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x				x

FINAL REPORT 2019

Winetech Number : TO JvZ Soil

1. PROGRAMME & PROJECT LEADER INFORMATION

	Research Organisation leader	Project leader
Title, initials, surname	Dr JE. Hoffman	Dr J Van Zyl
Present position	HOD Soil Science	Extraordinary Prof Soil Science
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2. PROJECT INFORMATION

Project title	Preparation of vineyard soils in South Africa: A Synopsis of 50 years of research information
Short title	Preparation of vineyard soils in South Africa

Fruit kind(s)	Wine grapes		
Start date (mm/yyyy)	04/2016	**End date** (mm/yyyy)	08/2017

Key words	research review, soil compaction, root distribution, ameliorants, implements, soil types

Applications submitted to	Winetech & SATI

3. TOTAL PROJECT COST

	CFPA	RAISIN SA	SAAPPA SASPA	SATI	Winetech	ARC	THRIP	OTHER
TOTALS All years	0	0	0	105340	105340	0	0	0
Total cost of entire project						**R210680**		

4. EXECUTIVE SUMMARY

Objectives and Rationale
Considering the determining role of soil preparation in the successful establishing of a vineyard and the huge costs involved, it is imperative that all the available information is compiled correctly in one place. The objective of the project therefore is to comprehensively review all literature on preparation of vineyard soils in South Africa and internationally to compile the existing information in a practical condensed hand book suitable for use by wine and table grape farmers, technical advisers and students.

Methods
South African as well as international literature has been reviewed, field trips have been undertaken and during a visit to the United States, Dr Hoffman viewed the newest drainage technology in that country. The available information together with relevant photographs were compiled in book form.

Key Results
The book “Soil preparation for sustainable wine and table grape vineyards” was printed and will be launched on 14 August 2019.

A reduction in available soil volume decreases the grapevine root system and subsequently also shoot growth and yield. The first sign of soil compaction is uneven growth which may eventually progress to dead patches in a vineyard. Experimental results showed that the soil must be loosened to a depth of at least 800 mm, but preferably to one meter. Adequate soil depth could compensate for lack of irrigation in the coastal region of the Western Cape.
The correct choice of implement for soil preparation is determined by soil type. Effective soil preparation means that the soil is uniformly loosened to a depth of at least 800 mm, that poor subsoil is not brought to the surface and that the loose soil has a good structure i.e. no large clods which cannot be exploited by roots. Conditions for preparation are best when the soil surface is dry to ensure good traction for tractors while the subsoil is still moist.
Deep tillage in two directions may be necessary when a uniformly loose medium is not achieved with working in one direction or better mixing is required. Soil preparation provides the only opportunity to apply lime on acid soils, remedy low P contents in the subsoil and also incorporate gypsum in the subsoil for the reclamation of saline soils. Loose soil re-compact after soil preparation and such re-compaction is especially harmful in newly planted vineyards.

Key Conclusion of Discussion
Roots visually illustrate what conditions they experience in the soil and therefore their distribution is important when soil preparation is planned or assessed. New technology makes root studies easier but the use of root inspection in soil profile pits is still essential. The penetrometer is the ideal instrument to detect soil compaction and penetrometer resistances of more than 2000 kPa is considered restricting to root growth. Methods to alleviate root restrictions depend on soil type, but an array of implements is available to provide a horse for each course.

Recommendation to Industry / Key take-home message
The correct soil preparation is essential for sustainable and peak grape production. Fortunately the knowledge to achieve this goal is available in South Africa and is now contained in the new book on soil preparation. This knowledge is interpreted into clear and concise recommendations.

5. PROBLEM IDENTIFICATION AND MOTIVATION

Problem Identification

South African vineyard soils are notoriously shallow i.e. restricting root penetration, due to various factors such as compaction, soil acidity and abrupt textural transitions. The result of such shallow soils, are uneven as well as poor vineyard performance and eventually unprofitable vineyards. This is not only true for establishing first generation vineyards but also for the replanting of existing vineyards.

Research regarding soil preparation of vineyards has been conducted over many years and different generations of researchers, and consequently the knowledge is fragmented among many articles, journals and experts. In short, a divide has developed between available knowledge and the end-users of the knowledge.

Motivation

The project aims to comprehensively review all literature on preparation of vineyard soils in South Africa and internationally to compile the existing information in a practical condensed handbook suitable for use by wine farmers, technical advisers and students.

