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EFFECT OF BIO AND ORGANIC NITROGEN FERTILIZATION AND ELEMENTAL SULPHUR APPLICATION ON GROWTH, YIELD AND FRUIT QUALITY OF FLAME SEEDLESS GRAPEVINES

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Abstract: This investigation was carried out during 2006 and 2007 seasons, to study the effect of organic manure, biofertilization and elemental sulphur application on growth, yield and berry quality of Flame seedless grapevines.

The obtained results showed that:

- Leaf area, pruning wood weight and leaf NPK percentage significantly increased by using biofertilization and organic nitrogen form as well as sulphur application compared to using mineral-N alone.

- Using 75% of recommended nitrogen dose (RND) at either bio or organic form plus 25% at mineral-N as well as 50% RND plus sulphur application gave the maximum values of these traits.

- Fertilizing the vines with RDN via 75% bio or organic form plus 25% mineral-N as well as 50% RDN plus 0.5 kg sulphur application/vine significantly increased number of clusters and yield/vine as well as improved the cluster and berry attributes compared to using RND via mineral form only.

It is evident from the foregoing results that using 75% RDN as bio or organic fertilizers plus 25% as mineral source or 50% RDN as organic or mineral source plus 0.5 kg/vine elemental sulphur application were sufficient to get good nutritional status, healthy and more productive Flame seedless grapevines.

Finally, it is concluded that replacing 75% of RDN for grapevines by either organic or biofertilizers as well as using 50% of RDN combined with sulphur application were very useful in improving growth, nutritional status of vines. In addition, get the high yield with good quality as well as minimize the production costs and environment pollution which could be occurred by excess of chemical fertilizers.

Key words: Fertilization – Bio - Organic – Elemental sulphur – Growth, yield – Fruit quality – Grapevines.

Introduction

Grape is considered one of the most popular and favorite fruit crops in the world, for being of an excellent flavour, nice taste and high nutritional value. In Egypt, it is the second fruit crop and is consumed mainly as fresh fruits. Due to its high net return, the cultivated area has grown rapidly in the last two decades reaching 159929 feddans, representing about 16.60% of total area occupied by fruit trees (Annual Reports, Ministry of Agric., Egypt 2005).

Fertilization is one of the most important tools to improve the soil fertility and increase crop yield. A major compensation to overcome the low fertility of soils is to use chemical fertilizers that became more expensive item for orchard management.

Nitrogen has a pronounced role in improving production and quality of fruits. In Egypt, fertilizer consumption per hectare of the cultivated area is 10 times more than consumption average per hectare of the whole world for all nutrients (FAO, 1994).

Moreover, mineral fertilizers and other chemicals commonly used in agricultural production not only have harmful effects on the environment, but also they can alter the composition of fruits, vegetables and root crops and decrease their contents of vitamins, minerals and other useful compounds. There is a very great danger that harmful residues may remain in food (Bogatyre, 2000).

In the recent years, the use of organic fertilizers instead of mineral fertilizers has become potentially attractive because of the harmful effect and high cost of mineral fertilizers. In sandy and sandy loam soils, the organic fertilization is a good source of nutrients. It also increases number and activity of microorganisms in the soil and helps to prevent breakdown of soil structure leaving good structure in the soil associated with greater water holding capacity (Nijjar, 1985; Miller *et al*., 1990; Darwish *et al*., 1995; Abdel-Nasser and Harhash, 2000 and Al-Wasfy *et al*., 2006).

Fertilizing various grapevine cultivars with organic manures beside the inorganic nitrogen source was accompanied by improving growth and leaf mineral content as well as yield and berry quality than using nitrogen as an inorganic source only (Bhangoo *et al*., 1988; Singh, 1999; Ahmed *et al*., 2000; Kassem and Marzouk, 2002; Abdel-Galil *et al*., 2003; Mohamed and Gobara, 2004; Rezk, 2005 and Al-Wasfy *et al*., 2006).

