A Frost Regime Microclimatological Study in Southern Argentina (Añelo, Province of Neuquén)

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Abstract

Frosts constitute a main hazard for most of the Argentine olive growing area. As a component of a feasibility assessment, financed by the Argentine Federal Investment Council (CFI) to introduce olive growing in southern Argentina (Neuquén), a microclimatological study of the frost regime in 3760 ha was conducted. The field occupies a band, with moderate gradient, which runs between the limit of the Patagonian plateau and the Neuquén River that flows in the lower part of a narrow valley, thus allowing cold air to drain, mitigating frost intensity. To evaluate frost hazard, a meteorological automatic station with capacity to transmit data, and 30 registering temperature sensors were installed, making observations from March to November 2010. Those registers were correlated with data from two neighbor climate stations, reconstructing the local series for the 2001-2010 decade. Those reconstructed data were introduced in a model developed taking as a basis the NCEP (National Centers for Environmental Prediction of NOAA) Climate Forecast System Reanalysis a downscaling process was carried on, for a 2.5 by 2.5 m grid, covering the area in study to a high degree of resolution. Maps of mean value, beginning, end and duration of the annual periods with temperatures equal or less than 0, -1, -3, -7, -10 and -12°C, were elaborated. For all thermal levels, it was observed that the lower portions of the fields are prone to suffer longer lasting and more intense frosts, making evident the importance of two main microclimate factors: (a) upper portion of the area, higher wind speed, impedes air stratification avoiding the thermal inversion necessary for radiation frost development; and (b) lower portions of the field, cold air drainage ads to thermal loss increasing cooling. Those criteria allowed dividing the field in sub-areas with different levels of frost hazard.

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INTRODUCTION

Due to the inherent seasonal variability of the oceanic South American climate, frosts constitute a main hazard for most of the Argentine olive growing area, to a far greater extent than they are in the European growing areas (Gómez del Campo et al., 2010). Therefore, the detection of areas with suitable frost regimes is an important requirement for the olive expansion in Argentina, as it is planned in the Olive Industry Strategic Plan for 2020 (Gallego et al., 2011).

As a component of a feasibility assessment, financed by the Argentine Federal Investment Council (CFI) to introduce olive growing in the Añelo area of Neuquén Province in southern Argentina, a microclimatological study of the frost regime was developed for 3,760 ha. It is an irrigated area close to Mari Menuco Lake, in the vicinity of Añelo City, Neuquén Province, Argentina (38°23'42"S; 68°55'02W, 450 m a.s.l.) (Fig. 1). The field occupies a band, with moderate gradient, which runs between the limit of the Patagonian plateau and a river that flows in the lower part of a narrow valley, thus allowing cold air to drain, mitigating frost intensity (Fig. 1).

Compared to the traditional argentine olive growing regions in northern Argentina, the Añelo is expected to show a more severe temperature regime (Gómez del Campo et al, 2010). Nevertheless, the strong and permanent winds, characteristic of the Argentine Patagonia, constantly impede the formation of thermal inversions, thus posing an effective deterrent to frost development. Additionally, among all Argentine olive growing areas in western territories, Añelo is the only one with a Mediterranean hydrologic regime, with winter rains, such as the European olive growing areas.

MATERIALS AND METHODS

To evaluate frost hazard, a meteorological automatic station (iMetos ET) with capacity to transmit data, and 30 registering digital thermometer (Thermochron iButton DS1922L), were installed in a grid distribution to obtain data from the entire area, making observations from March to November 2010. Minimum daily temperature registries, taken in the field during the 2010 season, were correlated with data from two neighbor climate stations, thus reconstructing the local series for the 2001-2010 decade, and therefore allowing the elaboration of a statistical analysis of the frost regime in the area. Those reconstructed data were introduced in a model developed taking as a basis the NCEP (National Centers for Environmental Prediction of NOAA) and Climate Forecast System Reanalysis (Suranjana et al., 2010). A downscaling process was used for a 2.5 by 2.5 m grid, covering the area to a high degree of resolution.

