INBIODYN: Integrated, bio-organic and biodynamic viticulture. A comparative study over a 10-year-period

G. Meißner[1], J. Döring[1],M. Friedel[1], M. Stoll[1], R. Kauer[1]

Key words: bio-organic viticulture, biodynamic viticulture, horn silica, biodynamic preparations

Abstract

Demand and production of organic and biodynamic crops have been growing exponentially in the last decades around the world. The organically managed viticultural surface in Europe increased substantially from 43.000 ha in 1998 to 230.000 ha in 2011, corresponding to around 5.3 % of all vineyards within Europe. Some of the most prestigious domains have converted to organic or biodynamic viticulture, respectively. However, little research has been conducted on the impact of these management systems on vine growth, yield and product quality.

In 2006 a viticultural field trial (INBIODYN) comparing integrated, organic and biodynamic viticulture was established at Geisenheim University in Germany. Yield, pruning weight and sugar content of the must differed significantly between treatments over a 7-year-period (2006-2012). The integrated treatment showed significantly higher pruning weight, yield and significantly lower sugar content of the must compared to the organic and the biodynamic treatment. Reasons for the changes in growth, generative performance and must quality will be discussed.

Introduction

Globally the viticultural surface managed according to organic and biodynamic standards tripled in the last 10 years.

Lately the biodynamic farming system is gaining more and more attention. Positive experiences of winegrowers working biodynamically stimulate the discussion within the wine sector.

A long-term field trial comparing integrated, bio-organic and biodynamic viticulture (INBIODYN) with a deeper look into the biodynamic system and the effects of the "biodynamic horn silica preparation" was established at Geisenheim University in 2006. The aim is to investigate the effects of the respective management systems on soil, vegetative and generative growth as well as on wine quality. The experiment is supervised by an advisory team with background from integrated, bio-organic and biodynamic agriculture.

Material and methods

The experimental field (0.8 ha; 49 ° 59'; 7 ° 56') was planted in 1991 (*Vitis vinifera* L. cv. Riesling, Gm clone 198-30; grafted on *Vitis berlandieri* Planch. x *Vitis riparia* Michx. cv. SO4 and *Vitis riparia* Michx. x *Vitis cinerea* Engelm. cv. Börner rootstock, respectively). The vines were planted at a spacing of 1.2 m within rows and 2 m between rows using a vertical shoot positioning system (VSP). Until the end of 2005 the vineyard was managed according to the code of *good practice* (BMELV 2010).

[1] Department of General and Organic Viticulture, Hochschule Geisenheim University, Germany, Georg.Meissner@hs-gm.de

Conversion to organic and biodynamic viticulture started in 2006. Each plot consisted of four rows with 32 vines each. Only the inner two rows of each plot were used for data collection. The outer rows were considered as buffer rows. The experiment was set up as a complete block design with four replicates.

In all three management systems compost was applied (same N-equivalents; 50 kg N ha^{-1} in 2006, 25 kg N ha^{-1} in 2007). In the integrated treatment green waste compost was used. In the organic and biodynamic management system compost made out of manure was used. In the case of biodynamic viticulture, the compost preparations 502-507 were applied.

In the integrated treatment (good practice) sward was mainly used as cover crop. In the organic (EC Regulation 834/2007 and ECOVIN standard) and the biodynamic (EC Regulation 834/2007 and DEMETER standard) plot a seed mixture rich in legumes (Wolff-mixture) was used. Nitrogen supply of the organic and the biodynamic treatment was ensured by ploughing up the cover crop mixture (rich in legumes) of every second row shortly before full-bloom. In the integrated treatment mineral fertilizer was added (25 kg N ha^{-1} in 2006, 50 kg N ha^{-1} in 2010, 25 kg N ha^{-1} in 2012) to compensate for the nitrogen introduction that occurred in the organic and in the biodynamic treatments due to the Wolff-mixture.

In the under-vine area of the integrated treatment herbicides (Glyphosate®) were applied twice a year. The under-vine-area of the organic and the biodynamic plot was worked mechanically.

Synthetic fungicides were used for plant protection in the integrated treatment. In the organic and the biodynamic plot, wettable sulfur, copper (max. 3 kg ha^{-1} a^{-1}) and plant strengtheners (Mycosin Vin® and Potassium Bicarbonate) were applied.

The organic and the biodynamic treatments received the identical plant protection and soil management except for the application of the biodynamic preparations that occurred only in the biodynamic plots. Horn silica (preparation 501) is applied three times during the growing season at the phenological stages shortly before full-bloom, at veraison and shortly before harvest. The horn manure preparation (preparation 500) was also applied three times per year during late autumn and spring. In the years where no compost application took place, the cow pat pit preparation was applied in the biodynamic plots.