6. ACCUMULATED OBJECTIVES TABLE

Performance chart

Objectives	Milestones	Original Target Date	Date achieved
O1. To compile a handbook on the preparation of vineyard soils aimed at farmers, technical advisers and students	M1.1 Completed manuscript for hand book	Dec 2016	Aug 2018
	M1.2 Manuscript refereed by experts	March 2017	Oct 2018
	M1.3 Printed and electronic copies of hand books delivered to SATI and Winetech	Sept 2017	July 2019

7. WORKPLAN (MATERIALS AND METHODS)

W1 - All scientific and popular articles published on the preparation of vineyard soils in South Africa and abroad will be reviewed and the compiled knowledge integrated into a practical handbook for wine and table grape farmers, students and technical advisers. The manuscript will be written in English and text will be illustrated by colour photographs. Recommendations will be made regarding preferred implements, techniques and ameliorants to be used depending on soil type.

W2 -Once the manuscript has been completed, it will be submitted to experts for refereeing. These referees will be selected on the basis of their expertise and practical experience under field conditions. A special effort will be made to involve the persons who conducted most of the ground breaking research originally such as Mr Dawid Saayman, Prof Leopoldt van Huyssteen, Dr Kobus Conradie and Mr Kobus Louw. All contributors, past and present, will be duly recognised in the publication.

W3 - The final stage of the project will entail the layout and printing of the handbook of an estimated 64 pages, size 168 mm x 240 mm. This will be outsourced, but the project team will carry the responsibility for proofreading and quality control. A total number of 500 handbooks will be printed for the first edition and it will also be available in electronic format

8. RESULTS AND DISCUSSION

South Africa is the leading country in the world regarding research and knowledge on soil preparation. This stems from the fact that the majority of soils used for wine and table grape production in South Africa are notoriously shallow, *i.e.* they are restricting root penetration. The result of such shallow soils is uneven and poor vineyard performance that eventually lead to unprofitable vineyards. Many investigations in South Africa have addressed the reasons for poor grapevine root development and methods to rectify this detrimental factor. This large body of knowledge is not only spread over different generations of researchers and experts, but also fragmented among many articles and journals. Consequently Winetech and SATI jointly funded the writing of a book on all aspects of soil preparation. This new book has been completed and was launched on 14th August this year.

This new book does not only deal with deep tillage. Wet soils have to be drained, ridgeing, terracing of steep slopes, plant holes and even reclamation of brack soils are further aspects of soil preparation that can only be done before planting a permanent crop. Since soil preparation is primarily aimed at creating soil conditions that will allow root growth to sustain the desired grapevine performance, knowledge about optimum conditions for root growth is essential. Good root distribution, *i.e*. deep, even and dense root systems, is needed for healthy and high yielding grapevines that are also buffered against drought and deficient nutrient applications. Soil layers that impede root growth, reduce the quantities of water and nutrients available to the plant. Furthermore, there is a balance between root size and aerial growth of grapevines. A restricted root system will consequently reduce above-ground growth.

Starting with recommendations for "dynamite-ploughing" in 1912, all research on soil profile modification was reviewed in the new book and a synopsis made regarding soil conditions, root studies, grapevine response and corrective measures. Fortunately, various types of implements are available in South Africa to achieve all kinds of loosening and mixing of the soil.

Soil restrictions to root penetration

Natural soil compaction is the main cause of root restriction in the majority of vineyard soils in the Western Cape, but compaction can also be man-made through vehicle traffic and implement use (Figure 1). When soil becomes more compact, its strength increases, and particularly the volume and continuity of large pores decrease. Soil compaction makes tillage more difficult and causes poorer root penetration. Soil strength can be measured by penetrometers of various kinds and sophistication. Grapevine root penetration is drastically impeded by penetrometer resistances above 2000-2500 kPa measured in soil near field capacity.

Soil compaction is the main impediment to vineyard roots, but soil acidity, water logging, salinity, soil stratification, hardpans, subsoil clays and rock are also limiting factors in many localities. In fact, there are very few South African soils without root-impeding layers within 0.8 meter depth that can be planted to grapevines without deep soil preparation.

