning wound infections and inoculum (fungal fruiting bodies) in MP vs. hand-pruned vines in selected vineyards in the Goudini and Aan de Doorns areas.	Identify mechanical pruned vineyards that are suitable for comparison studies (i.e. correct areas, cultivars, type of mechanical pruning, etc.). Determine the incidence and severity of pruning wound infections and inoculum (fungal fruiting bodies) in MP vs. hand-pruned vines.	2021-03-21
To compare the incidence and severity of pruning wound infections and inoculum (fungal fruiting bodies) in MP vs. hand-pruned vines in selected vineyards in the Vredendal area.	Identify mechanical pruned vineyards that are suitable for comparison studies (i.e. correct areas, cultivars, type of mechanical pruning, etc.). Determine the incidence and severity of pruning wound infections and inoculum (fungal fruiting bodies) in MP vs. hand-pruned vines.	2022-03-21

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To compare the incidence and severity of pruning wound infections and inoculum (fungal fruiting bodies) in MP vs. hand-pruned vines in selected vineyards in the Upington area.	Identify mechanical pruned vineyards that are suitable for comparison studies (i.e. correct areas, cultivars, type of mechanical pruning, etc.). Determine the incidence and severity of pruning wound infections and inoculum (fungal fruiting bodies) in MP vs. hand-pruned vines.	2023-03-21
Finalise data	Statistical analyses	2023-07-21
Final report		2023-08-18

6. WORKPLAN (MATERIALS AND METHODS)

Sampling sites

2019 Robertson

Three 22-year-old Sauvignon blanc / Ramsey vineyards near Robertson (Agterkliphoogte) were selected during the first season (2019). The vineyards were planted next to each other, one hand pruned (HP), one single cordon mechanically pruned (MP1), and one double cordon mechanically pruned (MP2). Each of the three vineyards was divided into six zone,s within which three “vakkies” across three rows were randomly selected in each of the six zones to get a good representation of the variation that might occur within a vineyard. The vineyards were pruned by the farmer in August 2019.

2020 Aan de Doorns and Goudini

The vineyards selected for the 2020 survey included an 8-year-old Colombar vineyard in Aan de Doorns and a 15-year-old Chenin blanc vineyard in the Goudini area. Both vineyards comprised one section that is hand pruned (HP) and one section that is mechanically pruned (MP1). The farmers pruned the vineyards in July/August 2020.

2021 Vredendal

Three 18-year-old Cabernet Sauvignon vineyards in Vredendal were selected for the 2021 survey, namely one hand-pruned vineyard (HP), a mechanically pruned vineyard (MP1) and a hand-pruned vineyard using shears and a mechanical saw that mimicked a mechanical pruning method (MP3). Vines were pruned by the farmers in August 2021.

2022 Upington

Two 35-year-old Colombar / 99 Richter vineyards in Upington were selected for the 2022 survey. In August 2022, the farmers pruned the vines, one hand (HP) and the other mechanical (MP1).

Assessing pruning wounds and wood infections

From the mechanically pruned vines (MP1, MP2, MP3), approximately 3-4 weeks after pruning, 10 pruning stubs plus at least 4-5 years older growth were removed (as one intact piece). In the hand-pruned vineyard (HP), the distal ‘tappie’ together with appr. 10cm of the cordon was removed. For 2019, a total of 60 pieces from each vineyard and 70 pieces for the subsequent years were removed. Wood pieces were individually placed in plastic bags in cooler boxes and immediately taken to the laboratory for fungal isolations. Wood pieces were stored in fridges (4ºC) until processed.

On the day of processing, the wood pieces were photographed, the outer bark removed as much as possible, the approximate age of each section determined, cut lengthwise to reveal inner necrosis or abnormalities, washed with tap water, photographed, cut into smaller pieces, washed in tap water, individually placed in plastic bags and taken to the laboratory for further analyses. In the lab, the wood pieces were subjected to triple sterilisation (70% ethanol for 30 sec, 3.5% sodium hypochlorite for 1 min and 70% ethanol for 30 sec). Isolations were conducted by aseptically removing 1x1x1 mm wood pieces, first from the internal woody tissues of the 1-year-old wood below the wound scar / healthy wood interface and then from internal symptoms in the older wood (representative of all the different ages, if possible). The wood pieces were plated onto PDA in Petri plates, wrapped with parafilm and incubated on a lab bench for 4 weeks at 23ºC. The dishes were monitored daily, and fungal cultures resembling trunk pathogens were hyphal-tipped/single-spored and identified based on morphology. Isolates were identified up to the species level using different species-specific PCRs and sequencing of representative and unidentified isolates.