Pruning weight was measured gravimetrically during the winter as the mean of 16 vines. Infestation with *Botrytiscinerea* and sour rot on clusters was determined shortly before harvest following the Eampp guidelines (Organisation Eampp Guideline for the efficacy evaluation of fungicides PP 1/31(3)). For this purpose 100 clusters per row were used for estimation of disease severity, 50 on each side of the canopy.

A balanced fixed factorial analysis of variance was carried out (fixed factors treatment, rootstock, block, year, interaction treatment:rootstock, treatment:year). If a main effect or an interaction was significant ($p<0.05$), a Tukey test ($p=0.05$) was carried out to compare the factor levels. For all the parameters measured averages per combination of treatment:rootstock:block:year (n=1) were calculated and used for statistical analyses. The statistical analyzes were performed with the software R®.

Results

Growth

During the investigation period, the growth rate of the organic and the biodynamic variant, as measured by the pruning weight, was significantly lower than in the integrated variant (ca.10-15%, Figure 1).

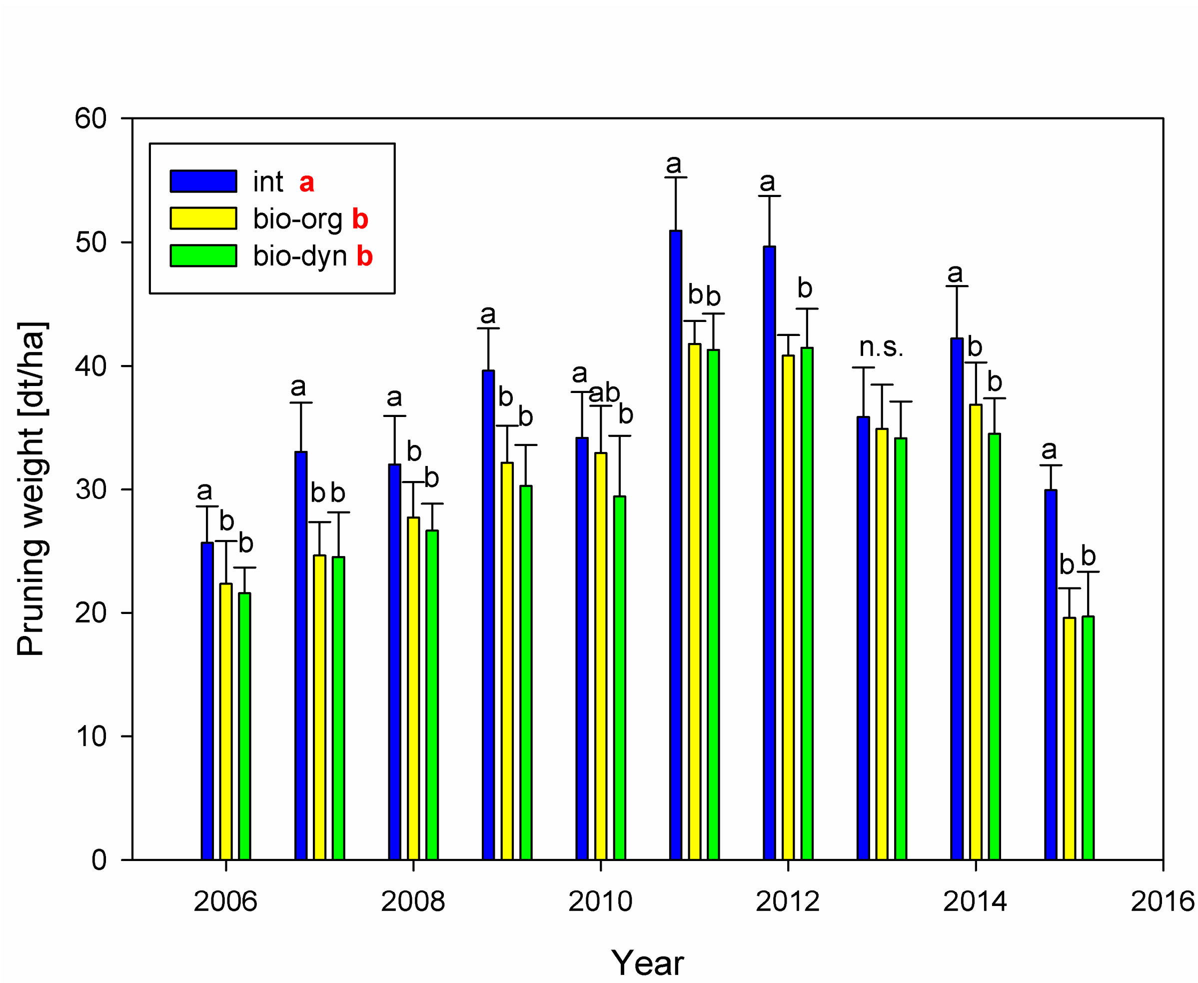

Figure 1. Pruning weight [dt/ha] in the system comparison INBIODYN

The significantly lower secondary shoot leaf area also contributed to the lower pruning weights within the organically managed plots (Döring et al. 2015; Meißner 2015).