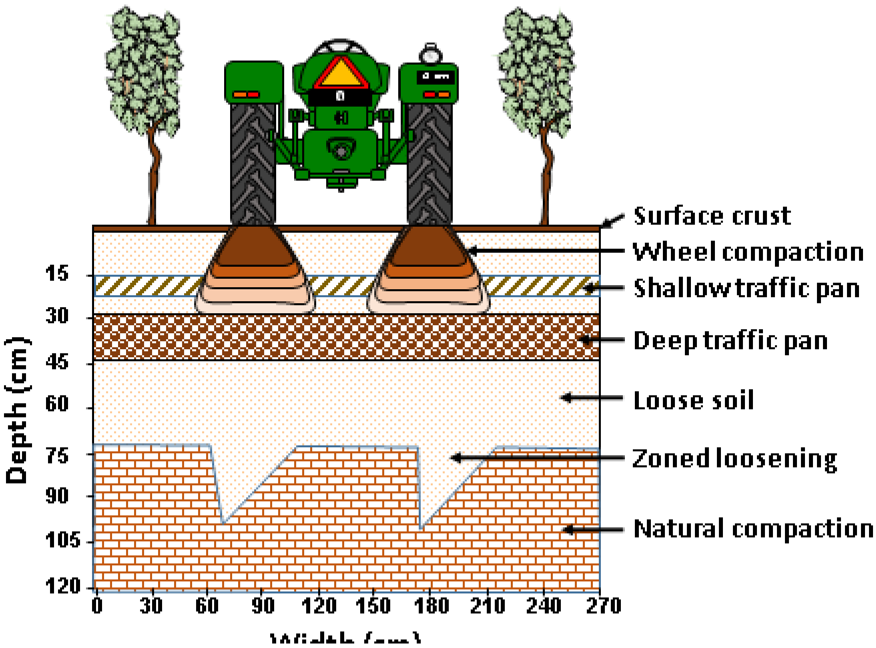

Fig. 1: Schematic illustration of the different types and positions of compaction generally found in vineyards (adapted from Van Huyssteen, 1989).

Root response to soil conditions

Grapevine root distribution is the most reliable, direct and accurate indicator of soil conditions. Unfavourable conditions in the soil, *e.g.* compaction and low pH, will be indicated by roots that cannot adequately penetrate such soil horizons, while roots which are well distributed laterally and vertically are proof of favourable soil properties (Figure 2).

The root systems of grapevines in South Africa are almost without exception shaped by soil conditions and cultivation practices such as tillage and planting density instead of the genetic traits of the rootstock. Assessment of grapevine root distribution in existing vineyards can, therefore, give an excellent indication of which type of soil preparation would be necessary when vineyards have to be replanted. Similarly, root distribution will clearly show how effective soil preparation was, before planting (Figure 2).

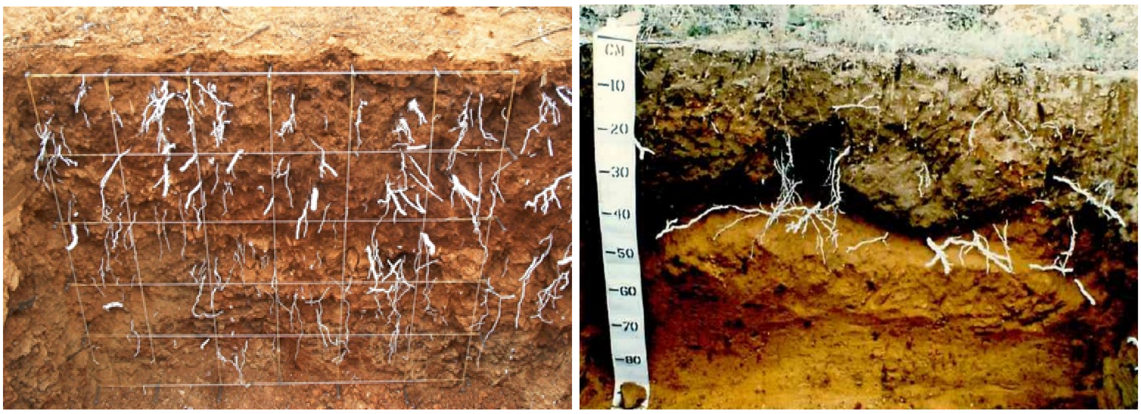

Fig.2: Good root distribution in a vineyard after effective deep soil preparation (left) and shallow grapevine rooting due to natural compaction in the subsoil of aTukulu soil that was poorly prepared before planting (right) (Photos: ARC Infruitec-Nietvoorbij).

Ridges

Ridging (also called mounding) is a soil preparation method for soils which cannot be prepared effectively through deep tillage or for waterlogged soils which cannot be drained by subsurface drainage. Ridging entails the hilling up of the topsoil to form a continuous elevated ridge on which a crop can be planted. This practice creates a larger root volume for exploitation over impenetrable subsoil or above water tables. In fact, ridging is a form of surface drainage and consequently ditches between the ridges must have a slope that allows outflow of water from a vineyard or an orchard.