Fungal fruiting structures

During the collection of the wood pieces for isolation (appr at the end of Aug.), pruned canes were also collected to observe fungal fruiting bodies. The canes were collected from within the pruning canopy where they landed after pruning (MP vineyards) or picked up from the vineyard floor (HP). Vines were also inspected for basidiocarps, the fruiting structures of Basidiomycete (wood-rot) fungi.

<u>Pathogenicity of lesser-known isolates from Upington</u>

Three lesser-known fungal species were identified as *Didymella negriana*, *Pyrenochaeta* sp. and *Stilbocrea banihashemiana* in Upington vineyards. These species are not well known to cause dieback or decline in grapevines in South Africa. Therefore, a pathogenicity trial was conducted on green shoots and canes for eight isolates per species. Ten shoots per isolate were inoculated with fungal plugs on 14 December 2023 and 26 April 2024, respectively. *Neofusicoccum parvum* and *Phaeomoniella chlamydospora* were used as the positive controls, and *Acremonium* sp. and a potato dextrose agar plug as the negative controls. The shoots were harvested on 29 May 2024 and 28 August 2024, respectively. Lesions were measured, and isolations were made from the lesions.

<u>Statistical analyses (conducted by Marieta van der Rijst at ARC Biometry):</u>

The experimental design was completely random with six (2019) and seven (2020, 2021, 2022) replicates for each of the pruning types. For each replicate (experimental unit), wood pieces were cut from 10 randomly selected vines, and from each wood piece, a varying number of isolations (2019: HP=24-208, MP1=24-152, MP2=24-136; 2020AdD: HP=8-96, MP1=8-88; 2020G=HP8-128, MP1=8-80; 2021: HP=44-292, MP1=64-200, MP3=60-168; 2022: HP=72-228, MP1=48-184) were made from wood showing internal symptoms. For each wood piece, the number of isolations and the number of incidences for each of the eight pathogens were recorded. The percentage severity was determined as a percentage of the total number of wood pieces from which a pathogen was isolated out of the total number of wood pieces for that sample. Additionally, the percentage incidence of each pathogen per vineyard was determined for the 60 (2019) or 70 samples (2020-2022).

Analysis of variance (ANOVA) was performed on percentage severity and percentage incidence of each pathogen species as well as fungal groups using the General Linear Models (GLM) procedure of SAS statistical software (Version 9.4, SAS Institute Inc., Cary, NC, USA). The Shapiro-Wilk test was performed to test for deviation from normality (Shapiro, 1965). Logit transformation was applied to improve normality where needed. Fisher’s least significant difference was calculated at the 5% level to compare treatment means (Ott, 1998). A probability level of 5% was considered significant for all significance tests. Principal component analysis (PCA), employing the correlation matrix, was performed using XLStat (Version 2016, Addinsoft; New York, USA) to elucidate the patterns of association between treatments and pathogen incidences.

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7. RESULTS AND DISCUSSIONS

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Fig and Tables P04000236 (2024).pdf

From the visual assessments made before isolations, dark brown vascular discolouration, typically associated with ascomycete canker pathogens, as well as soft rotten yellow wood surrounded by dark brown margins typically associated with wood-rotting basidiomycetes, causing esca, was associated with hand-pruned vines (represented by Figs. 3, 4, 5, 6, 7, 8a-c, 9). Wood samples collected from the mechanically pruned vineyards were longer and had less internal vascular discolouration and infection compared to the hand pruned vines (Figs. 1, 2, 8d-j). Typical mechanical pruned vines and hand pruned vines are shown in Fig. 10.

2019 Robertson

From the fungal isolations conducted from the pruning wounds and other internal symptoms, 16 208 wood pieces were incubated, from which 8 581 grapevine trunk pathogens of interest were collected and identified. These pathogens were *Eutypa lata* and *Eutypella microtheca* (causal organisms of Eutypa dieback / "tandpyn"), Botryosphaeriaceae spp. (Bot canker and dieback), *Phaeomoniella chlamydospora* and *Phaeoacremonium* spp. (Petri disease), *Pleurostoma richardsiae* (also associated with Petri disease), *Diaporthe* spp. (mainly *Diaporthe ampelina* / "*Phomopsis viticola*", but also other *Diaporthe* species associated with Phomopsis dieback) and Basidiomycete spp. (wood rot pathogens associated with esca).