Charts were elaborated by means of the Grid Analysis and Display System (GrADS) (Doty and Kinter, 1992), which is an interactive desktop tool that is used for easy access, manipulation, and visualization of earth science data. The BUFR version for station data of GRADS was employed to elaborate charts of mean value, beginning, end and duration of the annual periods with temperatures equal or less than 0, -1, -3, -7, -10 and -12°C, were elaborated. As a complement, rainfall (mm), wind speed (km/h), maximum temperature, atmospheric humidity, severe storm probability and evaporation regimens were also evaluated and are shown in comparison to other more northern Argentina olive growing areas (Table 1).

RESULTS AND DISCUSSION

The average date of beginning of the annual period with temperatures equal or lower than 0°C ranges from mid-February in the lower parts of the field (central and southern areas) to the last days of June, in the higher portions (northern area). The average date of ending of the annual period with temperatures equal or lower than 0°C, ranges from the last days of July in the higher portion of the field (northern part), to mid-November in the lower portions (southern area).

These features result in an average duration of the annual period with temperatures equal or lower than 0°C (Fig. 2) of about just one month in the higher portion of the field (northern part), to almost nine months in the lower portion (central and southern portion).

On the other extreme of the thermal range the average date of beginning of the annual period with temperatures equal or lower than -10°C ranges from mid-June in the lower parts of the field (central and southern portions) to mid-July, in the higher portions (northern portion). The average date of ending of the annual period with temperatures equal or lower than -10°C, ranges from late July in the higher portion of the field (northern part), to mid-August in the lower portions (southern part). This results in an average duration of the annual period with temperatures equal or lower than -10°C (Fig. 3) of about just ten days in the higher portion of the field (northern part), to almost two months in the lower portion (central and southern areas).

For the other thermal levels considered in the study, it was also observed that the mid and lower portions of the fields are prone to suffer longer lasting and more intense frosts, making evident the importance of two main microclimate factors:

a) In the upper portion of the surveyed area, higher wind speed, impedes air stratification avoiding the thermal inversion necessary for radiation frost development.
b) In the mid and lower portions of the field, cold air drainage adds to thermal loss increasing cooling. Those criteria allowed dividing the field in sub-areas with different levels of frost hazard.

Although climatic characterization of this new olive area seems to be very similar to other northern olive growing regions (Table 1), it was observed that the frost prone portions of the surveyed area are situated in its central and lower portions of the field, were the topography does not allow the cold air to go down slope. It was also found that wind regime in the Añelo area is far more intense and persistent than in other Argentine olive growing areas (Fig. 5).

Frost damage levels in olive are related to the plant age, the duration and the minimum temperature reached (Barranco et al., 2005). Although the olive tree is moderately resistant to freezing temperatures, below -7°C damage is observed affecting productivity, while at temperatures below -10°C the damage can be severe enough to threaten the plant survival (Barranco et al., 2005). In this study, lower portions of the area (central and southern), which represented more than 50% of the surveyed area, are at risk for one or more days with frost below -10°C (Vita Serman et al., 2011).

CONCLUSIONS

It can be concluded that the higher part of the field shows an acceptable aptitude for olive growing, while the lower portions are prone to a very severe frost regime that may severely hamper production. The results show that a microclimatological study of the frost regime is an interesting and reliable tool for the detection of suitable areas without frost risk.

ACKNOWLEDGEMENTS

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Tables

Table 1. Comparison of several annual climatic characteristics in different Argentine olive growing areas.

Parameter[1]	Añelo (Neuquén)	Sarmiento (San Juan)	Pocito (San Juan)	Junín (Mendoza)	San Rafael (Mendoza)
Altitude (m)	396	639	615	657	690
Annual average T° mean (°C)	14.5	17.6	17.0	15.2	15.0
Average T° max (°C) January	30.9	34.1	34.1	30.8	30.6
Average T° min (°C) July	-0.1	0.9	0.0	1.4	1.2
Annual rainfall (mm)	145	127	99	260	347
Annual Eto (mm)	1312	1600	1575	1475	1400
Chilling hours	880	761	733	783	822

[1] Source: National Weather Service of Argentina.

