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Full Length Research Paper

The effects of different nitrogen doses on yield, quality and leaf nitrogen content of some early grape cultivars (*V. vinifera* L.) grown in greenhouse

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Nitrogen deficiency is a worldwide problem, causing restrictions in productivity of many horticultural produces. Particularly, the issue is compounded when the greenhouse production is employed. Therefore, reliable knowledge on proper application of nitrogen ensures not only satisfactory yield but also balanced vegetative and reproductive growth in plants. This study was thus conducted to investigate the effects of different nitrogen doses (10, 20 and 30 kg N da^{-1}) on some quality properties with petiole nitrogen content of grape cultivars 'Early Cardinal' (EC), 'Yalova Incisi' (YI) and 'Ergin Cekirdeksizi' (ER) grown in plastic greenhouse for two years. Overall results indicated that cluster weight, cluster length and yield values increased depending on the nitrogen doses. On the other hand, increasing nitrogen applications generally resulted in higher petiole nitrogen content. The highest petiole nitrogen values were obtained from the treatment of 30 kg N da^{-1} for two phenologycal periods (1.29 and 1.59% for full bloom and veraison, respectively). Considering the general investigations, 20 kg N da^{-1} application could be recommended in terms of nitrogen supply under such conditions.

Key words: Grapevine, nitrogen fertilizing, yield, petiole analysis.

INTRODUCTION

Grapevine roots can spread to wide surface and depth within the soil under the appropriate conditions. The vine afterwards readily exploits the nutrition substances available around the root during vegetation period. However, if any nutrition matter is not supplied to the cultivated soil, the grape quality and yield decreases inevitably by years. Thus, the nutrition matters required by vine have to be added relevant to the consumption sum of the vine. Optimum fertilization with respect to requirements of vines also improves the physical, chemical and biological structure of the soil (Khattari and Shatat, 1993; Morlat and Jacquet, 2003).

Among nutrition matters, nitrogen is known as the foremost matter consumed by vine in protein structure and participates in tissue constitution. The nitrogen contents of most vineyard soil change between 0.02 - 0.50% with an average of 0.15%. The greater part of nitrogen in the soil is found in organic form and 2-3% of organic nitrogen is mineralized per year. The usage capability of the plant nitrogen that is fixed by clay mineral is very low and difficult (Celik, 1998).

From the physiological perspective, proper nitrogen fertilization induces cell formation that results in fruit enlargement. Nitrogen also increases the plant water scope since the water content in the protoplasm is fairly high. Additionally, nitrogen regulates the content and equilibrium of hormones in plant structure. Thick and good branched roots have been observed when the

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Abbreviations: EC, Early Cardinal; **YI,** Yalova Incisi; **ER,** Ergin Cekirdeksizi; **PE,** polyethylene; **N,** nitrogen; **TSS,** total soluble solids.

Table 1. The effects of nitrogen applications on yields of grape cultivars (g vine^{-1}).

Cvs	Applications (kg N da^{-1})									
	0		10		20		30		Mean	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
EC	4407	4694	3850	5771	6164	4318	6530	3931	5238^{a}	4678^{b}
YI	3053	4062	4103	3976	5680	5328	3939	4910	4194^{b}	4569^{b}
ER	4123	6306	2542	7797	4351	7511	3207	7872	3556^{b}	7372^{a}
Mean	3861^{b}	5021	3498^{b}	5848	5398^{a}	5719	4559^{ab}	5571		

D%5; (2003; cvs: 951, app.: 1098, cvs*app.: ns), (2004; cvs: 1893, app.: ns, cvs*app.: ns). EC: 'Early Cardinal', YI: 'Yalova Incisi', ER: 'Ergin Cekirdeksizi'.

concentration of nitrogen is sufficient in cultivated soil (Mengel et al., 2001). This formation, accordingly, provides stronger vegetative growth to bear heavier yields.

Grapevines demand much more nitrogen at especially flowering and veraison times. The typical symptom of nitrogen deficiency in such critical times is chlorosis which is generally distributed to the whole leaf surface and small leaflets. Chlorosis symptoms typically begin in old leaves and then distribute to young leaves. The fundamental reason for this defect is decreasing or stopping of chlorophyll synthesis after the break up of plastids follow to break up the responsible proteins. Nitrogen deficiency decreases vegetative growth, causing excessive generative growth and thus, decreasing the crop quantity (Kacar, 1997). Conversely, the presence of excessive nitrogen can lead to excessive vegetative growth and reduction in yield (Chang and Kliewer, 1991). Therefore, the selection of accurate nitrogen doses is an important issue to maintain a balance between vegetative and reproductive growth of vines.