Construction can be done by using an excavator, an offset disc-harrow and even a grader on condition that the wheels of the construction vehicle do not cause compaction under, or on the ridges. Ripping of the subsoil before ridging is beneficial and makes ridge construction easier.

In field trials with grapevines, raised beds (ridges) improved internal drainage and soil aeration, but temperatures in the upper parts of ridges were higher than on un-ridged soil and cause increased water loss. Irrigation is therefore recommended when grapevines are planted on ridges.

The dimensions of ridges are important. Single-row ridges with a soil surface to volume ratio of less than one cause soil temperatures and soil water depletion that are higher than normal, resulting in yield losses. Single-row ridges should be at least 500 mm wide at the crest with a base of at least one meter and lower than 400 mm. Double-row ridges that are 300-500 mm high with a flat or slightly concave crest are recommended. Ditches must be 1.5 m wide to prevent vehicles from driving on the slanting sides of the ridge.

In the Hex River Valley, table grapes are often planted on low ridges (*ca*. 20 cm high), popularly referred to as landscaping (Figure 3). Such landscaping will have no benefit on stony, sandy and other deep well-drained soils, but in a case study on a Westleigh soil, vines on ridges were visibly much more uniform and vigorous than grapevines on flat ground. Even though higher ridges would have been recommended on this wet Westleigh soil, raising the soil surface by 20 cm only, had already induced a significant advantage regarding drainage, aeration, temperature and consequently in grapevine growth.

Vineyard practices such as pruning and harvesting are more difficult to perform on ridges and therefore ridging should be reserved for conditions where the soil dictates it. Mulching and herbicide weed control is recommended on ridges while drip or micro-sprinkler irrigation should be used. Conventional sprinkler systems will cause too much run-off and erosion of the ridges.

Fig. 3: Well-constructed ridges (40 cm high) that were necessitated by dense clay in the subsoil of a wine grape vineyard in Stellenbosch (left). Young table grapes planted in a single row on a low ridge (20 cm high). The soil is a shallow Westleigh that is wet, and in this case also has a low infiltration rate and is hard-setting when dry (right) (Photos: JE Hoffman).

Implement choice for soil preparation

The correct choice of implement for soil preparation is determined by soil type. Soil that was effectively prepared, is loose to a depth of 800-1000 mm, poor subsoil was not brought to the surface, unloosened banks between adjacent furrows are absent and the loose soil has a good structure, *i.e.* no large clods occur that cannot be exploited by roots.

Rippers are useful to break up hard layers without mixing the soil and so is the wing plough, an adaptation to the ripper Figure (4A). Although the wing plough loosens a larger soil volume than the ripper, neither of these ploughs can mix ameliorants with the soil.

Delve ploughs are available in various adaptations, each designed for a specific goal. The standard delve plough is used for mixing of Dundee and Oakleaf soils, but has the disadvantage of bringing poor subsoil to the surface (Figure 4B). By changing the size and shape of the mould board, a shift-delve plough can be made (Figure 4C). This plough allows topsoil to flow over the mould board and mix with the subsoil behind the board. Soil layers will mainly be displaced sideways.

The finger delve plough loosens the soil thoroughly with little upward displacement of the subsoil (Figure 4D).

Soil preparation using excavators, the so-called “handjie-dol”, is also employed in South Africa. Soils having thick “dorbank” (hardpan) layers as well as soils containing lime “heuweltjies” are occasionally prepared through blade delving. This entails moving the topsoil aside and breaking up the subsoil with a ripper followed by moving and mixing the soil using the tractor blade.

