RESEARCH NOTE

Soil Management in the Breede River Valley Wine Grape Region, South Africa. 2. Soil Temperature

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Five soil management practices (treatments) were applied in a micro-sprinkler irrigated Chardonnay/99 Richter vineyard on a sandy clay loam soil near Robertson, commencing in April 1993 (one year after planting). The effect of the treatments on the soil temperature at a depth of 200 mm was measured on an hourly basis from April 1995 to March 1999. Differences in soil temperature between the un-mulched and mulched treatments, as measured in the grapevine rows, were negligible from late April to the end of August. From mid-September (grapevine bud break) to the end of March, the temperature of the mulched soil was, with the exception of the third week in October, lower than that of the un-mulched soil. Results indicated that soil temperatures during early spring had a slight effect on the onset of grapevine bud break. Mulching minimised the diurnal variation in soil temperature. The annual cover crop did not cause any delay in bud break and kept the soil temperatures below 25°C, with the exception of a three week period just before harvest.

INTRODUCTION

Mulched soils have lower overall mean temperatures throughout winter, spring and summer (Hartley & Rahman, 1997) and less seasonal temperature variation (Wooldridge, 1992), compared to soils without mulch. A mulch may reduce soil temperature by between 1°C and 4°C in a no-till soil compared to that of a ploughed soil as measured from 09:30 to 17:30 (Lal, 1974). The same mean temperatures may differ depending on their diurnal pattern (Walker, 1970). Under mulches soil temperatures are warmer in the morning and cooler in the afternoon (Hartley & Rahman, 1997). Extremes in soil temperatures are therefore minimized in mulched soils by reducing diurnal soil temperature fluctuations compared to soils without mulch (Wooldridge, 1992; McNab & Dick, 1995; Hartley & Rahman, 1997).

Soil micro-organisms have an optimal temperature range of approximately 15°C to 30°C (McNab & Dick, 1995). As a result the production of NO_3^- from NH_4^+ and urea is slower when the soil temperature is not optimal (McNab & Dick, 1995). A change of 1°C in soil temperature can induce significant effects on the growth and nutrient uptake in maize (Walker, 1969), the temperature during the period of daylight apparently having the greatest effect (Walker, 1970). Soil temperatures from 10°C to 25°C favoured the above-ground growth of a perennial ryegrass (*Lolium perenne* L.) (Davidson, 1969).

This study (part of a wider study on the effect of soil cultivation practices on grapevine performance and the soil) was conducted to determine the effect of five soil cultivation practices on the soil temperature at 200 mm depth of a medium textured soil in the grape producing areas of the Breede River Valley wine grape region of South Africa.

MATERIALS AND METHODS

Experiment vineyard and layout

The detailed experiment procedures and layout were previously described by Fourie (2010). The trial was conducted from April 1993 to March 1999 on a sandy clay loam soil in a four year old Chardonnay/99 Richter vineyard near Robertson (33°50'S, 19°54'E). The grapevines were spaced 1.5 m in the row and 2.75 m between rows and trained on a seven strand double lengthened Perold trellis system (Booysen *et al.*, 1992). Full surface irrigation was applied weekly from April to May and fortnightly from June to March by means of a micro-sprinkler system. This study is part of a bigger trial in which eleven treatments were applied as described by Fourie (2010). The five soil management treatments in which soil temperature was monitored are described in Table 1. The treatments were replicated four times in a fully randomized design. Ten experimental grapevines were used per replication for monitoring grapevine performance. Individual plots (replications) were separated by two border grapevine rows and five border grapevines within rows.

Measurements

Temperature sensors were placed at a soil depth of 200 mm in both the grapevine row (midway between the grapevines) and the work row (in the middle of the row, between the tractor tracks), as the grapevines received full surface irrigation by means of micro-sprinklers which resulted in significant root growth in both the grapevine row and work row (Brink, 2007). The temperatures (°C) in both the vine row and work row were monitored on an hourly basis (MCS 120EX data loggers) on two replications per treatment from April 1995 to March 1996 and repeated for another three consecutive seasons.

