Efficiency of slow release fertilizers on reducing the rates of mineral-N fertilizers in Flame seedless vineyards

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Abstract

This study was conducted during 2021, 2022 and 2023 seasons on 8 years old Flame Seedless vineyard. The vines were grown in Aiat vineyard for grapes production located in Luxor Governorate, Egypt. The perleka a slow release fertilizer, was used as a totally or partial replacement of the fast mineral N release fertilizer. The experiment was set up as a complete randomized block design. The results revealed that using the recommended dose of nitrogen (RDN) via 25% as a mineral source and 50% slow release or 60 to 80% slow release significantly increased the wood pruning weight and leaf area as well as their of total chlorophylls, N, P and K contents compared to use the RDN only as a fast mineral N fertilizer. Using 80% of RDN via slow release significantly stimulated these traits more than other used treatments. No significant differences were seen due to fertilize by either 80 or 60% slow release as well as 25% mineral plus 50% slow release fertilizer. Moreover, the N fertilization with a combination of 25% mineral and 50% slow release or 60-80% slow release significantly increased the yield and fruit quality compared to use the RDN only as a fast mineral release source. The promotion in the yield and fruit quality was associated with increasing the level of the slow release from 50 to 80% of RDN. Raising slow release used from 50 to 80% of RDN failed show any significant increase in fruiting traits. It is evident that fertilized with either 60% slow release or 25% mineral plus 50% slow release is very important for the grapevines production. It improves the nutrient status, yield and fruit quality of grapevines. In addition, it minimizes the production costs and environmental pollution which could be occurred with using fast release fertilizers.

Key words: Organic, slow-release, grapevines, yield, nutrient status, environmental pollution.

Introduction

Grapevines are considered the first main fruit trees in their products all over the world. World cultivated area about 7.5 million ha. produced about 67 m tons **[1]**. In Egypt, grapes rank third among fruit crops followed by citrus and mangoes. Especially in the reclaimed lands, the cultivated area of grapevines increased rapidly. It attained about

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184410 feddans, the fruitful vines are 157380 feddans, whereas, the total annual production attained 1472418 tons according to the statistics **[2].**

Flame Seedless is one of the most valuable grape cultivars in Egypt. It is large clusters and berries, red seedless, sweet flavor, and early ripening by the end of May under the Egyptian conditions.

Fertilization is one of the most important management to improve the soil fertility and increase crop yield. Nitrogen has many functions in plant life being part of proteins, an important constituent of protoplasm, responsible for biosynthesis of enzymes, amino acids, plant pigments and encouragement of cell division **[3].**The relationship between yield, fruit quality and health seems to be a complex and can be influenced by nitrogen fertilization **[4].**Continuous use of chemical fertilization leads to the deterioration of soil characteristics and fertility and might lead to the accumulation of metals in plant tissues, affecting the fruit nutritional value and edibility. They not only have harmful effects on the environment but also they are a very great danger that harmful residues may remain in food **[5]and[6].**

Controlling chemical fertilization, especially N fertilizer is very important for reducing environmental pollution and obtaining safe produce. Using bio-fertilizers relatively a good method in this respect **[7] and [8].**

Application slow release-N to fertilize vine yards had positively effected on growth and fruiting of vines. These formulation of fertilizers achieved were balanced of plant that improved substantially crop yield and berries quality. Also, slow release-N fertilizers techniques use to minimize the amount nitrogen release from fertilizer and in turn minimize nitrate pollution either of plants or water sources, and consequently minimizing nitrogen loss which induce an improving soil fertility and yield crop.

In general, using slow release nitrogen fertilizers reduce the total amount nitrogen needed, number of fertilizing applications, the residual of nitrogen fraction through the soil and plant as well as improves the efficiency of nitrogen fertilizer **[9] ; [10] and [11].**

Previous studies emphasized the benefits of using the suitable amounts of N as in organic and slow release on growth and fruiting of vineyards**[12]; [13]; [14]; [15]; [16]; [17]; [18] and [19].**

Therefore, the objective of this study is to examine the partial reduction of mineral N fertilization on Flame Seedless vineyard with using release fertilizers, as substitutes, in order to conserve the environmental and minimize the production costs.