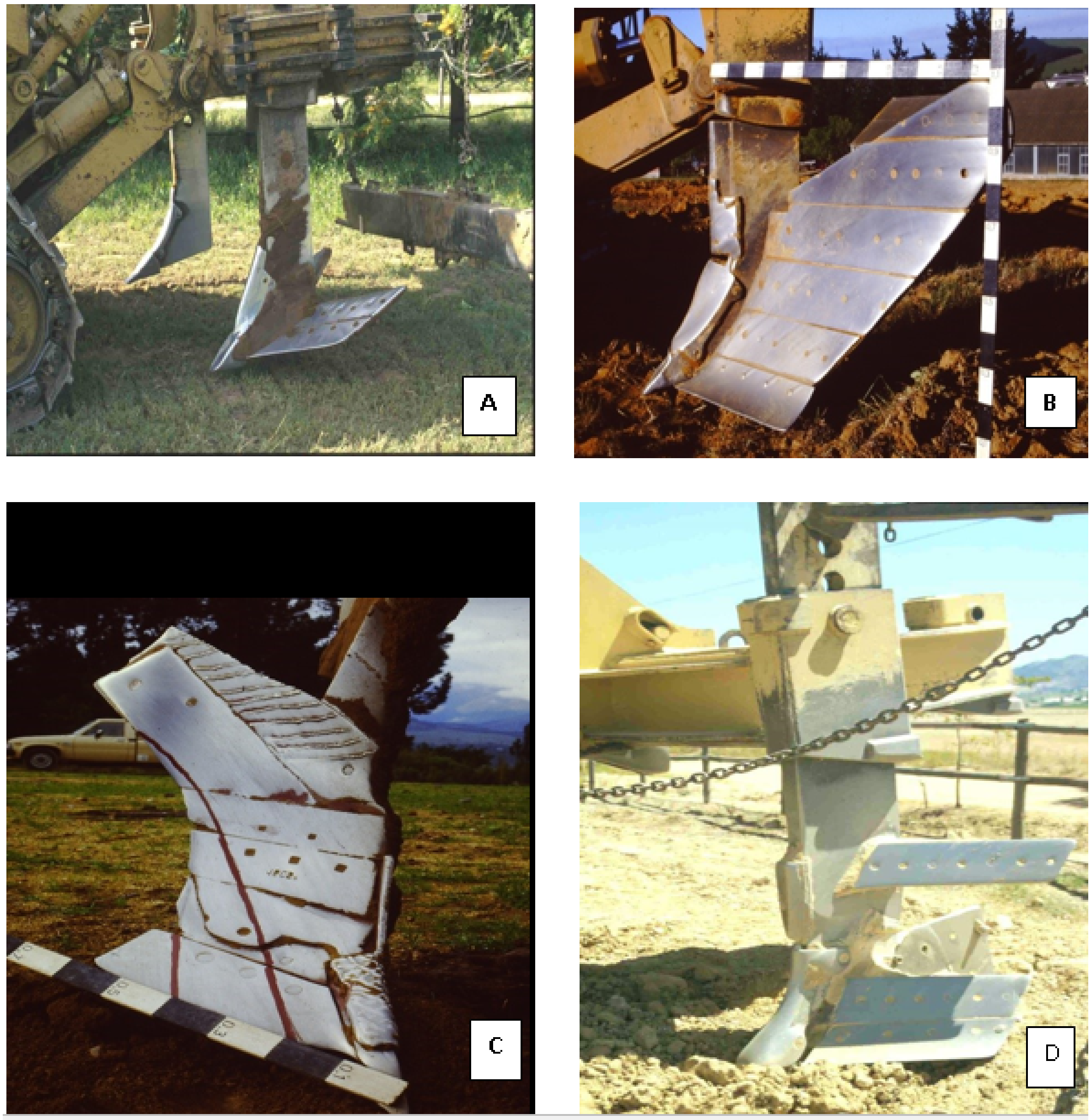

Fig.4 : Implements used in South Africa for deep soil preparation: A) Wing plough used in conjunction with ripper B) Delve plough for soil mixing C) Shift-delve plough for mixing and sideways displacement of soil and D) Finger plough for minimumupward displacement of subsoi (Photos: ARC Infruitec-Nietvoorbij).

Conditions for effective implement action

Soil water content to a large extent determines the effectiveness of implement action during soil preparation. Soils that are too dry break up into large clods and require maximum draw power. Soils that are too wet when tilled, result in poor crumbling and wheel slip. Conditions for preparation are best when the soil surface is dry to ensure good traction for tractors while the subsoil is still moist. Rippers and blade delving give better results when executed at drier conditions.

The direction of tillage should be perpendicular to the contour, *i.e.* down-slope. Deep tillage in two directions may be necessary when a uniformly loose medium is not achieved with working in one direction or better mixing is required. The second tilling must be done at an angle of 60° to the first work direction.

The cutting width of rippers is 66 % of their working depth, while 60cm is normally recommended for a delve plough that works in conjunction with a ripper.

Re-compaction

A key question regarding deep soil preparation has always been, "will the soil re-compact and how long will it take?" The positive effects of deep soil preparation can become undone through re-compaction which can either be man-made or due to natural processes. Man-made processes include vehicle traffic such as tractors and other machinery while soils re-compact naturally under their own weight and due to recurrent wetting by rain and irrigation. Some soils are more prone to consolidation than others. The grapevine root, however, does not make a distinction between natural and man-made soil compaction. Both types are equally harmful to the vine (Figure 5).