Figures

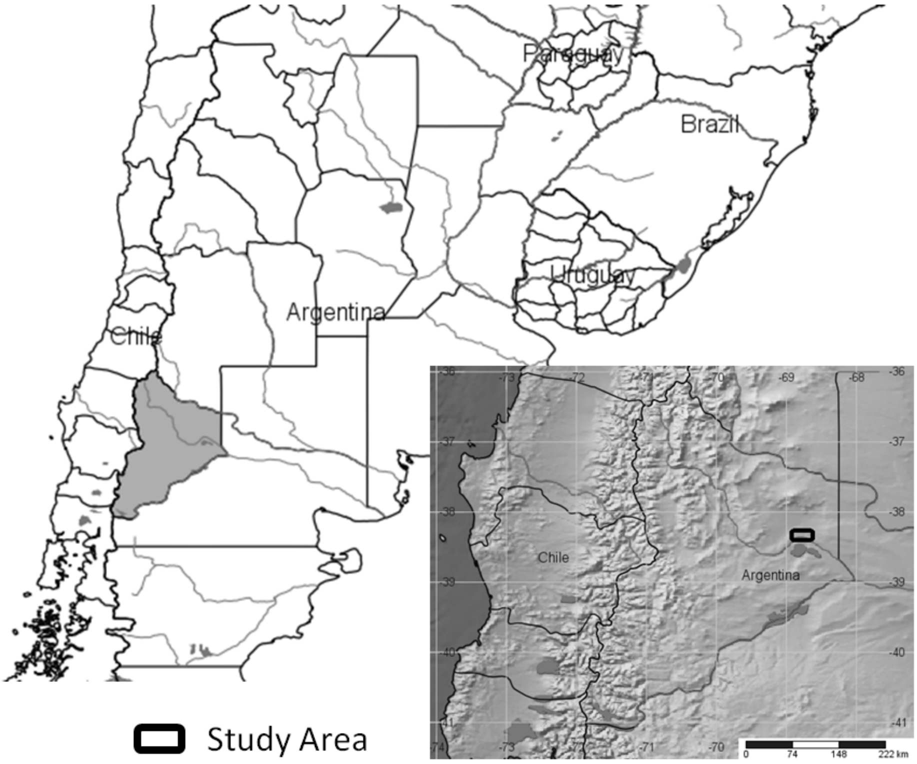

Fig. 1. The study area (3,760 ha) in the Department of Añelo, Province of Neuquén, Argentina (Lat. 38°25’S, Long. 68°56’W; altitude above sea level 423 m).