Biofertilizers are organisms that enrich the nutrient quality of soil and plant, the main sources of biofertilizers are bacteria, fungi and cynobacteria. Using bio-fertilizers is considered a promising alternative for chemical fertilizers. It is very safe for human, animals and environment. Merits of biofertilizers application were reducing plant requirements of NPK by 25%, enhancing the resistance of plants to diseases, stimulating growth of roots and improving the productive performance of the fruit trees (Suba Rao, 1984; Verna, 1990; Abdel-Hamid, 2002 and El-Akkad, 2004)

Supplying the various grapevine cultivars with biofertilizers caused a pronounced increased in the leaf area and weight of pruning wood and effectively enhanced the nutritional status of the vines. In addition, biofertilizer application beside mineral N source was effective in improving bud burst and fruiting buds percentages. Cluster number and cluster weight were remarkably improved when biofertilizer was added with the mineral source of N compared with using N mineral source only. Moreover, application of biofertilizer and its mineral source was very effective in enhancing the quality of berries in terms of increasing the berry weight, size, TSS and total sugars and decreased acidity % (Maroneke *et al.*, 1981; Mahmoud, 1999; Abdel-Hamid, 2002; Abdel-Hady, 2003; El-Akkad, 2004; Tawfik, 2005; Ibrahim, 2006 and Abbas, *et al.*, 2006).

Recently, elemental sulphur has been used to reduce alkalinity in order to reclaim the calcareous soil (Abo Rady *et al.*, 1988 and Modaihsh *et al.*, 1989). Elemental sulphur is oxidized by the soil microorganisms to sulphate which lowers soil pH, improves soil structure and increases the availability of certain plant nutrients (Abdel-Fattah and Hilal, 1984 and Hilal *et al.*, 1990).

Many investigators reported the importance of sulphur in increasing growth and yield of various grapevine cultivars (Harhash and Abdel-Nasser, 2000; Kassem, 2002; El-Dsouky *et al.*, 2002; El-Akkad, 2004 and Zayan *et al.*, 2006).

Therefore, the objective of this investigation was to study the possibility of using bio, organic fertilization and sulphur application partially instead of completed mineral fertilizers of Flame seedless grape cultivar.

Materials and Methods

The present study was executed in 2006 and 2007 seasons on Flame seedless grapevines in a private vineyard situated in Qena Governorate. Soil of the vineyard is sandy loam and its some physical and chemical properties were determined according to Wilde *et al.* (1985) and are present in Table (1). The vines were 10 years old at the starting of this experiment spaced at 1.5x3 meters apart, trained according to the double cordon system and supported with three wires. Pruning was carried out at the first week of January leaving 16 fruiting spurs with 3 buds plus six replacement spurs with 2 buds. Forty two healthy vines with no visual nutrient deficiency symptoms and at almost uniform in their vigor were chosen and divided into seven different treatments including the control. The treatments were as follows:

1- The application of 100% mineral nitrogen (control).

2- The application of 25% mineral nitrogen + 75% organic nitrogen.

3- The application of 25% mineral nitrogen + 75% biofertilizer.

4- The application of 33.3% mineral nitrogen + 33.3% organic N + 33.3% biofertilizer.

5- The application of 50% mineral nitrogen + 0.5 kg elemental sulphur.

6- The application of 50% organic nitrogen + 0.5 kg elemental sulphur.

7- The application of 20% organic nitrogen + 30% biofertilizer + 0.5 kg elemental sulphur.

Table(1): Some physical and chemical properties of the experiment soil and compost El-Neel used.

Soil properties	Values	Compost El-Neel properties	values
Sand %	85.6	M^3 weight (kg)	450
Silt %	9.3	Moisture %	26
Clay %	5.1	pH (1:5 extract)	8.2
Texture grade	Sandy	E.C (1:5 extract)	4.1
pH (1:2.5)	8.04	Total N %	2.15
$CaCO_3$ %	6.58	O.M. %	65
Organic matter %	0.93	Total P %	1.5
Total nitrogen	0.19	Total K %	1.3
Available P (ppm)	2.7	Available Fe (ppm)	1025
Na mg/100 g	1.01	Mn (ppm)	115
K mg/100 g	0.78	Cu (ppm)	180
DTPA-Extractable		Zn (ppm)	128
Fe (ppm)	7.50		
Mn (ppm)	5.20		
Zn (ppm)	1.80		

Each treatment had under the recommended N level (80 g N/vine/year) or its half, as shown in Table (2). The experiment was arranged in a randomized complete block design with three replications consisting of two vines per each replication.

The elemental sulphur and compost El-Neel as a source of organic-N fertilizer, analysis is given in Table (1), were added once at the first week of January in both seasons. Ammonium sulphate (20.6%N) as a mineral source was applied at three times: growth start, immediately after berry set and at two months late. The active nitrobien as a commercial biofertilizer (120 g/vine) was added once at growth start. It was mixed with moist sand and added in soil holes around the trunk of each vine and was directly irrigated after covering the holes with soil. Normal agricultural and horticultural practices used in vineyard (except fertilization) were carried out.