Phaeomoniella chlamydospora was the pathogen that occurred the most, namely in 86.6-100% of all vines sampled (Table 1) and 30.9-50.4% of all wood pieces isolated from (Table 2). In general, pathogen incidences were significantly higher (i.e. Diatrypaceae, Togniniaceae, Basidiomycetes) or similar (i.e. Diaporthales, Botryosphaeriaceae, Pleurostoma) in HP vines than in MP1 and MP2 vines, except for Phaeomoniellaceae in MP2, which was similar to HP (Table 1; Table 11). Pathogen severities followed exactly the same pattern (Table 2; Table 12). The higher Phaeomoniellaceae severity in the double-cordon pruned vines compared to the single-cordon vines could be explained by the higher number of wounds created in the double-cordon pruned vines. The fact that *Pa chlamydospora* is associated with the highest severity (across all the pathogens identified) is also an indication of the high inoculum levels that are present in this particular location.

The second highest pathogen incidence was represented by Eutypa dieback fungi (Diatrypaceae, mostly *Eutypa lata* and *Eutypella microtheca*). Interestingly, the incidence and severity of MP1 and MP2 vines were significantly less than those of HP vines. The explanation for this could be two-fold: in the hand-pruned vines, there were significantly more larger wounds, and secondly, the length of the 2-bud spur is significantly shorter than the "spurs" created in the single and double cordon pruned vines. In the hand-pruned vines, the pathogen has only a short distance to colonise before it reaches the older wood of the 'tappie', and due to the "severe" cutback of 'tappies' (to prevent the build-up of old wood), it usually has only a short distance to make it to the cordon where it colonises and kills the wood.

Botryosphaeriaceae spp. inoculum also appears to be quite high in this area. Although significant differences could not be seen between the pruning types, Bot incidence was markedly (61.7%) higher in HP vines compared to MP1 (45.0%) and MP2 (46.3%). Togniniaceae incidence (36.7%) was also high in HP (Table 1), but significantly less in MP1 and MP2 (5.0 and 13.5%, respectively).

Another very interesting and significant finding was the occurrence of the wood-rotting Basidiomycete species associated with esca. These pathogens were only found in the hand-pruned vines (incidence 35.0%, severity 5.5%) and were not observed in any of the mechanically pruned vines. From the visual assessment after the wood pieces were cut open before isolations were made, typical wood rot symptoms associated with esca (soft rotten yellow wood surrounded by a dark brown to black margin, black spots and with or without brown to black v-shape or central necrosis) were observed only in the HP vineyard. Again, the

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explanation could be due to the generally larger wounds created by the severe cutback practices during hand pruning, as well as the relatively short distance the pathogen has to colonise before reaching older wood and/or the cordon.

2020 Aan de Doorns and Goudini

In general, pathogen incidences (Table 3; Table 11) and severities (Table 4; Table 12) were similar in the HP and MP1 sections of the 8-year-old Colombar vineyard in **Aan de Doorns**, except for Togniniaceae incidence that was significantly higher in the HP section (46.7%) compared to MP1 (31.6%) and Botryosphaeriaceae that was significantly higher in the HP section (15.7%) compared to MP1 (3.5%). Phaeomoniellaceae had by far the highest incidence across the pruning methods (100% HP and 95% MP1), followed by Togniniaceae, which comprised of *Pm minimum*, *Pm sicillianum* and *Pm parasiticum*. As in most countries, *Pm minimum* is the dominant *Phaeoacremonium* species in the esca complex, usually followed by *Pm parasiticum*. Interestingly, in this vineyard, *Pm sicillianum* (20.6%) and *Pm minimum* (29.2%) had the highest incidences, a phenomenon previously observed in a vineyard in Rawsonville (Project WW06/41). Despite the relative "young" age of this vineyard, the presence of Diatrypaceae and wood rot Basidiomyctes was already noticeable. Interestingly, *Cryptovalsa ampelina* occurred at the highest incidences (HP=7.3% and MP1=3.2%), and *E. lata* only occurred in the HP vines. Although not statistically, Basidiomycetes incidences in HP vines (7.3%) were markedly higher than in MP1 (3.6%) vines.
In general, pathogen incidences (Table 5) and severities (Table 6) in the HP of the **Goudini** vineyard were higher or similar to incidences in the MP1, except Diaporthales incidence, which was significantly higher in MP1 (70.7%) compared to HP (28.9%). The high Diaporthales incidences, mainly *D. ampelina* (Table 5), can be attributed to the geographic location of Goudini / Slanghoek, which is known as a Phomopsis cane and leaf spot ("streepvlek") hotspot with high inoculum pressure. Phaeomoniellaceae (*Pa chlamydospora*) had by far the highest incidences across the pruning methods (98.6% HP and 90.9% MP1) and was also the pathogen isolated from the most wood pieces, namely 35.4% in the HP section which was significantly more than 24.9% in the MP1 section of the vineyard. The two Basidiomycete species identified, namely Taxon 1 (8.7%) and *Fomitiporia capensis* (1.4%), only occurred in the HP section.

