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WIRELESS SENSOR NETWORK FOR PRECISION VITICULTURE: THE N.A.V. SYSTEM

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INTRODUCTION

Precision viticulture (PV) aims to optimize vineyard performance, in particular maximizing grape yield and quality while minimizing environmental impacts and risk. PV depends on new and emerging technologies, such as a wireless sensor network (WSN) which provides an useful and efficiency tool in order to remote and real-time monitoring for high quality productions and processing systems. In PV the WSN can be fundamental where the measurement of environment parameters is difficult to access and when a multi-point monitoring stations are necessary. The present work is a focus on N.A.V. system (Network Avanzato per il Vigneto - Advanced Vineyard Network), a WSN installed in the fields, designed and realized for the requirements of "Consorzio Tuscania" research project, with the aim of monitoring and collecting agrometeorological parameters of the vineyard, in order to understand the effects of differents canopy management options on wine quality.

SYSTEM

Fig.1 Master Unit

Fig.2 Slave Unit

The N.A.V. system was installed and tested in 3 wine vocation area of Tuscany (Italy). It consists of a network of wireless stations, and in particular a base station (Master Unit, fig.1) and 10 peripheral nodes (Slave Unit, fig.2) in each experimental vineyards. The Master Unit is a typical single point monitoring station and collects traditional agrometeorological data, placed outside the vineyard in a representative location, while each Slave Unit was distributed within the vineyard, in agreement with the experimental plan of the project, in order to evaluate the microclimatic variability associated with management practices in different vigour areas of the vineyard. A test period preceded the installation in the vineyard, during which have been assessed hardware functionality, data acquisition, power supply and data transmission.

SENSORS

The Master Unit includes sensors for the measurement of the main agro-meteorological parameters such air temperature, wind speed and direction, precipitation, atmospheric pressure, air humidity and global solar radiation. The sensors are conformed to Guide to Meteorological Instruments and Methods of Observation (World Meteorological Organization, 2008), standards for agrometeorological weather stations. Each of the Slave Unit is equipped with the sensors listed in tab.1. Sensors utilized (fig.3-4) are reported in tab.1, and installed in accordance with project protocol (fig.5). The agrometeorological parameters acquired are listed in tab.2. Every station is completely independent in terms of energy supply, in fact it is powered by a solar panel with a battery, which guarantees operation up to 3 days in complete absence of solar radiation.

Fig.3 Air and leaf temperature sensors

Fig.4 Grape radiation sensor

SLAVE SENSORS	Chn	Parameter	Sensor
ADC - 12bit Range = 0 ÷ 3V Res =0.73mV	P1	Air Temperature	*Thermocouple type T - 1/0.315mm*
	P2	Grape Temperature	*Thermocouple type T - 1/0.2mm*
	P3	Leaf Temperature	*Thermocouple type K (Omega IR OS36SM)*
	P4	Soil Temperature 30cm Soil Water Potential 30cm	*Water Matric Potential Sensor (Campbell 229-L)*
	P5	Soil Temperature 60cm Soil Water Potential 60cm	*Water Matric Potential Sensor (Campbell 229-L)*
	P6	Grape Radiation	*Prototype with silicon photocell*
	P7	Leaf Wetness	*Prototype leaf wetness sensor*
Counter	IMP1	Wind Speed	*Prototype 3-cup anemometer*
Power Supply		**Voltage** V-IN / + 6 V V-OUT / + 3 V	Slave Unit extra

Tab.1 Sensors equipped on Slave Unit

	n°	Variables	Units
Master Unit	1	Date	dd/mm/yy
	2	Hour	hh:mm:ss
	3	Air temperature	°C
	6	Relative humidity	%
	9	Pressure atmospheric	hPa
	10	Global radiation	Wm^{-2}
	11	Precipitation	mm
	12	Wind velocity	ms^{-1}
	13	Wind direction	°
	14	Num. of acquisition	#
	15	Battery level	mV
	16	Alarm	flag
	n°	**Variables**	**Units**
Slave Unit	1	Date	dd/mm/yy
	2	Hour	hh:mm:ss
	3	Global radiation	Wm^{-2}
	4	Air temperature	°C
	5	Grape temperature	°C
	6	Leaf temperature	°C
	7	Soil Temperature 30cm	°C
	8	Soil Temperature 60cm	°C
	9	Soil Water Potential 30cm	MPa
	10	Soil Water Potential 60cm	MPa
	11	Wind velocity	ms^{-1}
	12	Leaf wetness	# minutes
	13	Battery level	mV

Tab.2 Data acquisition output.