In further investigations, a positive influence of the reduced growth of the organically managed plots on the canopy structure (shoot length, number of secondary shoots as well as secondary shoot length) could be demonstrated. In eight out of ten experimental years, the biodynamic management showed a tendency towards lower vigor compared to bio-organic management.

Botrytis cinerea and sour rot

The effects of the management systems on plant health also showed interesting results. Despite the use of botryticides in the integrated variant (twice a year), no lower disease incidence of *Botrytis cinerea* could be documented in this variant.

In the years 2008, 2009, 2010, 2011 and 2014, an incidence of sour rot could be observed due to humid weather conditions during the ripening phase. The organically and the biodynamically managed plots exhibited a significantly lower disease incidence of sour rot than the integrated treatment (Figure 2).

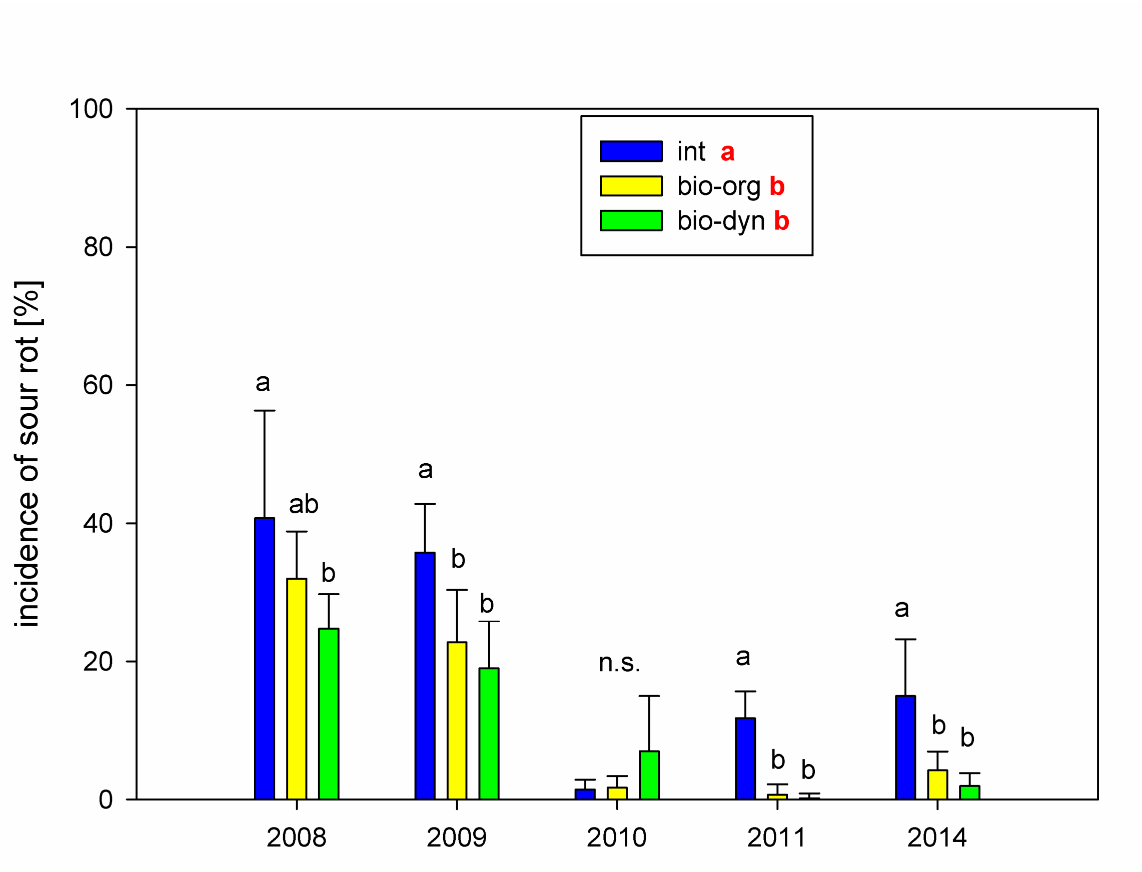

Figure 2. Incidence of sour rot [%] in the system comparison INBIODYN

The smaller berries as well as the improved cluster structure of the grapes combined with the bactericidal effect of the continuously used copper preparations in the bio-organic and biodynamic treatment can account for these differences (Döring et al. 2013; Meißner 2015). It is assumed that the biodynamic preparations stimulate the secondary metabolism of the vines by reducing the water potential (Botelho et al. 2015). Also effects on the regulation of phytohormones by the use of the biodynamic preparations have been observed (Fritz 2000). Some more favorable values for biodynamic farming could also be determined for the canopy structure (vegetative growth, secondary shoot leaf area), as well as for disease incidence of sour rot and downy mildew.

Discussion

These results of an experimental activity during a ten-year-period in the Geisenheim system comparison trial (INBIODYN) show that a conversion into bio-organic or biodynamic viticulture has significant effects. The differences between the systems can be observed in the soil, in vegetative and generative growth and in grape quality.

One reason for the differences in growth of the respective systems could be a regulation through certain phytohormones. In the future studies on various phytohormones should be carried out. According to Fritz (2000), the sensitivity of the plants to phytohormones could be influenced by the use of the biodynamic preparations, in particular the horn silica preparation.

Another reason could be the influence of different cover crop systems on vine growth. Several studies (Lopes et al. 2004; Monteiro and Lopes 2007) show that the management parameter, which highly influences the water availability and the growth of the vines in the existing systems, is the type of cover crop and its transpiration.