Materials and Methods

The present work was conducted through three successive seasons of 2021, 2022 and 2023 on 30 uniform vigour eight years-old Flame Seedless grapevines. The vines were grown in Aiat vineyard for table grapes production, El-Odesate district, Luxor Governorate, Egypt. They had grown in sandy soil at 2x3 meters apart under

drip irrigation system. Some physical and chemical properties of experimental soil and irrigation water are shown in Table (1) according to **[20].**All vines received the standard agricultural practices that are used in the vineyard including spraying dormex, irrigation and pest control. The Spanish Barron system was used as a trellising system. The vines were short pruned (80 eyes/vine were left, 16 spurs x 5 buds/spur). The pruning was done during the second week of January each season. Crop load at all vines was adjusted to 30 clusters/vine after berry set. The chosen vines were devoted to achieve this experiment.

The experiment included five nitrogen fertilization treatments as follows:

1- Application the recommended dose of nitrogen (RDN) via 80 g N/vine/year (240 g ammonium nitrate g/vine) as mineral N form, control.
2- Using RDN as 80% mineral N (192 g NH_4NO_3).
3- Using 80% of RDN via slow release.
4- Using 60% of RDN via slow release.
5- Using 25% of RDN via mineral-N plus 50% of RDN via slow release.

The mineral nitrogen source was ammonium nitrate (33.5% N), where the slow release is perleka (19.8%) was applied once on at the growth start.

Table (1): Some physical and chemical properties of the experiment soil site.

Soil property	Value (0-60 cm)	Soil property	Value (0-60 cm)
Sand (%)	88.0	Available Ca (meq/100 g)	4.7
Silt (%)	4.0	Available Mg (meq/100 g)	1.11
Clay (%)	8.0	$CaCO_3$ (%)	0.5
Texture	Sandy	Available Na (meq/100 g)	0.73
ECe (mS/cm)	0.382	Cu mg/kg	2.26
pH (1:1 suspension)	8.10	Fe mg/kg	4.0
Total mg/kg	0.361	Mn mg/kg	8.12
Available K (meq/100 g)	0.26	Zn mg/kg	4.97

The experiment was set up as a complete randomized block design with three replicates, two vines each.

To evaluate the effect of these treatments on growth, nutrient status, yield and berry quality, the following parameters were studied.

1- Vegetative growth criteria:

All vegetative growth criteria, leaf area and pruning wood weight (kg/vine). Leaf area (cm^2) **[21].**In addition, leaf total chlorophyll was estimated by chlorophyll meter (Minolta SPAD 502 plus).

Samples of 30 leaves for each treatment were collected from the first full mature leaves from the top of shoots in mid of July 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. One part of each ground sample was analysed to determine total nitrogen by the semi-microkjeldahl technique **[22].** Other part or wet digestion was done by using concentrated sulphuric acid and hydrogen peroxide for overnight. Percentages of P and K (on dry weight basis) was determined in the digestion by colorimeters and flame photometry method, respectively according **[23].**

2- Yield:

At harvest date, the yield per vine was recorded in terms of weight (kg) per vine.

3- Cluster and berry characteristic:

Two clusters were randomly taken from each vine, at harvest date to determine the cluster and berry properties. Berry quality i.e. berry weight, reducing sugar percentages, total soluble solids and total acidity (expressed as g tartaric acid per 100 ml juice), berry traits were estimated according to **[24].**In addition, the anthocyanin content was determined according to **[25].**All the obtained data were tabulated and analyzed according to **[26].** using L.S.D. test for distinguishing the significant differences between various treatment means according to **[27].**

Results

1- Vegetative growth as well as leaf total chlorophylls, N, P and K:

Tables (2, 3 & 4) show the effect of nitrogen fertilization sources on the wood pruning weight, leaf area and total chlorophylls as well as leaf N, P and K contents of Flame Seedless during 2021, 2022 and 2023 seasons. It is obvious that the results showed a similar trend during the three studied seasons. Such results indicate that the application of the required N dose (RND) through using 25% of the recommended dose of nitrogen as mineral N along with using 50% as a slow release, 60 or 80% (RND) via slow release significantly increased such traits compared to using RDN only as a mineral N fertilizer. The promotion on such growth traits was associated with increasing the applied level of the slow release from 50 to 80%. Hence, applications of the suitable amount of N via 80% RND slow release had stimulated the shoot length and leaf area as well as total chlorophylls, N, P and K contents of leaves more than other used fertilization. The maximum values of wood pruning weight and leaf traits were recorded on the vines that were fertilized with the required N as 80% as an slow release followed 60% as a slow release. On other hand, the lowest values of the growth traits as well as leaf total chlorophylls, N, P and K contents were recorded for the vines that were treated with followed 80 or 100% mineral N (check trees). The

recorded leaf area was (130.9, 123.4, 145.9, 143.3 & 141.6 cm^2) and wood pruning weight was (1.72, 1.63, 1.89, 1.84 & 1.83 kg/vine as an av. of the three studied seasons) due to fertilize via of 100% mineral-N (T_1), 80% mineral-N% (T_2), 80% slow release (T_3), 60% slow release (T_4) and 25% mineral-N plus 50% slow release (T_5), respectively. Then, the attained increment of the leaf area was 11.46, 9.47 & 8.17% due to T_3, T_4 and T_5 compared to T_1 (check treatment), respectively. No significant differences were found due to use either 80% or 60% slow release as well as 25% mineral plus 50% slow release fertilizers.

Therefore, N fertilization with slow release fertilizers significantly increased the total leaf surface area, nutritional status and vegetative growth of Flame Seedless grapevines.

Also, the corresponding, recorded total chlorophyll was 39.3, 38.2, 43.6, 43.9 & 42.6 SPAD and leaf-N was 1.71, 1.59, 1.86, 1.84 & 1.83 as an av. of the three studied seasons, due to T_1 to T_5, respectively. Hence, the increment percentage of total chlorophyll was attained (10.94, 11.70 & 8.40) and leaf-N was attained (8.77, 7.60 & 7.02%) due to use slow release fertilizers (T_3, T_4 & T_5) over check treatment (T_1), respectively.

Table (2): Effect of slow-release fertilization on wood pruning weight (kg) and leaf area (cm^2) of Flame Seedless grapevines during 2021, 2022 and 2023 seasons.

Charac. / Treat.	Leaf area (cm^2)				Wood pruning weight (kg)			
	2021	2022	2023	Mean	2021	2022	2023	Mean
T1	127.6	131.4	133.6	**130.9**	1.58	1.76	1.81	**1.72**
T2	116.2	125.8	128.2	**123.4**	1.47	1.68	1.73	**1.63**
T3	141.3	146.6	149.8	**145.9**	1.74	1.94	1.98	**1.89**
T4	139.2	144.1	146.7	**143.3**	1.73	1.87	1.84	**1.84**
T5	136.4	142.6	145.8	**141.6**	1.70	1.86	1.92	**1.83**
LSD	**8.12**	**8.33**	**7.85**		**0.07**	**0.09**	**0.09**	

T1: Control. T2: 80% T3: 80% slow release.
T5: 60% slow release. T6: 25% mineral and 50% slow release.

Table (3): Effect of slow-release fertilization on total chlorophyll (SPAD) and leaf-N (%) of Flame Seedless grapevines during 2021, 2022 and 2023 seasons.

Charac. / Treat.	Total chlorophyll (SPAD)				Leaf-N (%)			
	2021	2022	2023	Mean	2021	2022	2023	Mean
T1	39.9	38.6	39.5	**39.3**	1.66	1.72	1.74	**1.71**
T2	37.5	37.9	39.2	**38.2**	1.54	1.60	1.63	**1.59**
T3	44.3	42.9	43.7	**43.6**	1.81	1.88	1.90	**1.86**
T4	42.8	44.1	44.7	**43.9**	1.78	1.85	1.88	**1.84**
T5	42.4	42.0	43.5	**42.6**	1.78	1.84	1.87	**1.83**
LSD	**2.14**	**2.32**	**2.06**		**0.06**	**0.08**	**0.08**	

Table (4): Effect of slow-release fertilization on leaf P (%) and K (%) of Flame Seedless grapevines during 2021, 2022 and 2023 seasons.