2021 Vredendal

From the fungal isolations conducted from the pruning wounds and other internal symptoms during the 2021 season, 24 944 wood pieces were incubated, from which 7004 harboured grapevine trunk disease pathogens, which were collected and identified. These were *Diaporthe ambiqua* and *D. ampelina* (Phomopsis dieback), *Cryptovalsa ampelina* and *Eutypella microtheca* (Eutypa dieback/ tandpyn), *Peroneutypa* sp. 3 (dieback pathogen on grapevine, Moyo et al., 2019), Botryosphaeriaceae spp. (Bot canker and dieback), *Phaeomoniella chlamydospora* and four *Phaeoacremonium* species (Petri disease) and Basidiomycete spp. (wood rot pathogens associated with esca).
Similar to the previous two seasons, pathogen incidences (Tables 7, 11) and severities (Tables 8, 12) were significantly higher (i.e. Botryosphaeriaceae, Togniniaceae and Basidiomycetes) or similar (Diaporthales, Diatrypaceae) in the HP vineyard, compared to MP1 and MP3 vineyards, except *Ph chlamydospore* incidence in MP1 that was similar to the HP vineyard (Table 7). These groups are considered to be aggressive canker and dieback pathogens. The higher occurrence of these pathogens in HP is due to the higher number of large wounds made during pruning (Figs. 8,9). Conventional hand pruning generally cuts back 2-bud spurs, resulting in more severe cutbacks creating larger wounds (Figs. 8,9). Additionally, pathogens have a shorter distance to travel to reach older wood, such as the cordon.
Similar to the 2019 and 2020 surveys, *Ph. chlamydospora* was the pathogen that occurred most frequently with high incidences of 100% (HP), 97.1% (MP1) and 84.3% (MP3) (Table 7). Botryosphaeriaceae species were the second most abundant (Tables 7, 8). *Diplodia seriata* was identified in all three vineyards but significantly more in HP (80% incidence) compared to MP1 (45.71%) and MP3 (42.86%). Interestingly, the Togniniaciae species that occurred at the highest

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incidences were *Phaeoacremonium parasiticum* (52.86%), *P. minimum* (30%) and *Pm sicillianum*, which occurred at significantly higher incidences in the HP vineyard compared to MP1 and MP3. This is the first record of *Pm sicillianum* in the Vredendal area. Contrary to the 2019 and 2020 surveys, Diatrypaceae species causing Eutypa canker were not abundant, with incidences of only 4.29-2.86% (Table 7). Additionally, *Eutypa lata* was not identified in the 2021 survey. *Eutypa lata* requires a minimum of ~250 mm annual rainfal,l which is less than the annual rainfall in Vredendal (~200 mm). This could explain the lower incidence of Eutypa canker species.

A very interesting and significant finding was the high severity (4.11%) and incidence (62.86%) of wood-rotting basidiomycetes in the HP vineyard (Tables 7, 8). Only a very small number of basidiomycete species were identified in the two mechanically pruned vineyards (1.43% and 2.86% incidence). Soft, yellow wood rot internal symptoms were present in most hand-pruned samples (Fig. 8). Similarly, basidiomycetes were only found from the hand-pruned vineyards in the 2019 samples and also had a significantly higher occurrence in the hand-pruned vineyard in 2020. The damage caused by these pathogens is irreversible and will ultimately lead to a significantly shorter productive lifespan. Taxon 1 (*Fomitiporella* sp.) and taxon 9 (*Fomitiporia capensis*) are the most commonly isolated basidiomycetes from grapevines in South Africa, which is similar to our findings (Bester et al., 2015; White et al., 2011). However, taxon 6 (38.57%), which was abundantly isolated from the HP block, was previously only known from Malmesbury and taxon 5 (10%) from Darling, Ladismith, Malmesbury, Montagu and Tulbagh (White et al., 2011).