Despite the use of botryticides in the integrated variant twice a year, no lower incidence of *Botrytis cinerea* could be observed in this variant. However, incidence of sour rot was significantly lower in the bio-organic and the biodynamic variant. Sensorial ranking tests of the wines in different panels (Meißner 2015; Nikolaus 2014) revealed that the wines from biodynamic management were most frequently ranked #1 and the wines from integrated management were most frequently ranked #3.

For the following years further studies are planned on the canopy structure, the leaf angle and the aromatic potential of the berries.

Acknowledgments

Authors would like to thank the Departments of Geisenheim University (Soil Science and Plant Nutrition; Wine Chemistry and Beverage Research; Phytomedicine) and the different partners of the international advisory team for their help and their support. Furthermore, authors would like to thank Software AG Foundation and FDW for partially funding the project.

References

Botelho R.V., Roberti R., Tessarin P., Garcia-Mina J.M., and A.D. Rombolà. Physiological responses of grapevines to biodynamic management. Renewable Agriculture and Food Systems 2015; 31: 402-413.

Döring J., Frisch M., Tittmann S., Stoll M., and R. Kauer. Growth, Yield and Fruit Quality of Grapevines under Organic and Biodynamic Management PLoS ONE 10(10): e0138445. doi:10.1371/journal.pone.0138445 (2015).

Döring J., Kauer R., Meißner G., and M. Stoll. Lockerere Trauben durch biodynamischen oder ökologischen Weinbau? Lebendige Erde; 6/2013: 42-44.

Fritz, J. Reaktionen von Pflücksalat (*Lactuca sativa* L. var. crispa) und Buschbohnen (*Phaseolus vulgaris* L. var. nanus) auf das Spritzpräparat Hornkiesel. Verlag Köster, Berlin, Dissertation Universität Bonn (2000).

Lopes C., Monteiro A., Rückert F.E., Gruber B., Steinberg B., and H.R. Schultz. Transpiration of grapevines and co-habitating cover crop and weed species in a vineyard. A "snapshot" at diurnal trends. Vitis 2004; 43: 111-117.

Meißner G. Untersuchungen zu verschiedenen Bewirtschaftungssystemen im Weinbau unter besonderer Berücksichtigung der biologisch-dynamischen Wirtschaftsweise und des Einsatzes der biologisch-dynamischen Präparate. Geisenheimer Berichte Bd.76, Dissertation, Justus-Liebig-Universität Gießen (2015).

Monteiro A. and C. Lopes. Influence of cover crop on water use and performance of vineyard in Mediterranean Portugal. Agriculture, Ecosystems and Environment 2007; 121: 336-342.

Nikolaus, F. "Sensorische und analytische Untersuchungen zu Weinen aus verschiedenen Bewirtschaftungssystemen." Bachelor Thesis, Studiengang Weinbau und Oenologie, Hochschule Geisenheim University, Sommersemester 2014.

Organisation Eampp Guideline for the efficacy evaluation of fungicides PP 1/31(3).