Charac. / Treat.	Leaf-P (%)				Leaf-K (%)			
	2021	2022	2023	Mean	2021	2022	2023	Mean
T1	0.121	0.135	0.129	**0.128**	1.15	1.11	1.14	**1.13**
T2	0.117	0.129	0.127	**0.124**	1.10	1.08	1.10	**1.09**
T3	0.141	0.154	0.149	**0.148**	1.24	1.25	1.28	**1.26**
T4	0.138	0.151	0.147	**0.145**	1.27	1.24	1.28	**1.26**
T5	0.136	0.148	0.146	**0.143**	1.26	1.23	1.26	**1.25**
LSD	**0.008**	**0.009**	**0.010**		**0.05**	**0.05**	**0.06**	

2- Yield

It is clear from Table (5) that the fertilization of Flame Seedless grapevines with the combination of mineral N and slow release N sources as well as slow release significantly increased the yield/vine and cluster weight compared to use the RDN only as a fast mineral N source (check treatment, T_1). Presented data showed that the results took similar trend during the three studied seasons. The promotion in the yield was associated with increasing the applied level of slow release from 50 to 80% of RDN. The maximum yield/tree and cluster weight was recorded on the vines that were treated with 80% of RDN as a slow release followed using slow release at 60% of RDN. The recorded yield/tree was 9.57, 9.49, 10.78, 10.54 and 10.39 kg/vine as an av. of three studied due to use T_1, T_2, T_3, T_4 and T_5, respectively. No significant differences were seen due to fertilize with 80% or 60% slow release, as well as 25% fast mineral-N plus 50% slow release fertilizers. The obtained increment of yield/tree as averages of three seasons was 12.64, 10.14 & 8.57% as a result of using T_3, T_4 and T_5, respectively, compared to T_1 (check treatment). Therefore, it is clear that the totally or partial substitution of mineral N with use slow release in the N fertilization of grapevines has beneficial effects.

Table (5): Effect of slow-release fertilization on yield/vine (kg) and cluster weight (g) of Flame Seedless grapevines during 2021, 2022 and 2023 seasons.

Charac. / Treat.	Yield/vine (kg)				Cluster weight (g)			
	2021	2022	2023	Mean	2021	2022	2023	Mean
T1	9.53	10.93	8.25	**9.57**	318.7	365.8	275.1	**319.9**
T2	9.51	10.74	8.22	**9.49**	316.9	361.9	274.0	**317.6**
T3	10.83	12.12	9.38	**10.78**	361.2	413.4	312.5	**362.4**
T4	10.59	11.88	9.16	**10.54**	352.6	405.2	305.3	**354.4**
T5	10.33	11.85	8.99	**10.39**	344.5	396.5	299.6	**346.9**
LSD	**0.66**	**0.63**	**0.55**		**16.89**	**20.65**	**15.75**	

3- Fruit Quality

It is evident from Tables (6 & 7) that using N fertilization as 25% of the RDN as a fast N mineral source and 50% slow release, as well as, use 60 or 80% of RDN via slow release fertilizers significantly improved the fruit quality in terms of increasing the berry weight, T.S.S.% and reducing sugar, anthocyanin content and decreasing the total

acidity compared to use the recommended dose of nitrogen (RDN) only as a fast mineral N source. The N fertilization of grapevines using 25% of RDN in a mineral form plus 50% as a slow release, as well as slow release fertilizers significantly improved the fruit quality more than using mineral-N alone. The highest values of berry traits were recorded on the vines that were fertilized with the RDN via 80% as a slow release followed by using 60% RDN via slow release. Raising slow release fertilization from 50 to 80% of RDN failed show any measurable improved the berry quality.

The recorded average berry weight was 2.23, 2.19, 2.50, 2.42 and 2.40 g as an av. of the three studied seasons for the vines that treated with T_1, T_2, T_3, T_4 and T_5, respectively. The respective TSS of juice berry was 14.5, 15.3, 15.9, 15.6 and 15.5%. Hence, the increment percentages of the attained berry weight were 12.11, 8.50 and 7.62% due to using T_3, T_4 and T_5 treatments, respectively, compared to T_1 (check treatment). In addition, the respective average increment of TSS that was attained using these treatments was 9.66, 7.59 and 6.90, respectively.