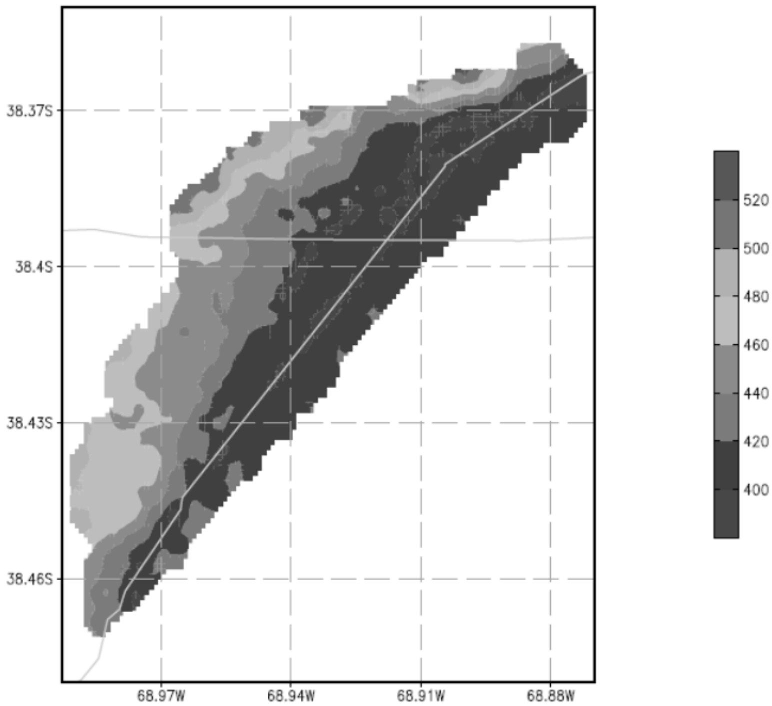

Fig. 2. Altitudinal distribution above sea level of the study area in the department of Añelo in the Neuquén province (Argentina).

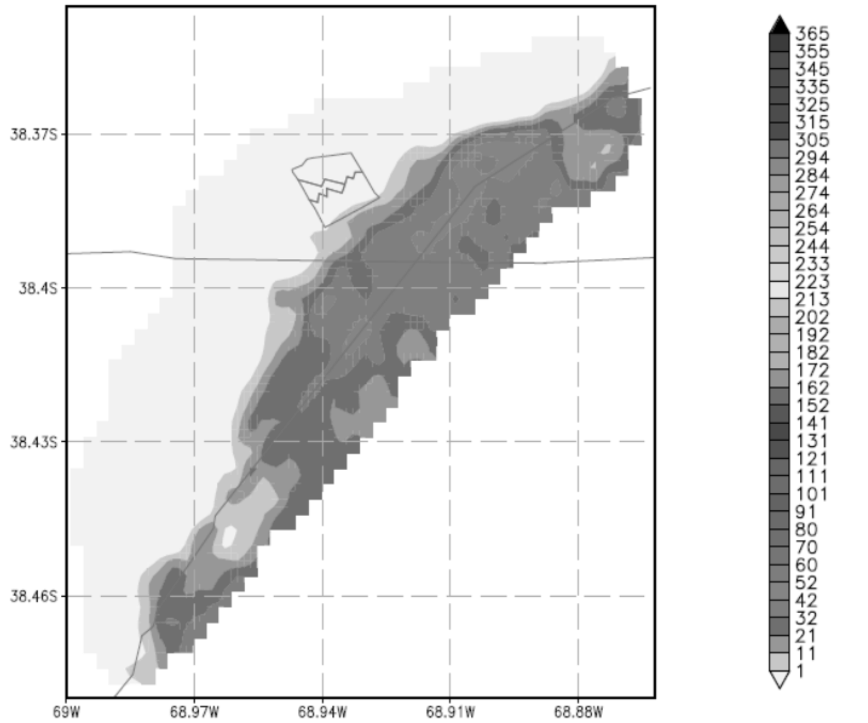

Fig. 3. Average duration (in days) of the annual period with temperatures equal or lower than 0°C.