This study was aimed to investigate the proper nitrogen doses in greenhouse grape production and to determine the effect of different nitrogen doses on yield, quality and petiole nitrogen contents of grape cultivars.

MATERIALS AND METHODS

This study was conducted at the Viticulture Research and Implementation area of Cukurova University, Agriculture Faculty, during two years (2003 and 2004). Five years old vines of 'Early Cardinal' (EC), 'Yalova Incisi' (YI) and 'Ergin Cekirdeksizi' (ER) cultivars (*cvs*) were used. Vines were planted with a rectangular configuration (1.0 and 1.5 m between vines and rows) in three equal sized polyethylene (PE) (300 µm thick, UV + IR) greenhouses (2 m in height, 3 m wide and 33 m long). The trunks of all grapevines were trained along wires with cordon extending horizontally.

The experiment was a randomized complete block including three replicates of four nitrogen (N) applications (app.): (1) Unfertilized (0 N), (2) 10 kg N da^{-1}, (3) 20 kg N da $^{-1}$ and (4) 30 kg N da^{-1}. Three vines were used per replication. The N application was performed with urea form including 46% nitrogen. All vines were drop irrigated with equal amounts of water. The applications were performed at the same time for all cultivars. Half of the nitrogen doses were applied before the bud burst and the remaining was given after fruit set. All vines including the control were fertilized with P (3 kg P_2O_5 da^{-1}) and K (10 kg K_2O da^{-1}) (Ahlawat and Yamdagni, 1988; Orphanos, 1998; Khattari and Shatat, 1993; Zanathy et al., 1996; Abha et al., 1997; Bell and Robson, 1999).

Bud burst, full blooming, veraison, ripening dates, grape yield, cluster and berry weight, TSS (total soluble solids), acidity and petiole N content were investigated to determine the effects of different nitrogen levels. Petiole analysis is presently approved as the most reliable technique for establishing fertilizer needs or diagnosing nutritional problems. Hence, representative samples of leaf petioles were collected at full bloom and veraison times for further analysis of nitrogen changes in leaves by Kjeldahl method (Hortwitz, 1970).

Data were statistically evaluated by one way analysis of variance (ANOVA) in order to compare the effects of different doses of nitrogen applications. Statistical differences with p values under 0.05 were considered significant and means were compared by Tukey's test, using JMP 5.1 (SAS Institute Inc., Cary, NC, USA) program.

RESULTS AND DISCUSSION

The effects of nitrogen applications on phenological stages of overall vines were insignificant. Nonetheless, when the cultivars were considered, the earliest maturity was recorded on 'Early Cardinal' (data not shown).

Grape yield was significantly affected by N applications (Table 1). In 2003, the highest yield was obtained from the application of 20 kg N da^{-1} with 5398 g vine^{-1}, according to the general means. In 2004, 10 and 20 kg N da^{-1} applications were outstanding with their relatively higher values (5848 and 5719 g vine^{-1}). In a previous study, grape yield was similarly increased by N application (Terra et al., 2000).

Considering the mean values of cluster weights among the applications, N doses significantly increased the cluster weights (Table 2). This case was especially apparent for the findings obtained in 2003. The highest mean value on this criterion was obtained from the application of 10 kg N da^{-1} (481.8 g) for the first year. Similarly, Abha et al. (1997) also observed heavier clusters by N applications in their research. As for the cultivars, highest cluster weights were obtained from 'Ergin Cekirdeksizi' (509.7 and 604.5 g for two years). Interaction between varieties

Table 2. The effects of nitrogen applications on cluster weights of grape cultivars (g).

Cvs	Applications (kg N da^{-1})									
	0		10		20		30		Mean	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
EC	293^{ab}	275	246^{b}	354	356^{a}	289	354^{ab}	294	312^{c}	303^{c}
YI	278^{b}	356	442^{a}	372	352^{ab}	431	448^{a}	364	380^{b}	381^{b}
ER	337^{c}	546	637^{a}	718	525^{b}	571	538^{ab}	581	509^{a}	604^{a}
Mean	303^{b}	392^{b}	442^{a}	481^{a}	411^{a}	431^{b}	447^{a}	413^{ab}		

D%5; (2003; cvs: 54, app.: 62, cvs*app.: 108), (2004; 50.2, app.: 64, cvs*app.: ns).