The following parameters were determined to evaluate the effects of different fertilization treatments on growth, nutrient status, yield and berry quality.

1 – Some vegetative growth parameters:

- The average leaf area (cm^2): Twenty leaves from those opposite to basal clusters were measured according to the following equation that was reported by Ahmed and Morsy (1999)

leaf area $= 0.56\ (0.79 \times w^2) + 20.01$, where, w= the maximum leaf width.

- Weight of pruning wood (kg) was estimated by weighing the removal one year old wood after pruning

2 – Leaf nutritional status:

Samples of 30 leaves for each replication were collected from the first full mature leaves from the top of growing shoots in mid of July in three seasons and leaf petioles were separated from the blades. The petioles were washed with tap water, distilled water, air-dried, oven-dried at 70°C to constant weight, then ground in a stainless steel mill and kept for chemical analysis. Wet digestion was done for all samples by using concentrated sulphoric acid and hydrogen peroxide for overnight. Percentages of N, P and K (on dry weight basis) were determined in the digestion according to standard methods which were outlined by Wilde *et al.* (1985).

3– Yield and yield components:

- At harvesting date, the yield per vine was recorded in terms of weight (kg) and number of clusters per vine.

4-Cluster and berry characteristic:

At harvesting, two clusters were taken at random from the yield of each vine to determine cluster and berry traits such as

cluster weight and length as well as cluster compactness coefficient that according to Winkler *et al.* (1974). Berry quality such as 25 berry weight, reducing sugar percentages, total soluble solids, total acidity (expressed as gm tartaric acid per 100 ml juice), then the ratio between total soluble solids and total acidity was calculated. Chemical berry properties were evaluated according to A.O.A.C. methods (1985).

All the obtained data were tabulated and analyzed according to Gomez and Gomez, (1984) using L.S.D. test for distinguishing the significance differences between various treatment means according to Steel and Torrie (1980).

Results and Discussion

1 – Vegetative growth and leaf nutritional status:

Leaf area and pruning wood weight are the best parameters indicating the growth and vigour of the vines which show the positive response to the different applications of N and sulphur fertilization. As a general view, it can be seen in Table (3) that these parameters were significantly increased by using bio, organic-N form and sulphur application compared to using mineral-N only. Using 75% bio, organic- fertilizer +25% mineral source of nitrogen or 50% organic-N combined with sulphur application gave the maximum values of these vegetative traits. Also these treatments induced more announced and highly significant percentages of N, P and K in leaves. These values were (178.1, 166.3 & 169.5) and (181.8, 178.7 & 186.3 cm^2) and (1050, 996 & 1004) and (1269, 1258 & 1235 g/vine) for leaf area and pruning wood weight during the two studied seasons, due to using either 75% organic-N or 75% bio plus 25% mineral-N (T_1, T_2) and 50% organic-N combined with sulphur application (T_5), respectively. The corresponding values of N, P and K were (1.98, 1.85 & 2.03%), (2.21, 2.02 & 2.06% N) & (0.241, 0.193 & 0.246%), (0.265, 0.228 & 0.263% P) and (1.79, 1.58 & 1.83%) & (1.95, 1.71 & 2.02% K), respectively, whereas, such values were (156.6 & 163.2 cm^2), (912 & 1118 g/vine), (1.73 & 1.85% N), (0.158 & 0.163% P) and (1.38, 1.43% K) on vines that fertilized by 100% mineral only.

So, using organic manure and biofertilizer combined with elemental sulphur application improve the growth and vigour and sufficiently improve leaf nutritional status of vines.

In general, the increase in the nutrients in leaves by using organic manure, biofertilizers and sulphur application could be related to:

1- The effect of organic manure on enhancing the activity of microflora, water holding capacity, soil structure aggregation, soil

organic matter and humid substances may increase the availability of elements and reduce soil pH and salinity. The higher content of the organic manure from essential nutrients could give another explanation (Nijjar, 1985 and Miller *et al*., 1990). These results agree with those of Bhangoo *et al.* (1988), El-Sayed (1994), Ahmed *et al.* (1996), El-Morsy (1997), Singh (1999), Ragab and Mohamed (1999), Ahmed *et al.* (2000), Abdel-Ghafar (2002), Kassem and Marzouk (2002), Ahmed *et al.* (2003), Mohamed and Gobara (2004), Rezk (2005) and Al-Wasfy *et al.* (2006). They reported that there was a positive improve in the vegetative growth of various grapevine cultivars in response to the annual application of organic fertilizer.