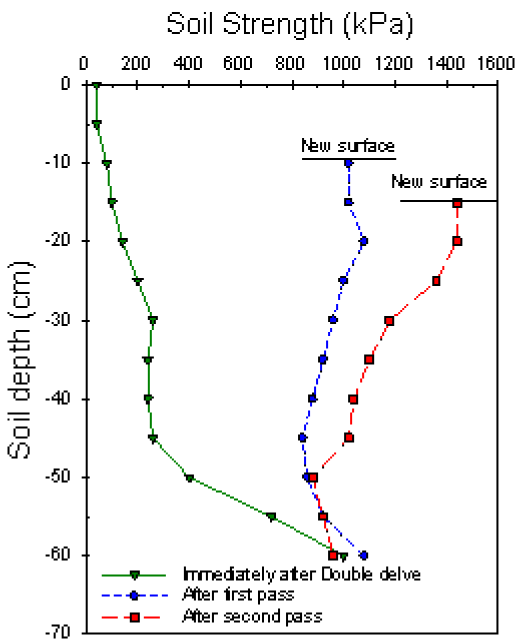

Fig. 5: Re-compaction due to a varying number of passes by tractor wheels on loose soil (redrawn after Van Huyssteen, 1983).

Tractor wheels cause serious compaction with the first pass resulting in the worst compaction down to as deep as 45 cm. A second pass of tractor wheels increases soil strength significantly to a much shallower depth. Most man-made re-compaction happens in the first four months after planting of the vineyard. It is therefore recommended that wheel tractors should not be used on newly prepared soil for at least one year after planting.

Re-compaction under the tractor tracks in existing vineyards can sometimes be so severe that it requires deep loosening of the soil between the tracks.

Re-compaction is a function of time and, amongst others, soil type. Studies in existing vineyards on Hutton/Clovelly, Cartref and Oakleaf/Tukulu soils showed that these soils are relatively stable against re-compaction. The beneficial effect of soil preparation was evident even 26 years after deep tillage was done. The re-compaction that did take place, however, dictates deep tillage before planting a new vineyard.

More research is necessary to predict which soils are prone to natural re-compaction. At this stage the recommendation to growers is to redo soil preparation on all soils after the productive life time (20 – 25 years) of a vineyard has expired.

Plant holes

It is not uncommon to see young vineyards growing poorly and/or unevenly (Figure 6). Such unwanted results may have many causes, but root studies showed that this is often caused by re-compaction of wheel traffic on loosened soil before the vineyard was established or by inadequate plant holes. In a case study, the reasons for uneven growth problems were investigated by means of root studies and the use of a penetrometer and bulk density determinations (Louw & Van Huyssteen, 1993). Their study showed that soil compaction, high soil strengths, and smeared planes are the main causes of problems with plant holes.

Roots having to grow from loose soil in a plant hole to more compact soil outside must force soil particles out of the way through longitudinal growth. The medium from which the root is growing has consequently to be firm enough to support the root section behind the tip, otherwise the root will buckle (so-called root buckling stress) and grow in another direction. A good preventative measure will consequently be lightly stamping down the soil with which the plant holes are filled to support the roots.

In the past, to save time and costs, growers have tried planting grapevines in small furrows made by a spade (Figure 7) or directly in ripper furrows and even, using crowbars, in holes having the diameter of the crowbar shaft. These practices restrict root development and shoot growth suffers as a consequence. In most soils, except on very loose and sandy ones, a fork should be used to dig plant holes since it causes less compaction than a spade (Archer & Hunter, 2010). When spades are used to dig plant holes, a fork can be employed to just loosen the sides and bottom of the hole. This will allow roots to easily expand in all directions and use the soil volume maximally.

Fig. 6: Uneven growth in a young vineyard, typical of compacted soil. In this case vehicle traffic, after the soil had been deep-tilled, caused re-compaction, poor root development and uneven vegetative growth (Photo: JE Hoffman).

A potting effect can also be created by plant holes with smeared sides, round plant holes (Louw & Van Huyssteen, 1993) and plant holes in heavy-textured soils filled up with different soil of a lighter texture, e.g. sand. Smearing and compaction of the sides of plant holes can be minimised by not working in soils which are too wet. As a rule of thumb, plant holes should not be dug while the soil still sticks to the spade. Furthermore, plant holes should not be re-filled with material - including organic material and inorganic fertilizer - other than what was removed while digging them. This will eliminate the risk of roots being restricted to lighter-textured porous material used to fill up plant holes in clayey soils. A disadvantage of round plant holes is the angle of incidence between root tips and the side of the hole. The larger the angle of incidence, the easier a root will grow parallel to the soil layer instead of penetrating it. Square plant holes with uneven sides are the best.