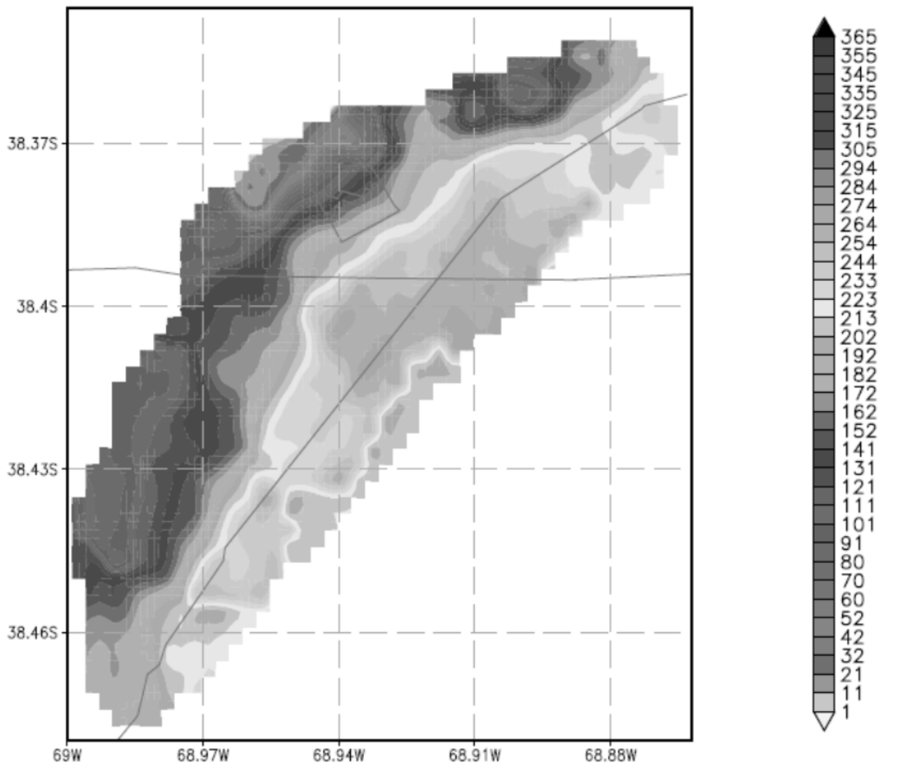

Fig. 4. Average duration of the annual period (in days) with temperatures equal or lower than -10°C reference.

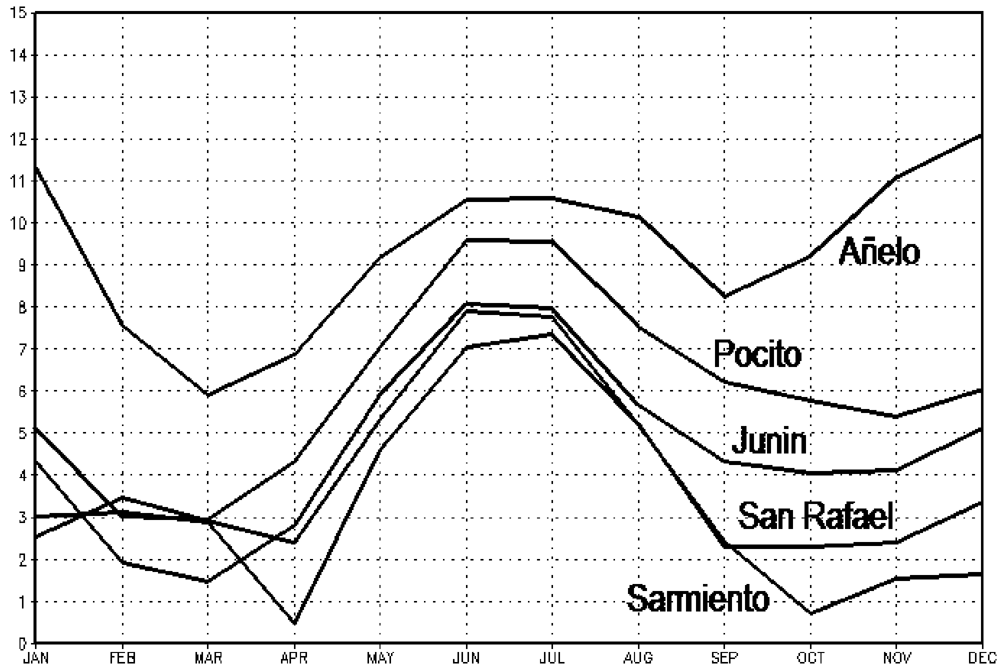

Fig. 5. Wind speed monthly average in five different olive growing areas of Argentina: Añelo (Neuquén), Sarmiento (San Juan), Pocito (San Juan), Junín (Mendoza) and San Rafael (Mendoza).