Journal of Agricultural Science; Vol. 8, No. 1; 2016
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Effect of New Environmentally Friendly Fertilizers in a Commercial Vineyard

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Received: August 11, 2015 Accepted: November 24, 2015 Online Published: December 15, 2015

doi:10.5539/jas.v8n1p132 URL: http://dx.doi.org/10.5539/jas.v8n1p132

Abstract

In this study the effectiveness of the environmentally friendly fertilizers AXION RED, BIO.L.A and QUATTRO to improve soil fertility and the nutrition status of vines was examined. Application of above three fertilizers increased significantly the level of organic matter, K, P, Mn and Fe in soil. AXION RED also improved the concentration of Zn, B, and Cu. Tissue analyses showed that the leaf P content was significantly increased in the vines treated with the fertilizers in comparison to control in 2012. The fertilizer QUATTRO increased the leaf concentrations of Fe and Mn contents in 2012. It was found that the fertilizer BIO.L.A significantly increased the leaf N content, while the fertilizer QUATTRO increased the leaf B content in 2013. Although there was no statistically difference, the leaf P, K and Fe contents were increased in vines treated with each one of the fertilizers tested.The results also showed that all fertilizers increased the fruit N content in comparison to control. The percentage of fruit rot was significantly higher on bunches treated with each one of the fertilizers tested than the untreated control. Finally, the results of this study showed that only the fertilizer QUATTRO significantly increased the bunch weight in 2012.

Generally, the above fertilizers improved the nutrition status of vine plants and also improved the soil fertility. However, the increased fruit N content in the grapes treated with each one of the fertilizers increased the susceptibility of fruits to pathogens causing fruit rots and therefore growers should consider its use carefully.

Keywords: bunch rot, grapes, nutrition status, soil fertility

1. Introduction

Vine development, yield, and grape quality depend on many environmental variables. Among them mineral elements have an important effect on canopy size and yield level, influencing berry composition and quality. The timing and amount of fertilizer application affects the amount of mineral elements leached from the root-zone (Bryla, 2011). The two above inputs are interactive and need to be managed better in order to ensure minimal impact of viticulture production on the environment and to optimize berry composition. A common cultural practice consist is to incorporate fertilizers in the soil surface at the end of winter, a period in which the vine needs in nitrogen are negligible (Lie et al., 2015). However, excessive nitrogen concentration in the soil leads to a decreased grape quality and increased sensitivity in grape pests and diseases (Vartholomaiou et al., 2008). This may damage vines and increase the cost of plant protection.

All plants receive their nutrients in chemical form. When referring to plant nutrition, the terms organic or natural generally refers to any fertilizer which is derived from plant, animal or mineral origin. It must have one or more essential nutrients for plant growth. Non-organic fertilizers (also known as synthetic) are manufactured chemically. They are made to deliver nutrients rapidly, such as those that are water-soluble, or over time as a controlled release fertilizer. Although very effective for providing rapid or prolonged periods of feeding, these have a high salt index. The potential risk to plants and the soil food web is scorching and dehydration with the leeching of unabsorbed chemicals into waterways.

Organic nutrients on the other hand, must first be broken down and digested by soil microorganisms which then release these nutrients in a form available to plants. This process also produces humus, a vital ingredient to improving soil structure. As part of this structure, organically derived nutrients are very resistant to leaching and contain a very low salt index. The net result is nutrients that remain in the soil until utilized by plants and little

risk of scorching or dehydration, even in periods of extreme drought or over application.

The main aim of this study was to evaluate the environmentally friendly fertilizers BIO.L.A (6-5-6 + 1,5 MgO + CaO + 60% organic matter + 1% microorganisms + micronutrients + vegetable proteins + amino acids + zeolite), AXION RED (10-10-10 + 10% organic matter + 2% MgO + 2% Fe + 0.2% Zn + 0.2% B), QUATTRO (13-13-13 + 13% organic matter) produced from the Greek Company AGROLA ABEE (Old Road Thessaloniki - Kilkis (12 Km., Ionia, 57008) on nutrition status of commercial vineyards (wine cultivar Xinomavro Naoussa) and the susceptibility of grapes on *Botrytis* bunch rot.

2. Materials and Methods

2.1 Soil Analysis

Soil analysis is presented in Table 1. Three soils samples, each 500 g (represented 10 sub-samples), were taken from 30 and 60 cm in depth in December. They were transferred in the Laboratory of Soil Science of Alexander Technological Educational Institute of Thessaloniki, where large chunks of soil were broken up and placed in a forced air oven set between 35 °C and 55 °C for 24 h. Soil was then crushed in a soil pulverizer to pass through a 2 mm mesh screen, to achieve sample homogeneity. The soil was silt-clay-loam, alkaline and calcareous.