2022 Upington

From the fungal isolations conducted from the pruning wounds and other internal symptoms during the 2021 season, 19 168 wood pieces were incubated, from which 6305 harboured the grapevine trunk disease pathogen, which were collected and identified. These were *Cytospora magnoliae* (Cytospora canker), *Eutypella microtheca* (Eutypa dieback/ tandpyn)*, and* five Botryosphaeriaceae spp. (Bot canker and dieback), *Phaeomoniella chlamydospora* and six *Phaeoacremonium* species (Petri disease), *Pleurostoma richardsiae* (also associated with Petri disease), one Basidiomycete sp. (wood rot pathogens associated with esca) and three potential pathogen species (Tables 9, 10).

Phaeomoniella chlamydospora was the pathogen that occurred the most, specifically in 97.14%-98.57% of all vines sampled (Table 9) and 18.37%-29.36% of all isolated wood pieces (Table 10). In general, pathogen incidences were significantly higher (i.e. Basidiomycetes, Botryosphaeriaceae, Lesser known) or similar (i.e. Diaporthales, Diatrypaceae, Togniniaceae, Phaeomoniellaceae, and Pleurostoma) in HP vines than in MP1 vines (Table 9; Table 11). Pathogen severities followed the same pattern (Tables 9 and 12). The second highest pathogen incidence was *Phelinus resupinatus* (Taxon 10), which is a wood-rotting pathogen that occurred in 74.81% of HP vines and only in 5.7% of MP1 vines (Table 9). No other wood-rotting Basidiomycete was isolated in any of the samples, and Upington was the only area where taxon 10 was isolated. This is not surprising, since Taxon 10 has only been reported from the Northern Cape vineyards (White et al. 2010). The high incidence of *Phellinus resupinatus* from HP vines is not surprising, as the majority of samples had typical soft, yellow wood rot internal symptoms. Botryosphaeriaceae spp. were also significantly higher in HP compared to MP1 with *D. seriata* (60.52%) and *Lasidiplodia crassispora* (9.87%) dominant (Table 9).

For the lesser-known fungal species, *D. negriana* (19.74%) and *S. banihashemiana* (20.91%) occurred at a significantly higher incidence and severity in the HP compared to the MP1 vineyard; however, the incidence and severity of *Pyrenochaeta* sp. did not differ significantly between the HP and MP vines (Tables 9 and 10). For the pathogenicity trials, for both green shoots and canes, the isolates differed significantly from one another ($P < 0.0001$). On green shoots, only two isolates (*S. banihashemiana* isolate 4MP589 and *D. negriana* 4MP559) caused lesions that were not significant from the negative controls (Table 13). Six *D. negriana,* five *S. banihashemiana* and three *Pyrenochaeta* sp. isolates caused lesions that were significantly similar to the *N. parvum* positive control (Table 13). On canes, all isolates caused lesions that

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were significantly larger than the negative controls and all isolates except for the *S. banihashemiana* isolate 4MP593 caused lesions that were not significantly different from *N. parvum* (Table 14). The isolates had varying levels of pathogenicity, with *S. banihashemiana* causing the largest lesion (98.64 mm) apart from *P. chlamydospora* and the smallest lesion (49.15 mm) (Table 14). These species are not well known to cause dieback or decline in grapevines in South Africa. However, *D. negriana* have been reported to cause disease in grapevines in the Netherlands and Poland (de Gruyter et al. 1998, Machowicz-Stefaniak and Król, 2010), several *Pyrenochaeta* species have been reported to cause a decline in woody hosts and *S. banihashemiana* to cause stem and twig blight on several fruit trees (Bolboli et al. 2022). The occurrence of these unknown pathogens could be due to the fact that Upington vineyards have not been as regularly surveyed for canker and dieback pathogens as the Western Cape vineyards.