2- The role of biofertiliz on facilitating the fixation of atmospheric N as well as activating the availability uptake and translocation of most nutrients, in addition accelerating carbohydrate and protein synthesis and movement which aid to encouraging cell division and the development of meristematic tissues. The obtained results are in harmony with those reported by Mahmoud (1999), Abdel-Hady (2003), El-Akkad (2004), Tawfik (2005), Ibrahim (2006) and Abbas, *et al.* (2006)

3- The beneficial effect of adding elemental sulphur is probably due to raising the oxidation rate of elemental S resulting in improving some physical and chemical properties of soil and increasing nutrient availability. The obtained results were similar to those of Peterson *et al.* (1987); Hening *et al.* (1991); Harhash and Abdel-Nasser (2000), Kassem (2002), El-Dsouky *et al.* (2002), El-Akkad (2004) and Zayan *et al.* (2006).

2 – Yield and cluster characters

Data presented in Table (4) showed that the number of clusters born on the vine in 2006 season did not alter with varying the fertilization treatments. Using bio, organic-N form and sulphur application significantly caused a remarkable promotion on cluster length, cluster weight and yield/vine compared to using RDN via mineral source only**.** Whereas, compactness coefficient decreased as influenced by using bio, organic-N form and sulphur application.

Moreover, Using 75% bio, organic- fertilizer +25% mineral source of nitrogen (T_1, T_2) or 50% organic-N combined with sulphur application (T_5) gave the highest values of yield/vine, cluster weight and cluster length comparing with other fertilization treatments. The obtained cluster weights were (486.6, 466.1, 462.0, 465.3, 481.5, 473.2 & 435.0 g) and (501.8, 491.6, 488.0, 480.1, 490.7, 482.2 & 446.0 g) due to T_1, T_2, T_3, T_4, T_5, T_6 and control during two studied seasons, respectively. The

increment percentages were (11.68, 7.15, 6.21, 6.97, 10.69 & 8.78%) and (12.51, 10.22, 9.42, 7.64, 10.02 & 8.12%) compared to control during two studied seasons, respectively.

Moreover, using mineral-N at half of recommended dose combined with sulphur application (T_4) significantly caused a remarkable increase in yield/vine and cluster traits compared to using RDN via mineral source only. This means that addition of sulphur saved about half of recommended dose of nitrogen. Therefore, it could be assied that using sulphur plus 1/2 RDN was sufficient to get the high yield with good quality and very useful in saving N fertilization cost and reducing nitrate pollution.

Improving vine growth and nutritional status can enhance percentage of productive buds. As well as their impotent action in maintaining a good balance between total carbohydrates and nitrogen in favour as improving bud burst and fertility coefficient that lead to an increase in cluster number per vine, hence the yield was increased.

These results are in accordance with those obtained by Bhangoo *et al*. (1988), Akyuz *et al*. (1997), Abdel-Ghafar (2002), Kassem and Marzouk (2002), Ahmed *et al*. (2003), Mohamed and Gobara (2004), Rezk (2005) and Al-Wasfy *et al*. (2006). In addition, the beneficial effects of biofertilizers supported by Mahmoud (1999), Abdel-Hamid (2002), Abdel-Hady (2003), El-Akkad (2004), Tawfik (2005), Ibrahim (2006) and Abbas *et al*. (2006). As well as the favourable influence of sulphur application on cluster traits were emphasized by Harhash and Abdel-Nasser (2000); Kassem (2002); El-Dsouky *et al*. (2002); El-Akkad (2004) and Zayan *et al*. (2006).

3 – Berry quality:

It can be concluded from data in Table (5) that using 75% bio, organic- fertilizer + 25% mineral source of nitrogen or 50% organic-N combined with sulphur application were very significantly effective in improving weight of berry compared to using mineral-N only. The increase in berry weight and its size is an important target, as grape quality due to the increase in berry weight and size result in an increase in packable yield.

Also, all fertilization treatments significantly increased total soluble solids, reducing sugars and TSS/acid ratio and reduced the total acidity (as tartaric acid), compared to using mineral-N only. Furthermore, vines fertilized with 75% bio, organic- fertilizer + 25% mineral source of nitrogen or 50% organic-N combined with sulphur application recorded the maximum values of these traits compared with other fertilization treatments.

These findings may be related to the effect of organic-N,

biofertilizer and sulphur application on activating the synthesis of total carbohydrates and proteins which enhances cell division and enlargement leading to increase berry weight and size as well as, hasten the maturation of berries.