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The number of grapevine buds that had opened by mid-September was counted in all four replications per treatment and expressed as a percentage of the total number of buds allocated per vine during pruning. This was done for three consecutive years (1996 to 1998). Grapevine bud break was assumed to have been reached when 50% of the buds had reached stage four of the modified E-L system (Coombe, 1995).

RESULTS AND DISCUSSION

Average daily soil temperatures in the grapevine row throughout the season

The four year averages of the mean daily temperatures are presented in Figs 1 to 4. The differences in the soil temperatures between the un-mulched (T1 – representing the un-mulched treatments) and mulched (T2) treatments were negligible from late April to the end of August (Fig. 1). Soil temperatures in the un-mulched and mulched treatments were below 15°C from the third week of May to 11 and 15 September, respectively (Figs 1 & 2). The mulched soil therefore took four days longer than the bare soil to reach the temperature level at which soil micro-organisms become more active and increase production of NO_3^- from NH_4^+ and urea (McNab & Dick, 1995). From mid-September (grapevine bud break) to the end of March, the soil temperature of the mulched soil was, with the exception of the third week in October, lower than that of the bare soil (Fig. 2). This supports the results of Wooldridge (1992) and Hartley & Rahman (1997). From the end of December to the end of March the difference in temperature between the mulched and un-mulched soil exceeded 3°C with the biggest difference of 4.3°C being recorded on 8 February, approximately one week before the grapes were harvested. From the end of December to mid-February (véraison to harvest) the temperature of the bare soil (T1) exceeded 25°C (Fig. 2), the level above which plant growth may become sub-optimal (Davidson, 1969).

Average daily soil temperatures in the work row throughout the season

The temperature of the soil covered with straw mulch (T2) was the lowest throughout the season (Figs 3 & 4). Soil temperatures measured in the work row of all the treatments, with the exception of the treatment in which the soil surface was left bare (T1), dropped below the optimal temperature range of 15°C to 30°C for soil organism activity (McNab & Dick, 1995) from 21 May (Fig. 3). In treatment T1 this occurred slightly later, namely from 27 May. The post-harvest application of fertilizer should, therefore, be completed before mid-May in the Breede River Valley, especially where NH_4^+ and urea products are used. From late August the soil temperatures in all the treatments gradually increased and, with the exception of T2, reached the level of 15˚C between 7 and 10 September (Fig. 4). The mulched soil (T2) reached this level approximately one week later and continuously exceeded 15°C from 2 October onwards. This was the treatment with the lowest percentage of opened buds in mid-September (Fig. 5). This indicated that soil temperatures during early spring do have an effect on the onset of grapevine bud break, supporting the results of Alleweldt & Hofäcker (1975). During the grapevine growing season, the soil temperature in T2 never exceeded 25°C (Figs 1 to 4), the level above which plant growth may become sub-optimal (Davidson, 1969). For most of the grapevine growing season, the highest soil temperatures in the work row were recorded for T1 (Fig. 4). In this treatment the soil temperature exceeded 25°C from 26 December to 11 March. Soil temperatures exceeded 25°C from 29 December to 27 February where the work row was mechanically cultivated (T3) and from 30 December to 22 February where a permanent sward was growing in the work row (T5). The mulch from the annual cover crop (T4) kept the soil temperatures below 25°C up to 22 January and again from 13 February onwards, thereby restricting unfavourable soil conditions to a period of three weeks before harvest.

Diurnal variation in soil temperature in the work row

The diurnal variation in soil temperature (maximum minus minimum temperatures) measured in the different treatments, was the highest during the 1997 season and more specifically during grapevine berry set (Fig. 6). The difference in the daily minimum and maximum temperatures of T1 was 4.42°C. By comparison, the diurnal variation in soil temperature was slightly less in the treatments in which mechanical cultivation was applied (T3) and in which a permanent sward was slashed throughout the season (T5), namely 4.11°C and 3.67°C, respectively. The two mulched treatments, namely T2 and T4, limited the diurnal variation in soil temperature to 1.74°C and 2.01°C, respectively. This was between 1.66°C and 2.68°C less than that of the un-mulched treatments and supports the results of Wooldridge (1992) and McNab & Dick (1995).

TABLE 1

Soil management treatments applied from April 1993 to March 1999.