2.2 Tissue Analysis

Tissues (leaf, grape) were first cleaned with washing powder (Tide, 2%), then washed with tap water and finally with distilled water. The samples were dried in oven at 70 °C for 48 h and ground to pass through a mesh screen to achieve sample homogeneity before analyzing for mineral concentration.

Nutrients were determined by ashing 1 g at 540 °C, treating with concentrated HCl and using the Kjeldahl method (N). Phosphorus was determined spectrometrically (the method is based upon the development of a blue complex of molybdenum with P), potassium was determined flamephotometrically and calcium and magnesium were determined volumetrically with 0.001 N EDTA (Kalra & Maynard, 1991). The concentration of trace elements Mn, Zn, Fe, and Cu were determined with atomic absorption spectrophotometry (Meyer & Keliher, 1992) and colorimetry for B (Bingham, 1982) and are reported as percentage for N, P, K, Ca, Mg, and as ppm for micronutrients

2.3 Effect of the Environmentally Friendly Fertilizers

Experiments were conducted in a commercial vineyard (wine cultivar Xinomavro Naoussa), located in Strantza Naoussa. The fertilizers BIO.L.A was applied at the rate of 1650 kg/hr, AXION RED at the rate of 1000 kg/hr and QUATTRO at the rate of 800 kg/hr. All applications were made in March 2012 and again in March 2013. Fertilizers were hand-applied to specific plants using the top-dressing in a ring around each plant in proportion to its size and rooting area. There were three treatments (fertilizers), each with 20 replicated plants. Plants without fertilization were used as control. The experimental design was completely randomized.

Samples of leaves for tissue analyses were collected in July of 2012 and again in July 2013.

Samples of fruit bunches were collected in September of 2012 and 2013. A scale of infection rates, with 0 = healthy and 100 = surface totally infected, was used to assess the treatment effects on fruit rot. Tissue analysis of fruits was conducted as described above.

In addition, fifteen randomly selected bunches without any symptoms of disease were collected from each treatment to record their weight.

In a second experiment, an isolate of *Botrytis cinerea* from infected grapes was used. This isolate was maintained on potato dextrose agar (PDA). Ten bunches for each treatment were collected from plants treated with one of the fertilizers tested. They were disinfested by dipping in 10% domestic bleach solution for 20 min. Bunches were washed with water, dried on sterilized paper and then sprayed with a spore suspension of about $4x10^{-5}$ conidia per mL *B. cinerea* with 0.1% (v/v) Tween 20. Bunches sprayed with tap water were used as control. After drying at room temperature, the inoculated bunches were packed into cardboard boxes and stored at 4°C for 2 weeks.

The scale of infection rates was used to assess treatment effects. This experiment was conducted for 2 consecutive years (2012-2013).

2.4 Statistical Analysis

To analyse data for significant differences of treatment means at $\alpha = 0.05$, the Generalized Linear Model (Wald's Chi-Square) was applied and for multiple comparison treatment means, the LSD0.05 was used.

3. Results

The effectiveness of the environmentally friendly fertilizers AXION RED, BIO.L.A and QUATTRO to improve the soil fertility and vines nutrition status were examined in this study. Application with the above fertilizers increased the content of organic matter in soil. Of all the components of soil, organic matter is probably the most important and most misunderstood. According to Craswell and Lefroy (2001), soil organic matter has many functions, the relative importance of which differs with soil type, climate, and land use. Commonly the most important function of organic matter in soil is as a reserve of the nitrogen and other nutrients required by plants, and ultimately by the human population. Other important functions include: the formation of stable aggregates and soil surface protection; maintenance of the vast array of biological functions, including the immobilization and release of nutrients; provision of ion exchange capacity; and storage of terrestrial carbon. Adding new organic matter to soil every year (by spreading a thin layer of compost on top of grass) is perhaps the most effective way to improve and build soil organic matter in established lawns (Toor & Shober, 2015). They also reported that once the soil organic matter reaches sufficient levels, it would maintain steady supply of nutrients for plant growth and promote infiltration of water. This nutrient supply from the organic matter saves growers the cost and hassle of buying and applying frequent applications of fertilizers. Lawns with good availability of nutrients will have well-established root systems, which would require less amounts of irrigation water to keep the lawns healthy. At the same time, there will be less runoff of water and nutrients from lawns and reduced potential of water quality degradation (Toor & Shober, 2015).

This study also showed that all fertilizers increased the soil K, P, Mn and Fe contents (Table 1).