Advantages and disadvantages of mechanical prunings

Many wine farmers globally, especially large-scale wine farms, are starting to look into the possibility of mechanical methods as an alternative to conventional pruning. The biggest drive is the significant cost of labour (Allegro et al 2003; Archer and van Schalkwyk, 2007; Kriel, 2016). You require trained, capable and productive pruners, which are becoming scarce. Another drive is the rising production costs in the wine industry. Due to global warming, cooler climates are becoming less available, and warmer production areas are becoming more common. Additionally, land use for wine grapes are scares. Research has shown that mechanical pruning can increase yields per ha (Archer and van Schalkwyk, 2007; Kriel, 2016)

In Vredendal, a case study showed that 10 permanent skilled workers are required for mechanical pruning of vines compared to the average of 260 seasonal workers per year, which reduced the labour cost. However, the expenses per ha were similar between hand-pruned and mechanically pruned vineyards since mechanically pruned vineyards had higher fuel use, higher electricity and fertilizer as well as the pruning equipment had to be purchased and serviced (Kriel 2026). Even though the expenses were similar, the gross income per ha was nearly double (R60 000/ha vs R39 000/ha) for the mechanical pruning compared to the rest of the region using hand pruning methods.

Archer and van Schalkwyk (2007) evaluated the effect of mechanical pruning on the growth response, grape composition and morphology, wine quality and labour inputs in three important growing regions in South Africa on nine cultivars. The amount of labour required significantly reduced in mechanically pruned vineyards. Although berry mass and volume, as well as physical bunch size, were reduced by alternative pruning methods, resulting in lighter bunches, the increased number of bunches increased the yield considerably compared to hand pruning. The wine quality in most cases was either not affected or it was improved.

Cultivars adapt differently to mechanical pruning. According to Archer and van Schalkwyk (2007), Cabernet Sauvignon, Pinotage and Chardonnay adapted the best to alternative pruning, whereas Sauvignon blanc and Merlot, which prefer cooler climate,s were less adaptable. However, Sauvignon blanc/Ramsey block has won the VinPro block competition two years in a row (Kriel 2016). Contrary to Archer and van Schalwyk (2007), Pinotage do not adapt well to mechanical pruning in the Northern production areas (van Schalwyk, 2024). This is due to the poor vigour of Pinotage, which cannot sustain the increased number of bunches produced (van Schalkwyk, 2024).

There are, however, disadvantages to mechanical pruning. If fertiliser and water are not sufficient, vines do not have the ability to ripen the harvest (van Schalkwyk, 2024). Additionally, in some instances, there was too much dry wood that arrived in the cellar, which impaired the wine-making process. In the Western Cape, heavy winter rain can compact the soil along with the weight of tractors and mechanical pruning, and harvesters can lead to soil compaction if driven over wet soils. When ordinary tractors and multipurpose mechanical harvesters are used simultaneously on the same vineyards, the soil is compacted in the middle of the row and at the foot of the vines. In these cases, soil profile inspections will ascertain whether the soil must be loosened after harvest to decrease soil compaction.

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Another downfall of mechanical pruning is that the machines and blades can rip the vines, leaving uneven jagged which could leave more points of entry for pathogens to attack vines. Due to the greater production and increased pruning wounds sustained, it was expected that the life span of the vineyards would decrease. However, our results over the five regions contradicted this, where significantly fewer canker and wood-rotting pathogens were found in the mechanically pruned vineyards. Even though mechanically pruned vines have more wounds and wounds were in many cases uneven and jagged (Fig. 10), the wounds are smaller, further from the older wood, and the longer canes give the vine more opportunity to compensate when infection occurs.

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8. CONCLUSIONS AND RECOMMENDATIONS

During four seasons, vineyards in five grapevine regions were sampled specifically in Robertson (2019), Aan de Doorns (2020), Goudini (2020), Vredendal (2021) and Upington (2022). In all seasons, each sampling time had one vineyard that was hand pruned (HP) and at least one vineyard that was mechanically pruned (MP1, MP2, MP3). In 2020, the Aan de Doorns vineyards did not differ significantly in disease incidence except for Botryosphaeriaceae species. This could be due to the fact that these vines were only 8 years old, and disease incidence and severity may increase as the vineyards accumulate more larger wounds in the hand-pruned vines. Only *D. amelina* (which is also the causal organism of Phomopsis cane and leaf spot) had a higher incidence in the Goudini mechanically pruned vineyard compared to the hand pruned vineyards. In this case, if farmers are made aware of this, spray programs can be adjusted to take this into account, especially early in the season and especially in wetter seasons.