Treatment number	Description
T1	No cover crop, full surface post-emergence chemical weed control from the end of August to the end of January (FSWC).
T2	Full surface wheat straw mulch packed out annually approximately two weeks after grapevine bud break (third week of September) at a density of 8 tons/ha, FSWC.
T3	No cover crop, post-emergence chemical weed control of a 1 m wide strip in the grapevine row (GRWC) and mechanical weed control in the work row from the end of August to the end of January.
T4	*Triticale* v. Usgen 18 (triticale) sown annually at a seeding density of 100 kg/ha, FSWC.
T5	*Festuca arundinacae* L. v. Cochise (dwarf Fescue) sown during 1993 and 1998 at a seeding density of 15 kg/ha, GRWC and slashing in the work row throughout the season.

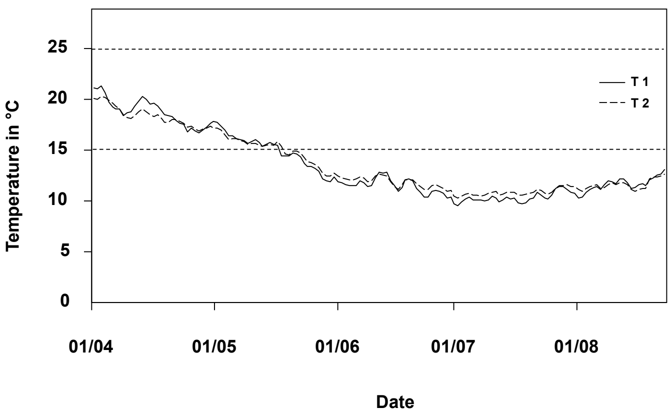

FIGURE 1

Effect of two soil management practices applied in the vine row on the average daily soil temperature at a depth of 200 mm as measured from April to August. Data presented are the average of four seasons (treatments are described in Table 1).

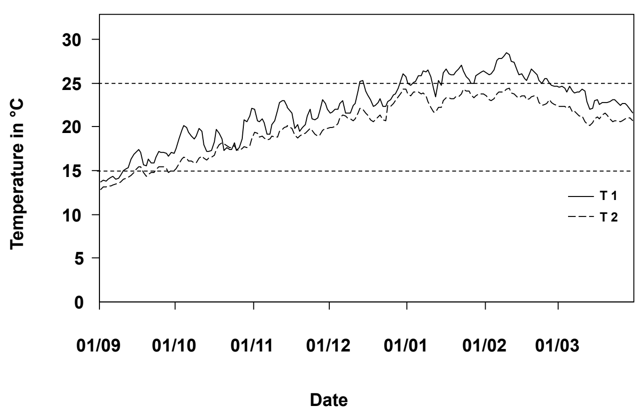

FIGURE 2

The effect of two soil management practices applied in the vine row on the average daily soil temperature at a depth of 200 mm as measured from September to March. Data presented are the average of four seasons (treatments are described in Table 1).

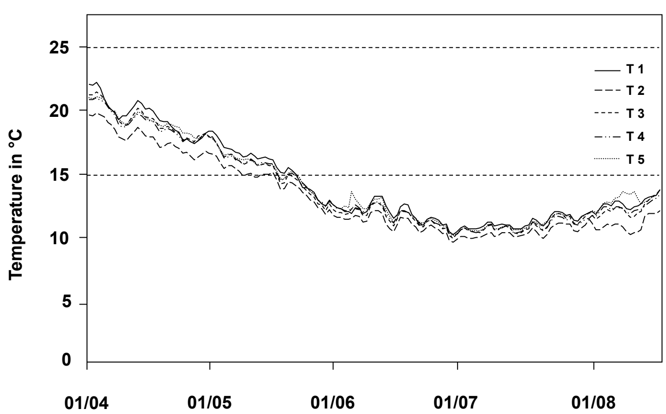

FIGURE 3

The effect of five soil management practices applied in the work row on the average daily soil temperature at a depth of 200 mm as measured from April to August. Data presented are the average of four seasons (treatments are described in Table 1).