The best results with regard to quality of the berries were obtained on vines fertilized with 75% bio, organic- fertilizer + 25% mineral source of nitrogen or 50% organic-N combined with sulphur application

Moreover, vines fertilized with half of recommended doses of nitrogen either mineral or organic form combined by sulphur application recorded the maximum values of these traits compared with other fertilization treatments. This means that addition of sulphur saved about half of recommended dose of nitrogen (RDN). Therefore, it could be concluded that using sulphur plus $^{1}/_{2}$ RDN via other organic or inorganic source was sufficient to get the high yield with good quality and very useful in reducing nitrogen fertilization cost and nitrate pollution.

These results are nearly in the same line with those obtained by Bhangoo *et al*. (1988), Ahmed *et al*. (1996), El-Morsy (1997), Ragab and Mohamed (1999), Ahmed *et al*. (2000), Abdel-Ghafar (2000), Rezk (2005) and Al-Wasfy *et al*. (2006) who stated that replacing 50-75% of N requirements for grapevines by organic manures improved the quality of berry. In addition, Mahmoud (1999), Abdel-Hamid (2002), Abdel-Hady (2003), El-Akkad (2004), Tawfik (2005), Ibrahim (2006) and Abbas *et al*. (2006), concluded that application N via mineral and bio form was improved the berry quality. Furthermore, Harhash and Abdel-Nasser (2000), Kassem (2002), El-Dosouky *et al*. (2002), El-Akkad (2004) and Zayan *et al*. (2006) stated that elemental sulphur application improved the berry quality.

So, it could be concluded that replacing 75% of nitrogen requirements for grapevines by either organic manure or biofertilization, as well as using half of nitrogen requirements combined with 0.5 kg elemental sulphur application are sufficient to improve nutritional status of grapevines and gave a suitable yield with high cluster and berry traits. This reduces the need of mineral nutrients, the high cost and the environmental pollution which could be occurred by excess of chemical fertilizers.

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تأثير التسميد الحيوى والعضوى النيتروجينى واضافة الكبريت المعدنى على النمو والمحصول وخصائص ثمار كرمات العنب الفليم

رأفت أحمد على مصطفى

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أجريت هذه الدراسة على كروم العنب الفليم بمزرعة خاصة تقع فى محافظة قنا خلال موسمى ٢٠٠٦ و ٢٠٠٧ لدراسة تأثير التسميد الحيوى والعضوى النيتروجينى واضافة الكبريت المعدنى على النمو الخضرى والحالة الغذائية والمحصول وصفات العناقيد والحبات .

وقد أوضحت النتائج ما يلى :

- أدى إحلال ٧٥% من جرعة النيتروجين السمادية بالأسمدة الحيوية أو العضوية أو استخدام ٥٠% من الجرعة السمادية بالإضافة إلى الكبريت المعدنى إلى زيادة جوهرية فى وزن خشب التقليم ومساحة الأوراق ومحتواها من النيتروجين والفوسفور والبوتاسيوم مقارنة باستخدام الأسمدة الآزوتية بمفردها .

- سبب التسميد بمعدل ٧٥% حيوى أو عضوى بالإضافة إلى ٢٥% معدنى ، أو استخدام ٠,٥ كيلوجرام كبريت معدنى إضافة إلى نصف الجرعة السمادية فى صورة معدنية أو عضوية لكل كرمة زيادة مؤكدة فى المحصول مع تحسن واضح فى خصائص العناقيد والحبات .

- كانت أحسن المعاملات السمادية هى احلال ٧٥% من الجرعة السمادية بالأسمدة العضوية أو إضافة ٠,٥ كجم كبريت معدنى إلى ٥٠% من الجرعة السمادية فى صورة عضوية حيث أدت هذه المعاملات إلى زيادة نمو الكرمات مع إعطاء محصول عال ذو خصائص ثمرية جيدة .

من نتائج هذه الدراسة يمكن التوصية بإحلال ٧٥% من جرعة النيتروجين بالأسمدة العضوية أو الحيوية . وكذلك يمكن استخدام نصف الجرعة السمادية بالإضافة إلى ٠,٥ كجم من الكبريت/ كرمة حيث يؤدى ذلك إلى تحسين النمو الخضرى والحالة الغذائية للكرمات التى تعطى محصول عال ذو خصائص ثمرية جيدة مع تقليل تكلفة السماد ومشاكل تلوث البيئة الناشئ عن زيادة الأسمدة المعدنية .