Table 3. The effects of nitrogen applications on berry weight of grape cultivars (g).

Cvs	Applications (kg N da^{-1})									
	0		10		20		30		Mean	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
EC	6.7^{b}	5.7	6.6^{b}	5.9	7.3^{a}	5.9	7.0^{ab}	4.8	6.9^{a}	5.6^{a}
YI	4.7^{b}	4.3	4.5^{b}	4.4	4.6^{b}	4.2	5.4^{a}	4.1	4.8^{b}	4.3^{b}
ER	4.4^{a}	4.1	3.9^{b}	4.0	3.2^{c}	4.4	4.1^{ab}	3.9	3.9^{c}	4.1^{b}
Mean	5.2^{ab}	4.7	5.0^{b}	4.8	5.0^{b}	4.8	5.5^{a}	4.3		

D%5; (2003; cvs: 0.20, app.: 0.23, cvs*app.: 0.41), (2004; cvs: 0.58, app.: ns, cvs*app.: ns).

Table 4. The effects of nitrogen applications on total soluble solids of grape cultivars (%).

Cvs	Applications (kg N da^{-1})									
	0		10		20		30		Mean	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
EC	10.5^{b}	11.9	11.4^{ab}	11.6	11.9^{a}	12.1	10.7^{b}	13.0	11.1^{c}	12.2^{b}
YI	12.8^{b}	15.6	11.5^{c}	14.5	11.6^{c}	14.3	13.9^{a}	13.3	12.5^{b}	14.4^{a}
ER	12.8^{c}	15.1	14.4^{b}	13.3	13.9^{b}	15.2	15.8^{a}	13.1	14.2^{a}	14.2^{a}
Mean	12.0^{b}	14.2	12.4^{b}	13.1	12.5^{b}	13.9	13.5^{a}	13.2		

D%5; (2003; cvs: 0.5, app.: 0.6, cvs*app.: 1.0), (2004; cvs: 1.6, app.: ns, cvs*app.: ns).

and treatments for this character was significant in 2003. In this respect, the highest value was obtained from 10 kg N da^{-1} application of 'Ergin Cekirdeksizi' (637.2 and 718.6 g for two years, respectively). The increase rates in cluster weight values were especially clear in this variety for both years when compared with the control values (337.5 and 546.2 g). N applications resulted in statistically significant increases in cluster weights of overall genotypes and thus, this observation is in general agreement with Amiri and Fallahi (2007) who obtained heavier clusters with N applications.

Although N applications affected the berry weight, there was no clear effect on this criterion (Table 3). Nonetheless, the highest value was obtained from 30 kg N da^{-1} in 2003. Therefore, results presented here are in partial agreement with Khattari and Shatat (1993) who reported that berry weight of Salti cultivar was not affected by different nitrogen doses (0, 100, 200 and 400 g N $vine^{-1}$). Interaction was significant between varieties and applications. This outcome could have arisen from distinct reactions of cultivars to different applications.

It is well-known that TSS in grape berries may reduce with high level of N application (Okamoto et al., 2003). Application of N significantly reduced the TSS in accordance with the previous reports (Ahlawat and Yamdagni, 1988; Okamoto et al., 1991; Hirano et al., 2002) (Table 4). According to first year's results, interactions between cultivars and applications were significant. While 'Early Cardinal' gave the highest value in TSS by application of 20 kg N da^{-1}, the highest TSS content was obtained from treatment of 30 kg N da^{-1} for 'Yalova Incisi' and 'Ergin Cekirdeksizi'.

Table 5. The effects of nitrogen applications on acidity of grape cultivars (%).