In general, HP vines had significantly higher incidences and severities of aggressive canker and dieback pathogens, especially wood-rotting Basidiomycetes, Botryosphaeriaceae, Togniniaceae and Diatrypaceae (only in 2019). Very few basidiomycetes were observed in the mechanically pruned vines; however, abundant in the HP vineyards. The damage caused by these pathogens is irreversible and will ultimately lead to a significantly shorter productive lifespan. The explanation for this could be two-fold, firstly, the hand-pruned vines had larger wounds (Figure 10). This is likely due to the technique of conventional hand pruning, which generally cuts back to two-bud spurs, resulting in “severe” cutback of spurs to prevent the build-up of old wood, creating larger wounds. Larger wounds have a higher chance of spores landing on the wounds, infecting and colonise and increasing the chances for multiple infections from different GTD pathogens. Secondly, the length of the 2-bud spur is significantly shorter in hand-pruned vines, and the pathogen only has a short distance to colonise before it reaches the older wood of the spur and cordon, where it can colonise and kill the wood. Even though mechanically pruned vines have more wounds since there is a larger number of shoots and wounds can be uneven and jagged (Fig. 10), the wounds are smaller, further from the older wood, and the longer canes give the vine more opportunity to compensate when infection occurs.

Similar conclusions were made for vines pruned using a minimal pruning method in Europe (Kaplan et al., 2016; Sanliang et al., 2005; Travadon et al., 2016). In these studies, smaller wounds resulted in grapevine trunk diseases occurring at a lower incidence in minimal pruned vines compared to spur-pruning, and less necrotic wood was present in the cordon and trunk. This led to lower economic loss due to trunk disease and reduced the cost of annual pruning. Another advantage is that mechanical pruning is faster and can be postponed to later in the winter, where fewer chances of fungal dispersion through water splash can occur (Kaplan et al., 2016; Gu et al., 2005; Travadon et al., 2016). We concluded that mechanical pruning in a single or double cordon, as well as using a mechanical saw that mimicked mechanical pruning as a viable option to limit the effect of trunk pathogens in South African vineyards. Mechanical pruning could increase the lifespan of vineyards to complement other benefits of MP, like reduced labour costs, increased yield and acceptable or increased wine quality. However, mechanical pruning is a good alternative to hand pruning if vines have sufficient vigour and are trained on the correct trellis system (van Schalkwyk, 2024). The larger crop load and expanded growth above ground require more water and fertiliser to apply mechanical pruning sustainably. Additionally, mechanically pruned vines must be mechanically harvested (van Schalkwyk, 2024). For these reasons, hand-pruned vineyards should not be converted to mechanically pruned vineyards. Preparation is key. Before considering mechanical pruning, ensure that you have the correct trellis system, row spacing, rootstock-scion combination, etc. and consult experts in the field.

9. PLANNED OUTPUTS

a) TECHNOLOGY DEVELOPMENT, PRODUCTS AND PATENTS

After 4 seasons, the data indicate that mechanical pruning could have a positive effect on the productive lifespan of vineyards, and, in the context of grapevine trunk diseases, harbour lower incidences/severities of the most aggressive dieback, canker and wood rot pathogens.

b) SUGGESTIONS FOR TECHNOLOGY TRANSFER

Six presentations at farmers/ information days were presented in the different regions where the study was conducted. Additionally, an oral presentation was given at the integrated control symposium in Spain.

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c) HUMAN RESOURCES DEVELOPMENT / TRAINING (STUDENTS)

Student Name and Surname	Student Nationality	Degree (e.g., Hons, MSc)	Level of studies in the final year of the project	Total Bursary Cost for Industry for the entire project
Honours				
Masters				
PhD				
Postdocs				
Meagan van Dyk	South African	Postdoc	Completed	R 410000

d) LIKELY PUBLICATIONS (POPULAR, PRESS RELEASES, SCIENTIFIC)

1x Scientific publication SAJEV (In progress)
1x Popular publication - Winetech Tegnies (In progress)
1x Press Release

e) PRESENTATIONS/PAPERS THAT COULD BE DELIVERED

VinPro / Winetech Paarl-Swartland Information Day (Webinar, 12 May 2020)
Management practices for trunk diseases and their role in the dieback of bearers and poor bud break.
F. Halleen

