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Research Note

Effects of nitrogen nutrition timing on fruit set of grapevine, cv. Grenache

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Introduction: A limitation of carbohydrate supply is known to reduce fruit set in grapevine (Coombe 1962, Koblet 1966, Caspari *et al.* 1998), however severe conditions which are far from usual vineyard conditions are required to obtain significant results. Nitrogen (N) deficiency can also reduce fruit set (Ewart and Kliewer 1977, Korkas *et al.* 1994). In order to precise the effects of timing of N nutrition on grapevine fruit set, we conducted experiments with various levels of N supply over two growing seasons.

Material and Methods: In 1998, nine 3-year-old *Vitis vinifera* L. cv. Grenache vines grafted onto SO 4 were grown in a glasshouse in 80 l containers in a mixture of sand and perlite (50/50, v/v). Only 5 shoots with one inflorescence each were maintained per plant.

From bud burst until the onset of flowering (April 30, 1998) the plants were irrigated with tap water. Subsequently they were irrigated with three different rates of N in the nutrient solution:
0: 0.3 meq $N \cdot l^{-1}$, tap water
N: 9.5 meq $N \cdot l^{-1}$ until July 20 and 10 meq $N \cdot l^{-1}$ thereafter
N/5: 2.1 meq $N \cdot l^{-1}$ until July 20 and 1.0 meq $N \cdot l^{-1}$ thereafter.

In 1999, the plants were irrigated throughout the season with a high N supply level (9.5 $meq \cdot l^{-1}$) starting 10 d after bud burst. They were treated as in 1998 except that the possible second inflorescence was not removed.

In 1999, fifteen 4-year-old plants of Grenache were grown in the same glasshouse as described previously. Only 6 shoots with one inflorescence each were maintained per vine. The vines were divided into three groups, each group was subjected to a different N nutrition level:
High N (HN = 7.3 meq $N \cdot l^{-1}$)
Medium N (MN = 1.3 meq $N \cdot l^{-1}$)
Low N (LN = 0.3 meq $N \cdot l^{-1}$).

After a period of irrigation with tap water, the treatments started on May 19, 1999, 10 d before the onset of flowering.

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At regular time intervals, the chlorophyll index was measured with a Minolta SPAD 502. This method has successfully been used to estimate the chlorophyll content of grapevine leaves (Keller and Koblet 1995). Three chlorophyll meter readings were taken on leaves opposite to the basal inflorescence. Two leaf disks (8 mm diameter) were subsequently punched out from these leaves for N analysis.

A digital photo of each of these leaves was taken before leaf fall. The corresponding area was determined by an image analysis software (Optimas 6.1 Media Cybernetics).

Just before flowering, the inflorescences were covered by fine-mesh nylon bags. Abscised ovaries and young fruits were regularly counted. After complete fruit set, the clusters were cut and berries with more than 3 mm diameter were counted. In each berry the number of seeds was recorded.

Statistical analysis was performed by SAS system for Unix (release 6.11).

The following denominations are used: S98-99: vines which received different levels of N in 1998 but which were not subjected to limiting N in 1999, and S99-99: vines which received different levels of N in 1999.

Results and Discussion: If N was limited in 1998 (S98-99), N content of the leaves showed significant differences ($p < 0.002$) in 1999 only from bud burst to flowering. Thereafter the N contents were similar.

In 1999 (S99-99), a lack of N supply had a rapid effect on the N content of leaves ($g \cdot g^{-1}$ dry matter or $g \cdot m^{-2}$). Differences after the onset of flowering were highly significant ($p < 0.002$).

These results indicate that a low N availability in the preceding growth period limited the N reserves in the perennial organs and induced an early N starvation (S98-99). In the S99-99 experiment, the levels of reserve were similar and treatments started before flowering, after low N supply from bud burst. N starvation occurred after the depletion of stored N by early growth.

In agreement with Keller and Koblet (1995), the chlorophyll index was affected by an N supply in the previous year. Significant differences in the chlorophyll index were observed in the year following the stress (S98-99) in the course of the first measurement ($p < 0.001$) when the plants had approximately 6-7 leaves. These differences were still significant at the onset of flowering (Table). For the S99-99 plants, at the onset of flowering, leaves of the HN treatment had a significantly higher chlorophyll index (Table).

For the S98-99 plants, the area of the leaves opposite to the basal inflorescence was affected by the N nutrition applied in the preceding season ($p = 0.03$). In case of N deficiency in 1998 the leaf area was reduced by 20 % (Table). No differences were measured among the S99-99 vines.

In both experiments, the fruit set ratio was very low in 1999.

In the S98-99 experiment, despite a high N supply in 1999, the number of berries per cluster was significantly

Table

Characteristics of the leaves opposite to the basal inflorescence, fruit set and seed formation for different N nutrition levels

Experiment and N nutrition level	Leaf area 1) (cm²)	N content of the leaves 2) (g.m⁻²)	Chlorophyll index 2)	Number of flowers per cluster	Number of berries per cluster	Fruit set (%)	Number of seeds per berry	Number of seeds per cluster
S98-99								
0	334 b	1.34 a	34.8 c	558 a	21 b	7.2 a	1.51 a	31 b
N/5	390 ab	1.38 a	36.1 b	497 a	28 ab	8.0 a	1.46 a	39 ab
N	410 a	1.52 a	38.7 a	532 a	45 a	15.6 a	1.55 a	68 a
S99-99								
LN	299 a	1.21 ab	32.7 b	902 a	31 a	4.9 b	1.28 b	42 a
MN	295 a	1.12 b	32.8 b	929 a	37 a	6.8 ab	1.21 b	45 a
HN	278 a	1.36 a	34.7 a	618 b	48 a	10.3 a	1.47 a	71 a

1) at leaf fall.
2) at the onset of flowering.
Means followed by the same letter within each experiment are not different at $p < 0.05$ (Tukey-Kramer test).
0, N/5, N, LN, MN, HN see Material and Methods.

reduced in vines with a low N nutrition during the preceding season. There was no effect of the N nutrition on the number of seeds per berry but the number of seeds per cluster increased with the level of N applied in the preceding season.

In the S99-99 experiment, the fruit set ratio increased with the level of N supply (Table). However this increase might be due to the lower number of flowers per cluster in the HN treatment (p = 0.006). Indeed, the number of berries or seeds per cluster were not statistically different (p = 0.17 and p = 0.06, respectively). Ewart and Kliewer (1977) observed a higher number of seeds per berry for the higher N nutrition as well.

Conclusion: If N deficiency occurs during the preceding season (S98-99), the amount of reserves can be reduced (Keller and Koblet 1995). In our experiments, some characteristics of the leaves in the fruiting zone (leaf area, N content, chlorophyll index) were significantly affected during the following season. Low N supply during the preceding season reduced berry set ratio without any effect on the number of flowers per cluster, and did not affect the number of seeds per berry.

A high N supply during spring growth decreased the number of flowers per cluster at the onset of flowering. Fruit set ratio was higher but the number of berries was not significantly different. The number of seeds per berry increased when the N supply was high.

Variation in the number of berries per cluster is more significant for a previous year N deficiency than for a current year stress. This result points out that berry formation strongly depends on the growing conditions with regard to the level of reserves during the preceding season whereas seed number per berry is strongly affected by late spring N supply.

In our experiments, however, fruit set was unexpectedly low, suggesting that even though the N supply modifies fruit set ratio, another factor may have played a more important role.

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