Cvs	Applications (kg N da^{-1})									
	0		10		20		30		Mean	
	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
EC	0.47^{b}	0.43	0.55^{a}	0.51	0.60^{a}	0.49	0.53^{ab}	0.52	0.54^{a}	0.49^{a}
YI	0.25^{a}	0.22	0.29^{a}	0.26	0.28^{a}	0.24	0.29^{a}	0.24	0.28^{b}	0.24^{b}
ER	0.53^{b}	0.49	0.50^{b}	0.54	0.61^{a}	0.51	0.43^{c}	0.51	0.52^{a}	0.52^{a}
Mean	0.41^{b}	0.38	0.45^{b}	0.44	0.50^{a}	0.41	0.42^{b}	0.42		

D%5; (2003; cvs: 0.03, app.: 0.04, cvs*app.: 0.06), (2004; cvs: 0.07, app.: ns, cvs*app.: 0.06).

Table 6. The effects of the nitrogen applications on petiole nitrogen content at full bloom (FB) and veraison (V) (%).

Cvs	Applications (kg N da^{-1})									
	0		10		20		30		Mean	
	FB	V	FB	V	FB	V	FB	V	FB	V
EC	1.03	1.29	1.08	1.20	1.08	1.27	1.02	1.94	1.05	1.42^{ab}
YI	0.91	0.94	1.25	1.20	1.33	1.07	1.73	1.10	1.31	1.08^{b}
ER	1.18	1.50	1.25	1.72	1.26	1.80	1.12	1.73	1.20	1.69^{a}
Mean	1.04^{b}	1.24	1.19^{ab}	1.37	1.22^{ab}	1.38	1.29^{a}	1.59		

D%5; (FB; cvs: ns, app.: 0.24, cvs*app.: ns), (V: cvs: 0.22, app.: NS, cvs*app.: ns)

Among the nitrogen applications, the highest acidity levels were obtained from 20 kg N da^{-1} (0.50 g L^{-1}) and 10 kg N da^{-1} in 2003, while the least values were observed in control group (0.41 and 0.38 g L^{-1} for consecutive years) (Table 5). When cultivar and application interactions were considered, significant differences were observed. Nevertheless, application of 20 kg N da^{-1} resulted in significantly higher acid content in most of 'Early Cardinal' and 'Ergin Cekirdeksizi' (0.60 and 0.61 g L^{-1}, respectively) for the first year. According to Abha et al. (1997), titretable acid content of Perlette was increased by different nitrogen applications. On the other hand, Muller and Peternel (1983), Ergenoglu et al. (1988) and Peacock et al. (1989) reported that increasing nitrogen doses had slight effect on acidity. In a more recent study, Amiri and Fallahi (2007) who aimed to investigate the effects of various macro and micronutrients on grape quality reported that acidity of grape juice was not affected by nutritional matters. Comprehensive literature data reveal that acid contents of grapes cultivated under different conditions are a subject of contradiction.

The effects of nitrogen applications on petiole nitrogen content also need to be further studied as it provides direct comparison of treatments. The findings upon petiole nitrogen content provided remarkable results, although the differences between the values were insignificant for many cases. Generally, the increase in nitrogen doses resulted in rises for the nitrogen content of petioles. The highest value of petiole nitrogen content was obtained from the treatment of 30 kg N da^{-1} for two periods (1.29 and 1.59% for full bloom and veraison, respectively). Nitrogen content of unfertilized vines showed the lowest value among the applications for both full bloom and veraison (1.04 and 1.24%, orderly) (Table 6). Ahlawat and Yamdagni (1988), Wolf and Pool (1988), Gao and Cahoon (1992), Christensen et al. (1994) and Bell and Robson (1999) obtained similar results with this study that nitrogen concentration in petiole was increased by augmentation of nitrogen doses. Petiole N contents among the cultivars were generally proportional to the doses that we applied. This relation is probably because petiole nutrients are primarily influenced by application doses as well as factors including availability of other nutrients, mineral interactions and plant physiological age.

Conclusion

Nitrogen doses increased the cluster weight, cluster length and yield values in varying degrees. Additionally, increasing nitrogen applications generally resulted in higher petiole nitrogen content. The highest petiole nitrogen values were obtained from the treatment of 30 kg N da^{-1} for two phenological periods (1.29 and 1.59% for full bloom and veraison, respectively). Considering the general investigations, 20 kg N da^{-1} application could be recommended in terms of nitrogen supply under such conditions. Further studies are anticipated to aid better understanding of detailed investigation of the impacts of mineral nutrients for optimum grape production. Hence, the results obtained here would be a valuable source and guideline for future investigations.

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