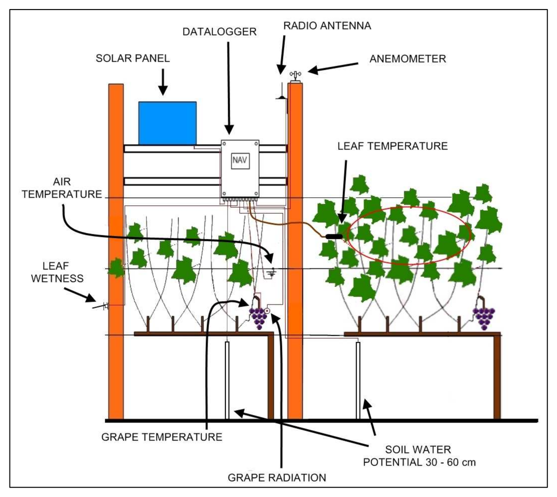

Fig.5 – Installation protocol of Slave Unit sensors

DATA TRANSMISSION

The project data transmission protocol uses both radio frequence and GSM/GPRS. The data collected by the Slave Unit are sent through a radio device to the Master Unit, which collects those data and subsequently transferred to a remote server at daily rate. Figure 6 illustrates the data transmission flow between acquisition hardware, where a specific software manages both hardware configuration, transmission, storage and data processing.

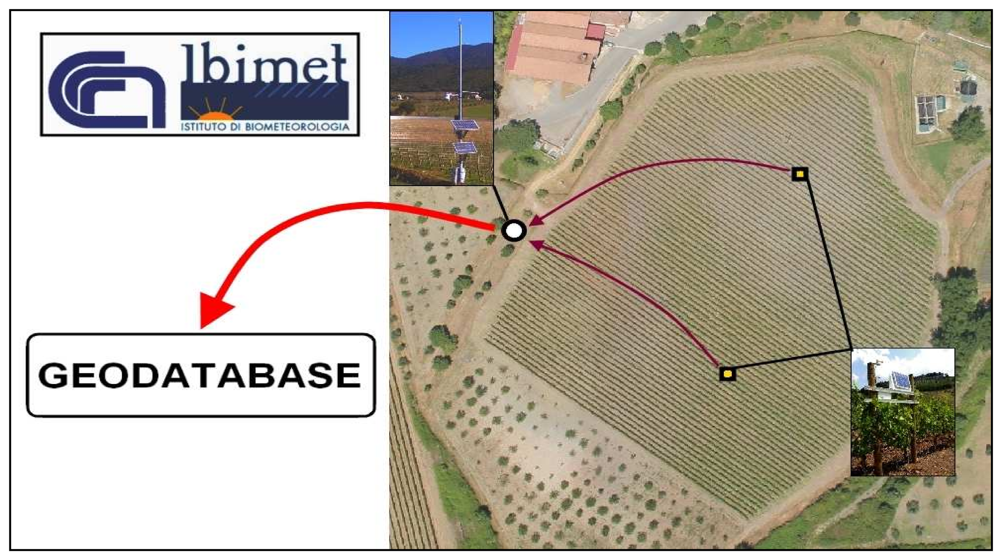

Fig.6 Data transmission flow chart

CONCLUSION

The aim of this work is to real-time monitoring micro-meteorological parameters of vineyard accordingly to the needs of "Consorzio Tuscania" project. The N.A.V. system is very useful in the vineyard for the study of soil and microclimatic conditions variability; it responds in exhaustive way to the aim of the project, but is also a complete monitoring system characterized by its flexibility of planning and installation. Real-time monitoring allows the winemaker a rapid adoption of best strategies management to obtain quality wines.

SOFTWARE

The firmware loaded in the CPU of the meteorological stations datalogger (fig.7), provides the user with a real time check of different parameters, as battery level or instantaneous sensors data acquisition.

The software, developed with language Borland C + + Builder, manages the procedure for data storage, it allows a daily and automatic acquisition on remote server from the meteorological stations with GSM technology. It also performs the procedure of data processing, which generates graph of the temporal trends of the whole agrometeorological parameters measured by the single stations (fig.8).

Fig.7 Master Unit hardware datalogger structure

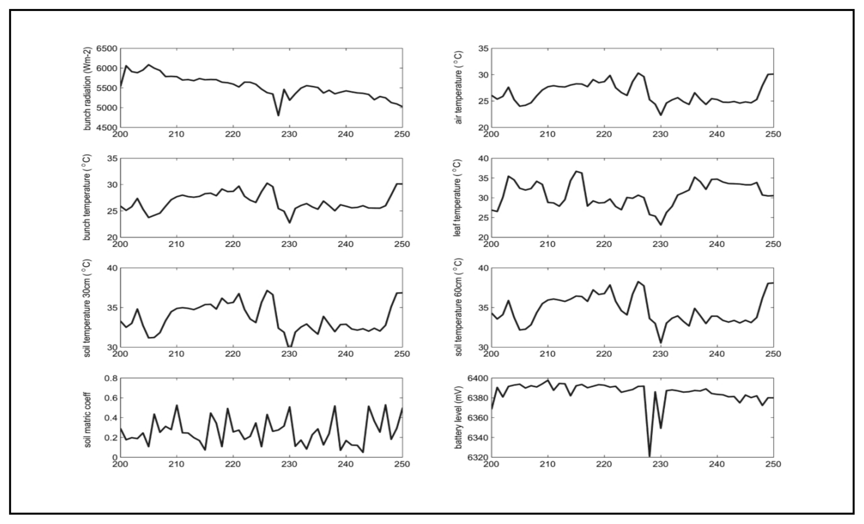

Fig.8 Temporal trends of the whole agrometeorological parameters measured by a single SU .

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