VinPro / Winetech Robertson Information Day (Webinar, 16 September 2020)
Management practices for trunk diseases and their role in the dieback of bearers and poor bud break. F. Halleen

International Organisation for Biological and Integrated Control (IOBC)/ WPRS Working Group "Integrated Protection in Viticulture", Logrono, Spain (3 October 2023)
Mechanically pruning vs hand-pruning: the effect on incidence and severity of grapevine trunk disease pathogens
M Havenga, M. Webber, L. Mostert, F. Halleen

Winetech/Vinpro Inligtingsdag (27 September 2023, Upington)
Meganiese snoei en wingerd stamsiektes.
F. Halleen, M. Havenga, M. Van Dyk, M. Webber & L. Mostert

Vinpro Regional Information Day Upington Upington (16 May 2024)
MEGANIESE SNOEI VS HAND SNOEI: DIE EFFEK OP VOORKOMS EN ERNS VAN WINGERD STAMSIEKTE PATOGENE
Havenga, M., Webber, MM., Mostert, L., Halleen, F.

Vinpro Regional Information Day Worcester/ Bredekloof Rawsonville (28 May 2024)
MECHANICAL PRUNING VS HAND-PRUNING: THE EFFECT ON INCIDENCE AND SEVERITY OF GRAPEVINE TRUNK DISEASE PATHOLOGY
Havenga, M., Webber, MM., Mostert, L., Halleen, F.

Vinpro Regional Information Day Olifantsrivier Vredendal (30 May 2024)
MECHANICAL PRUNING AND TRUNK DISEASE
Havenga, M., Webber, MM., Mostert, L., Halleen, F.

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10. PROJECT OUTCOME AND IMPACT

New Knowledge	Benefits Supply Chain	Direct Grower Application	Direct Packhouse/Winery/ Cellar Application	Other
X		X		

Other is:

The Value of the project to the industry

The industry will have scientifically
based information on the effect of mechanical pruning on the grapevine trunk
diseases and trunk disease management.

11. PERSONS PARTICIPATING IN THE PROJECT:

INITIALS AND SURNAME	HIGHEST QUALIFICATION	RACE (B, C, I, W)	GENDER (M, F, X)	INSTITUTE DEPARTMENT	POSITION	TOTAL COST TO PROJECT
RESEARCH PERSONNEL						R 0
F. Halleen	Phd	W	M	ARC Infr-Nietv	PL	R 0
M. Havenga	PhD	W	F	ARC Infr-Nietv	Co	R 0
L. Mostert	PhD	W	F	US-PP	Coll	R 0
SUPPORT PERSONNEL						R 0
Alwina Marais	Matric	W	F	ARC Infr-Nietv	RA	R 0
Julia Marais	Matric	W	F	ARC Infr-Nietv	RA	R 0
Carine Vermeulen	Matric	W	F	ARC Infr-Nietv	RA	R 0
Danie Marais	matric	W	M	ARC Infr-Nietv	RA	R 0
Palesa Lebenya	MSc	B	F	ARC Infr-Nietv	TA	R 0
M. Webber	MSc	W	M	ARC Infr-Nietv	TA	R 0

POSITION: Co = Co-worker (other researcher at your institution)
Coll = Collaborator (participating researcher that does not receive funding for this project from industry)
PF = Post-doctoral fellow
PL = Project leader
RA = Research assistant
TA = Technical assistant/ technician

12. TOTAL COST OF PROJECT

TOTAL ANNUAL COSTS (ALL YEARS)	CFPA	RAISINS SA	HORTGRO	SATI	WINETECH	ARC	OTHER	TOTAL
2018 and before	R 0	R 0	R 0	R 0	R 0	R 0	R 0	R 0
2019	R 0	R 0	R 0	R 0	R 176176	R 89693	R 0	R 265869

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2020	R 0	R 0	R 0	R 0	R 232402	R 143011	R 0	R 375413
2021	R 0	R 0	R 0	R 0	R 262403	R 158623	R 0	R 421026
2022	R 0	R 0	R 0	R 0	R 281297	R 173086	R 0	R 454383
2023	R 0	R 0	R 0	R 0	R 0	R 0	R 0	R 0
TOTAL	R 0	R 0	R 0	R 0	R 952278	R 564413	R 0	R 1516691

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