Table 1. Soil texture class and chemical analysis of the 0-60 cm of the soil profile from the experimental orchards

Soil Analysis	Depth in cm	Sand %	Clay %	loam %	Soil Texture	pH	EC	Organic Matter %	$CaCO_3$ %
Control	0-30	63	11	26	SL	8.11	0.489	1.8	28.8
	30-60	59	15	26	SL	8.06	0.541	1.6	30.9
QUATTRO	0-30	59	15	26	SL	8.04	0.608	2.2	25.5
	30-60	51	21	28	L	7.93	0.664	2.9	24.7
BIO.L.A.	0-30	61	11	28	SL	7.77	0.722	2.1	28.8
	30-60	55	15	30	SL	7.97	0.583	2.0	29.4
AXION RED	0-30	59	13	28	SL	7.96	0.649	2.3	29.4
	30-60	57	15	28	SL	8.07	0.588	2.2	31.2
2012									
Treatments	K ppm	Ca ppm	Mg ppm	P ppm	B (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Cu (mg/kg)
Control	194.0a[z]	8070a	325a	6.0a	3.05a	6.5a	1.0a	1.3a	1.0a
	184.2a	9380a	307a	3.4a	2.57a	4.5a	0.9a	1.5a	1.8a
QUATTRO	252.9b	8530a	367a	22.7c	3.79b	7.4ab	1.1a	2.3b	1.9a
	213.6a	8890a	286a	10.3b	3.05a	9.4b	1.0a	3.2b	1.8a
BIO.L.A.	264.6b	9020a	290a	15.1b	2.96a	8.0b	1.5ab	2.3b	3.9bc
	254.7b	9380a	306a	10.1b	3.00a	12.8c	0.9a	2.6b	2.8ab
AXION RED	262.7b	8860a	256a	22.3c	4.28b	7.5ab	2.1b	2.5b	5.8c
	235.1b	8560a	308a	20.7c	3.57ab	9.9b	1.3a	2.5b	1.4a
2013									
Treatments	K ppm	Ca ppm	Mg ppm	P ppm	B (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Cu (mg/kg)
Treatments.	K ppm	Ca ppm	Mg ppm	P ppm	B (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Cu (mg/kg)
Control	205.3a[z]	8563a	235a	8.3a	2.88a	5.5a	0.9a	1.7a	1.2a
	193.2a	8125a	288a	5.4a	2.36a	5.8a	0.8a	1.2a	1.7a
QUATTRO	273.9b	8832a	305a	21.8c	4.05b	9.4b	1.3a	2.5ab	2.1a
	217.4a	8636a	295a	13.4b	3.39ab	10.3b	1.0a	3.0b	1.9a
BIO.A.A.	284.0b	8897a	315a	19.2c	3.58ab	9.5b	1.6ab	2.7b	4.2cd
	255.2b	9137a	348a	15.1b	3.17ab	11.0b	1.1a	2.1ab	3.8bc
AXION RED	272.3b	8741a	288a	20.3c	4.00b	8.7b	2.5b	2.8ab	5.1d
	240.2b	8879a	302a	18.8c	3.43ab	10.0b	1.2a	2.1b	3.5bc

Note. [z]Values followed by the same letter are not significantly different according to Wald Test ($P < 0.05$).

The fertilizers AXION RED and QUATTRO also increased significantly the soil B contents, while the fertilizers BIO.L.A. and AXION RED increased significantly the soil Zn and Cu contents (Table 1). It is possible that the fertilizers enriched the soil nutrient contents directly by releasing the nutrient elements in soil and indirectly by improving the properties of soil (increased the soil organic matter).

Tissue analyses showed that the leaf P content was significant increased in the vines treated with each one of the fertilizer tested than in control in 2012 (Table 2). The fertilizer QUATTRO increased significant the leaf Fe and Mn contents in 2012. It was found that the fertilizer BIO.L.A increased significant the leaf N content, while the fertilizer QUATTRO increased the leaf B content in 2013. Although there were not statistically differences, the leaf P, K and Fe contents were increased in soils treated with one of the fertilizers tested (Table 2). These results showed a good correlation between leaf and soil mineral contents. Previous works have been proved the correlation of soil fertility with the nutrition status of plants (Lacertosa et al., 1999).

Table 2. Effect of QUATTRO, BIO.L.A and AXION RED fertilizers on leaf mineral contents of the vine variety Xinomavro

Treatments	N (%)	P (%)	K (%)	B (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Cu (mg/kg)		
July, 2012										
Control	1.93a[z]	0.17a	1.24a	36.6a	81.4a	12.25a	71.16a	40.24a		
QUATTRO	1.95a	0.28b	1.41a	45.68a	98.98b	11.49a	97.23b	40.45a		
BIO.L.A.	1.85a	0.24ab	1.44a	36.59a	88.71ab	11.49a	50.16a	40.48a		
AXION RED	1.95a	0.21ab	1.41a	33.45a	85.35ab	10.48a	70.72a	39.93a		
July, 2013										
Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	B (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Cu (mg/kg)
Control	1.77a[z]	0.098a	0.97a	3.2a	0.67a	162.5a	116.3a	13.93a	61.97a	299.63a
QUATTRO	2.21ab	0.129a	1.27a	2.88a	0.43a	221.31b	119.28a	13.96a	46.01a	235.42a
BIO.L.A.	2.35b	0.137a	1.31a	2.96a	0.36a	135.61a	136.3a	12.21a	41.38a	276.52a
AXION RED	2.11ab	0.105a	1.26a	2.8a	0.4a	137.61a	130.31a	13.14a	69.42a	329.7a

Note. [z]Values followed by the same letter are not significantly different according to Wald Test ($P < 0.05$).