Also, the highest reducing sugar and anthocyanin contents and least total acidity were recorded due to fertilize by 80% of RDN via slow release fertilizers during three studied seasons. On other hand, the least and highest one recorded due to 100% of RDN via fast mineral-N (check treatment, T_1). The recorded reducing sugar was 13.38, 13.94, 14.48, 14.17 & 14.48% and anthocyanin content was 0.98, 1.16, 1.20, 1.18 and 1.17 mg/g as an av. of the three studied seasons, due to T_1 to T_5, respectively. Hence the increment percentage of anthocyanin was attained 22.45, 20.41 and 19.39% as an av. of the three studied seasons due to T_3, T_4 and T_5 compared to T_1, respectively.

Hence, such fertilization program is very important for the production of grapevines, since improving of the berry quality induces an increase in the packable yield. In addition, these fertilization treatments reduce the production cost and environmental pollution.

Table (6): Effect of slow-release fertilization on berry weight and TSS of Flame Seedless grapes during 2021, 2022 and 2023 seasons.

Charac. / Treat.	Berry weight				TSS			
	2021	2022	2023	Mean	2021	2022	2023	Mean
T1	2.16	2.38	2.15	**2.23**	14.6	14.1	14.8	**14.5**
T2	2.09	2.29	2.18	**2.19**	15.0	15.7	15.2	**15.3**
T3	2.39	2.63	2.48	**2.50**	15.7	16.1	15.9	**15.9**
T4	2.33	2.55	2.39	**2.42**	15.4	15.8	15.6	**15.6**
T5	2.30	2.52	2.38	**2.40**	15.3	15.8	15.5	**15.5**
LSD	**0.10**	**0.12**	**0.10**		**0.50**	**0.56**	**0.43**	

Table (7): Effect of slow-release fertilization on reducing sugar, anthocyanin and acidity of Flame Seedless grapes during 2021, 2022 and 2023 seasons.

Charac. / Treat.	Reducing				Anthocyanin (mg/g)				Acidity (%)			
	2021	2022	2023	Mean	2021	2022	2023	Mean	2021	2022	2023	Mean
T1	13.13	13.59	13.41	**13.38**	0.95	1.00	0.99	**0.98**	0.570	0.556	0.542	**0.556**
T2	13.75	14.29	13.78	**13.94**	1.14	1.17	1.17	**1.16**	0.535	9.520	0.535	**0.530**
T3	14.38	14.66	14.39	**14.48**	1.18	1.22	1.21	**1.20**	0.518	0.502	0.516	**0.512**
T4	14.10	14.31	14.10	**14.17**	1.16	1.20	1.18	**1.18**	0.531	0.516	0.525	**0.524**
T5	14.10	14.36	13.98	**14.48**	1.14	1.18	1.19	**1.17**	0.528	0.514	0.525	**0.522**
LSD	**0.55**	**0.52**	**0.49**		**0.04**	**0.05**	**0.04**		**0.011**	**0.015**	**0.016**	

Discussion

Continuous use of chemical fertilization contributes to the degradation of soil characteristics, fertility, deposition of heavy metals in plant tissues, affecting the nutritional value and edibility of the fruit. There is a general agreement that nutrition is one of the most effective factors affecting vegetative growth, yield, and fruit quality, **[3].**The high cost of mineral fertilization is a major problem affecting fruit tree growers. In addition, chemical fertilization has a role to play in health issues and environmental degradation in long run **[7]; [5]** and **[8].**

The effect of the slow release-N fertilization in improving the growth, nutrient status and cropping trees could be attributed to their effect on regulating the release of its own N as the plants needed. Also, they gave the highest values of residual N due to their low activity index, while these soluble one gave the lowest values of available N left in the soil. In addition, the role of N as a constituent of amino acids and proteins as well as important effect in encouraging cell division and development of meristemic tissues **[28]**and **[29].**The advancing effect of long-term use of optimum level of slow release could give a logical explanation for its positive action on physiochemical parameters of the fruits. Because of the high availability of nutrients as a result of employing slow release fertilizers, cell division and cell expansion, may be stimulated, resulting in larger fruits **[28].** These results coincide well with those obtained by **[4];[7];[12];[13];[14]; [16];[17];[18];[28]and [30].**

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