Fig. 7: Confined root systems shaped by compaction outside the plant hole (left) and a small furrow made by a spade. The spade caused compaction on the sides of the furrow.

Sophisticated grapevine machine planters are available on the market and will replace the manual planting of grapevines in future (Fig. 8). The principles that are involved to prevent root restrictions, however, remain the same.

Fig. 8: Grapevine planter used for the establishment of new vineyards in South Africa. The planter is pulled by a tractor and does precision planting of grapevines at a fast rate (Photo: JE Hoffman).

Conclusion:

Roots visually illustrate what conditions they experience in the soil and therefore their distribution is important when soil preparation is planned or assessed. New technology makes root studies easier but the use of root inspection in soil profile pits is still essential. The penetrometer is the ideal instrument to detect soil compaction and penetrometer resistances of more than 2000 kPa is considered restricting to root growth. Methods to alleviate root restrictions depend on soil type, but fortunately we have experience and an array of implements available to provide a horse for each course. Effective soil preparation will result in soil loosened to 800-1000mm without unloosened banks and large clods present or poor subsoil that was brought to the surface.

The aspects discussed above are summaries of some chapters in the book “Soil preparation for sustainable wine and table grape vineyards”. These subjects are discussed in much more detail in the book while other subjects such as root studies, root pruning, terracing, drainage, reclamation of brack soils and application of ameliorants are also included in the book.

References

Archer, E. & Hunter, J.J. 2010. Praktyke vir volhoubare wingerdbou (Deel 3): Plant van wingerdstokke. *Wineland 249*, 87-94.

Louw, P.J.E. & Van Huyssteen, L. 1993. The effect of plant holes on the root distribution of grapevines. *Decid. Fruit Grow*. 374-384.

Van Huyssteen, L. 1983. Interpretation and use of penetrometer data to describe soil compaction in vineyards. *S. Afr. J. Enol. Vitic. 4*, 59-65.

Van Huyssteen, L. 1989. Quantification of the compaction problem of selected vineyard soils and a critical assessment of methods to predict soil bulk density from soil texture. PhD. (Agric.) thesis, Stellenbosch Univ., Stellenbosch.

Please indicate YES or NO if a PROJECT EXTENSION is required (if YES, contact Winetech)
No

Soil compaction is the main impediment to vineyard roots, but soil acidity, water logging, salinity, soil stratification, hardpans, subsoil clays and rock are also limiting factors in many localities. In fact, there are very few South African soils without root-impeding layers within 0.8 meter depth that can be planted to grapevines without deep soil preparation.

9. CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations are summarised after every chapter in the book. The following conclusions are emphasised:

- A reduction in available soil volume decreases the grapevine root system and subsequently also shoot growth and yield.
- Natural soil compaction is the main cause of root restriction in the majority of vineyard soils in the Western Cape, but compaction can also be man-made through vehicle traffic and implement use.
- Uneven growth in young vineyards is often the first sign of soil compaction
- A penetrometer is the ideal instrument to detect soil compaction. Penetrometer resistance above 2 000 kPa is considered to be restricting to root growth.
- Roots visually demonstrate what they experience in the soil. Technology make the study of roots easier.
- Grapevine response to root pruning depends particularly on timing and severity of pruning. In South Africa root pruning is recommended after harvest in autumn to improve grapevine shoot growth and yield of vineyards that decline as a result of soil compaction.
- Ridging is employed on shallow soil that cannot be prepared effectively by deep tillage. Ripping of the subsoil before ridging is beneficial and makes ridge construction easier.
- Terracing of sloping land becomes necessary when inclines become more than approximately 20%. It is an expensive exercise that should be reserved for table grapes and high quality wine grapes.
- Sophisticated grapevine machine planters are available on the market and will replace the manual planting of grapevines in future. The principles that are involved to prevent root restrictions, however, remain the same.
- The causes of drainage problems are many, but typically are over-irrigation, leaking earthen dams and canals, blocked natural waterways and soil layers with a slow permeability.
- Subsurface drainage is normally not done when soils are shallower than 800 mm. Cut-off drains are installed when water moves laterally on impermeable subsoil down-slope.
- Soils are saline (brack) when crop performance is reduced due to excessive salts and/or high Na content. Such soils need to be reclaimed before vineyards are planted. Improvement of drainage