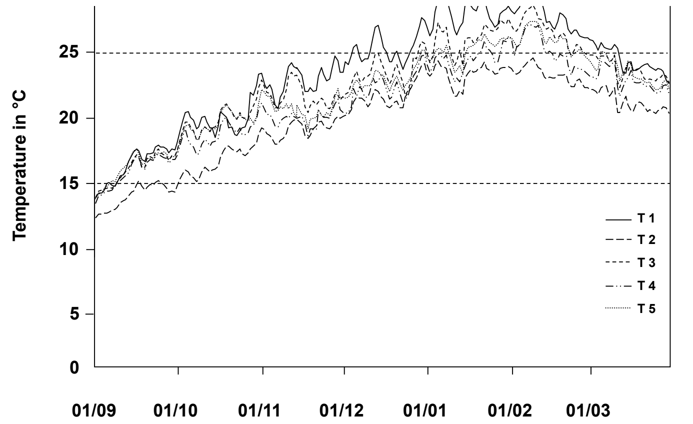

FIGURE 4

The effect of five soil management practices applied in the work row on the average daily soil temperature at a depth of 200 mm as measured from September to March. Data presented are the average of four seasons (treatments are described in Table 1).

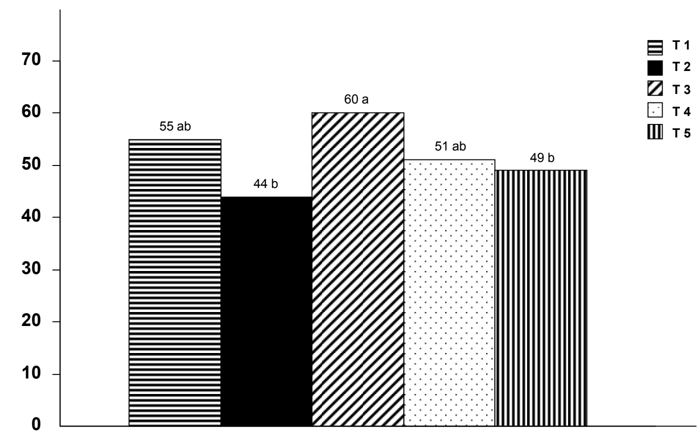

FIGURE 5

The effect of five soil management practices applied in the work row on the average bud percentage, as determined mid-September for three consecutive years. Data presented are the average of three seasons (treatments are described in Table 1).

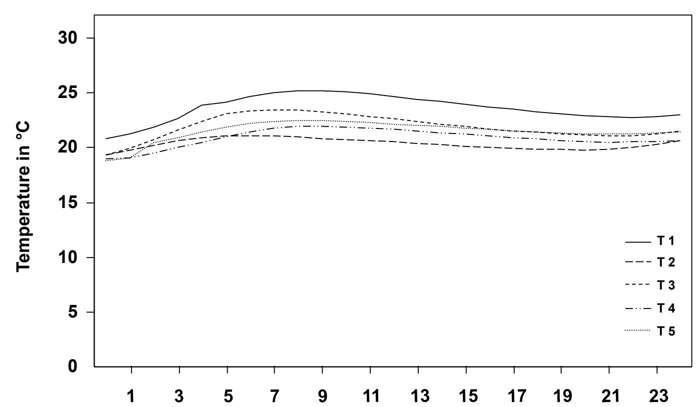

FIGURE 6

The effect of five soil management practices applied in the work row on the diurnal variation in soil temperature at a depth of 200 mm, as measured on 3 December 1997. (Treatments are described in Table 1).

CONCLUSIONS

A surface mulch limited the diurnal variation in temperature of a medium textured soil during the grapevine growing season.

A medium textured soil covered by a full surface straw mulch throughout the year takes approximately one week longer to reach temperatures conducive to soil organism activity during early summer than soils subjected to other management practices. It may also delay bud break slightly. It does, however, create a favourable environment for the grapevine roots throughout the grapevine growing season. By using an annual cover crop which is controlled chemically just before grapevine bud break, sub-optimal soil temperatures experienced with a full surface straw mulch during the first two weeks after grapevine bud break can be avoided.

To help ensure that N applied post-harvest in the vineyards of the Breede River Valley is readily available to the grapevines, irrespective of the soil cultivation practice applied, the application of N should be restricted to the period between mid-March and mid-May. Where an annual cover crop is used, the post-harvest application of N may be considered from as early as mid-February.

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