The results also showed that all fertilizers increased the fruit N contents in comparison to control in both years (Table 3).

Table 3. Effect of QUATTRO, BIO.L.A and AXION RED fertilizers on fruit mineral contents of the vine variety Xinomavro

Treatment	N (%)	P (%)	K (%)	B (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	Cu (mg/kg)
September 2012								
Control	0.37a[z]	0.07a	0.79a	18.88a	20.56a	5.44a	10.62a	19.93a
QUATTRO	0.68b	0.09a	0.89a	17.86a	20.35a	5.13a	10.39a	18.65a
BIO.L.A.	0.52b	0.10a	0.84a	19.13a	19.62a	4.87a	12.64a	20.64a
AXION RED	0.61b	0.07a	0.84a	21.64a	21.35a	5.13a	12.55a	19.32a
September 2013								
Control	0.44a[z]	0.09a	0.80a	20.01a	18.50a	4.99a	11.71a	22.49a
QUATTRO	0.77b	0.10a	0.91a	19.10a	20.21a	4.56a	9.72a	20.04a
BIO.L.A.	0.59ab	0.08a	0.84a	18.92a	18.72a	5.10a	10.50a	19.71a
AXION RED	0.75b	0.1a	0.90a	20.06a	19.61a	4.79a	12.26a	18.80a

Note.[z]Values followed by the same letter are not significantly different according to Wald Test ($P < 0.05$).

It was also found that the percentage of fruit rot was significant higher on bunches treated with each one of the fertilizers tested than untreated control in both years (Table 4). In addition, the artificial inoculated bunches from vines treated with each one of the fertilizers showed significantly higher percentage of fruit rot caused from *B. cinerea* than the untreated control (Table 5). The above results showed a direct relation between the fruit N content and fruit rots. Previous works also showed that high nitrogen fertilization predisposed grapevines to infection by *B. cinerea* and increased disease severity (R'Houma et al., 1998). According to Mundy (2008), direct changes due to increased nitrogen nutrition include greater thickness of the wax on berry surfaces and increased concentrations of the biochemical defence compounds produced in them. Indirect changes that result from increased nitrogen include development of tighter bunches and denser canopies (Mundy & Beresford, 2007).

Table 4. Effect of QUATTRO, BIO.L.A and AXION RED fertilizers on susceptibility of Xinomavro fruits to fruit rot

Treatments	Rots of Berries (%)							
	Natural Infections				Artificial Inoculations			
	2012		2013		2012		2013	
Control	4.5[z]	a	5.5	a	27.2	a	21.7	a
BIO.L.A.	12.5	b	9.6	b	35.6	b	30.6	b
AXION RED	16.4	bc	6.8	ab	33.4	b	24.7	ab
QUATTRO	19.1	c	13.8	c	37.1	b	28.6	b

Note. [z]Values followed by the same letter are not significantly different according to Wald Test (P <0.05).

Table 5. Effect of QUATTRO, BIO.L.A and AXION RED fertilizers on fruit weight of the bunch of Xinomavro Naoussas

Treatments	Fruit Weight (g/bunch)			
	2012		2013	
Control	168.1	a[z]	212.8	a
AXION RED	154.4	a	249.6	a
BIO.L.A.	173.3	ab	240.0	a
QUATTRO	197.0	b	224.5	a

Note.[z]Values followed by the same letter are not significantly different according to Wald Test (P <0.05).

Finally, the results of this study showed that only the fertilizer QUATTRO increased significantly the bunch weight in 2012 (Table 5). The effect of nutrition status of vineyards with the bunch size and weight has been reported in previous works with conflicting results (Abd El-Razek et al., 2011; Mohammed et al., 1993).

4. Conclusion

Generally, the fertilizers tested in this study and especially the fertilizer BIO.L.A. improve the nutrition status of vine plants and also improve the soil fertility. However, the increased fruit N content in the grapes treated with each one of the fertilizers increased the susceptibility of fruits to pathogens causing fruit rots and therefore growers should consider it.

Acknowledgements

This work was funded by O.P. Competitiveness and Entrepreneurship (EPAN II), ROP Macedonia-Thrace, ROP Crete and Aegean Islands, ROP Thessaly-Mainland Greece-Epirus, ROP Attica).

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