and the presence/addition of lime are key factors in restoring brack soils.
- The reclamation of brack soils that have high ESP values and poor internal drainage can take a long time and be expensive. With regard to waterlogging and salinisation, prevention is always better than cure.
- The correct choice of implement for soil preparation is determined by soil type. The soil must be loosened to a depth of 800-1000 mm, poor subsoil must not be brought to the surface, and the loose soil must have a good structure, i.e. no large clods which cannot be exploited by roots.
- The type and amount of ameliorants that should be applied during soil preparation can be determined by soil analyses. Soil preparation before planting is in fact the only opportunity to remedy low phosphorous (P) content and high acidity (i.e. low pH) of the subsoil, as well as to apply gypsum to the subsoil.
- Based on practical observations and field experiments, soil preparation in South Africa aims to loosen the soil to a depth of at least 80 cm, but preferably to one meter. Normally no further benefit will arise from loosening the soil deeper than one meter.
- Adequate rooting depth can reduce irrigation significantly in some viticulture regions.

10. ACCUMULATED OUTPUTS

a) TECHNOLOGY DEVELOPMENT, PRODUCTS AND PATENTS
None to date

b) SUGGESTIONS FOR TECHNOLOGY TRANSFER
Opportunity for a book launch with invited guests
Introduction to contents of the book at Winetech/Vinpro regional information days
SATI/SASEV information day
Radio talk at RSG
Popular magazines e.g. Farmers Weekly and Landbouweekblad

c) HUMAN RESOURCES DEVELOPMENT/ TRAINING (STUDENTS)

Student Name and Surname	Student Nationality	Degree (eg MSc Agric, MComm)	Level of studies in final year of project	Total cost to industry throughout the project
Honours				
Masters				
PhD				
Postdocs				

d) PUBLICATIONS (POPULAR, PRESS RELEASES, SCIENTIFIC)
Van Zyl, J.L. & Hoffman, J.E., 2019. Soil preparation for sustainable wine and table grape vineyards. Winetech, Paarl, South Africa.

e) PRESENTATIONS/PAPERS THAT COULD BE DELIVERED
Van Zyl, J.L. & Hoffman, J.E. 2019. Root development and the performance of grapevines in response to

natural as well as man-made soil impediments. 21st Giesco International Conference, Thessaloniki, Greece, June 23-28.
Hoffman, J.E. & Van Zyl, J.L. 2019. Soil preparation practices to eliminate soil restrictions to grapevine root distribution for the establishment of sustainable vineyards. 21st Giesco International Conference, Thessaloniki, Greece, June 23-28.

11. PROJECT OUTCOME AND IMPACT

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

Other is:
The information is suitable for student training and for researchers who wish to establish what has been done in the soil preparation field and where knowledge gaps still exist. Soil preparation contractors and technical advisors can also use the information in practice.

The Value of the project to industry
Clear recommendations were made regarding all aspects of soil preparation. Industry can identify soil problems and find the preferred practical solutions by following these recommendations. Application of these solutions will ensure the best practice for every situation and subsequently for sustainable uniform vineyards. Correct soil practices will not only yield better quality and production, but will ensure longevity of the grapevines and buffering against drought, nutrient shortages and other adverse conditions. Increased profits is the bottom line of good soil practices.

12. PERSONS PARTICIPATING IN THE PROJECT

Initials & Surname	**Highest Qualif**	**Race (B, W)**	**Gender (M, F)**	**Institution & Department**	**Position**	**Cost to Project**
Dr JL van Zyl	PhD	W	M	SU-Soil Science	PL	R92 000
Dr JE Hoffman	PhD	W	M	SU-Soil Science	Co	R52 000

** (Only applicable to persons who participate as Consultants or on Contract)

(3)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/ student
TA = Technical assistant/ technician

13. BUDGET

TOTAL COST SUMMARY OF THE ENTIRE PROJECT

TOTAL ANNUAL COSTS (ALL YEARS)	CFPA	RAISIN SA	SAAPPA-SASPA	SATI	Winetech	ARC	THRIP	OTHER	TOTAL
TOTALS	0	0	0	105340	105340	0	0	0	210680
2016				53820	53820				107640
2017				31000	31000				62000
2018				20520	20520				41040
2019									0
2020									0
2021									0
2022									0
2023									0
2024									0
2025									0
2026									0
TOTAL									210680