The Uptake and Distribution of ^{15}N enriched Nitrate by three Rootstock Cultivars grafted to Chenin blanc

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The uptake and distribution of nitrogen by the rootstocks 99R, 101-14 Mgt and 140 Ruggeri grafted to Chenin blanc in sand culture, were determined using ^{15}N enriched potassium nitrate. The $K^{15}NO_3$ was applied at the end of rapid shoot growth and the vines were sampled at véraison. Although vines grafted on 99R showed less aerial- and root growth than those on 101-14 Mgt and 140 Ruggeri, nitrogen was absorbed equally well by all three rootstocks.

The distribution of newly absorbed nitrogen could be accurately determined by means of ^{15}N, and at véraison more than half of newly absorbed N was found in the leaves and shoots, and about 15% in the bunches. It was clear that nitrogen which accumulated in the bunches during the period of investigation, was derived primarily from previously assimilated N in the roots and mature wood.

In a recent review Pate (1980) pointed out that the present state of knowledge on the nitrogen relationships of plants is inadequate and urged more detailed studies on individual plant species in order to obtain a clearer picture of N assimilation and partitioning, and its effect on plant growth and development. Some work in this respect was done for deciduous fruit such as apples (Hill-Cottingham & Lloyd-Jones, 1975; Cooper, Hill-Cottingham & Lloyd-Jones, 1976) and apricots (Weinbaum, Uriu & Muraoka, 1980) but as far as vines are concerned, basic research on N nutrition has to a large extent been confined to establishing seasonal absorption peaks (Lafon *et al.*, 1965; Conradie, 1980) and to the determination of the amount of N seasonally required by the vine for a specific crop level (Marocke, Balthazard & Correge, 1976; Conradie, 1981). Although the amount of N required by the vine as well as the periods of peak demand have been reasonably well established, many questions still remain. One of these is the effect of different rootstocks on the utilization of N. Although different rootstocks do not seem to affect the N concentration in leaves as much as the concentrations of P, K, Ca & Mg (Saric, Zorzic & Buric, 1977; Morard, Torres & André, 1981), more efficient use of available N may be one of the reasons why some rootstocks perform better under certain conditions than others. This could mean that vines should be fertilized differentially depending on the rootstock. On the other hand some rootstocks may induce specific growth patterns which would in turn have an effect on the way in which vines absorb and translocate N.

The first objective of this study was to determine which of three rootstocks (99R, 101-14 Mgt and 140 Ruggeri) used N most efficiently and, secondly, to determine whether the movement of small amounts of applied N could be followed directly in the vine through the use of ^{15}N as a label.

MATERIALS AND METHODS

Two year old *Vitis vinifera* L. cv. Chenin blanc vines, grafted on 99R, 101-14 Mgt and 140 Ruggeri were grown outdoors in 45 litre pots containing acid washed quartz sand and fed on alternative days with one litre of a standard Hoagland solution (Hoagland & Arnon, 1950). At the end of rapid shoot growth (mid December), four vines on each of the three rootstocks were selected for uniformity and labelled with ^{15}N by using, for each vine, 0,07g ^{15}N, i.e., 0,419g ^{15}N-KNO_3, containing 97,0 atom % ^{15}N to replace part of the standard KNO_3 in four litres of ordinary Hoagland solution. This resulted in the nutrient solution containing 7,23 atom % excess ^{15}N. The labelled nutrient was supplied in four equal doses (0,0175g ^{15}N/vine per dose) over a twelve day period (December 19th-31st) after the end of rapid shoot elongation. To maximise the uptake of ^{15}N, the nutrient leachate was collected and reapplied daily.

The sand was leached with tap water on January 5th to end the period of ^{15}N availability and received water only up to véraison on January 14th when the plants were sampled. As a control for $^{14}N/^{15}N$ ratios two additional vines which received the standard nutrient solution throughout the investigation period were harvested with the rest. Both these vines were grafted on 99R, as preliminary tests showed that different rootstocks had little effect on $^{14}N/^{15}N$ ratios in vines receiving the standard nutrient solution. The vines were separated into the following fractions: rootstock trunk, scion trunk and cordons (one to three year old scion wood including the graft union), medium roots (diameter $<$ 2mm), fine roots (diameter $>$ 2mm), shoots (current growth), leaf blades, leaf petioles, marc (skins, pips and stalks) and juice. Samples were prepared for analysis as described earlier (Conradie, 1980).

TABLE 1
The effect of three rootstocks on (a) dry mass of various fractions of Chenin blanc in sand culture and (b) the distribution at vèrasion of fertilizer N absorbed after the end of rapid shoot growth.

	Rootstock trunk	Scion trunk	Medium roots	Fine roots	Shoots	Leaf blades	Leaf petioles	Marc	Juice(1)	Total amount of fertilizer N absorbed (mg/vine)
(a) **Dry Mass (g/vine)**										
99 R	39,7(2) a	28,9 a	34,4 a	48,6 a	65,1 a	57,0 a	7,1 a	45,1 a	464 a	
101-14 Mgt	54,2 b	26,4 a	61,8 b	90,8 b	79,3 b	79,4 b	9,2 a	37,0 a	413 a	
140 Ruggeri	57,8 b	35,2 a	62,1 b	122,4 b	73,2 ab	71,6 ab	7,2 a	52,3 a	559 a	
(b) **Fertilizer N distribution (%)**										
99R	5,5 a	1,8 a	6,5 a	17,5 a	18,5 a	35,0 a	1,4 a	9,5 a	4,3 a	536 a
101-14 Mgt	2,5 b	1,3 a	8,.7 a	19,8 a	17,4 a	37,3 a	1,5 a	7,3 a	4,2 a	536 a
140 Ruggeri	3,3 ab	1,8 a	6,7 a	14,3 a	17,4 a	38,9 a	1,4 a	11,1 a	5,0 a	551 a

(1) Wet mass.
(2) Mean separation within columns by Duncan's multiple range test, 5% level.

Total N was determined by means of selenious acid/sulphuric acid digestion, followed by steam distillation with a Markham still into 0,01 M H_2SO_4 and back titration with 0,01 M NaOH to a pH of 6,0. For the determination of ^{15}N content the titrated samples were acidified and evaporated to a volume containing about 200μg N per ml. Ammonium in the sample was converted to N_2 gas using the method of Faust (1967), and sodium hypobromide as oxidant. The ^{15}N content of the gas samples was determined in a Statron NOI-5 atomic emission spectrophotometer. The atom % excess was obtained by subtracting the ^{15}N concentration found in the unlabelled controls from that found in the labelled sample. Fertilizer uptake was expressed as mg fertilizer N, calculated as follows:

$$\text{Fertilizer N(mg)} = \text{tissue N(mg)} \times \frac{\text{atom \% excess of tissue}}{\text{atom \% excess of applied nutrient.}}$$

RESULTS

The effect of three rootstock cultivars on the dry mass of the various fractions of Chenin blanc is shown in Table 1(a). The mass of the rootstock trunk and roots produced by 99R was significantly lower than than produced by 140 Ruggeri and 101-14 Mgt. The yield (marc plus juice) was not affected significantly. The vines on 99R also showed less shoot and leaf growth than those on 101-14 Mgt.

The amount of ^{15}N applied (0,07 g/vine) was sufficient to yield atom % excesses ranging from about 0,3% for rootstock to 1,5% for leaf blades and shoots (data not shown) and was therefore easily detectible. The distribution and total amount of fertilizer N absorbed is shown in Table 1(b). The 99R rootstock trunk accumulated a significantly larger fraction of the absorbed N than 101-14 Mgt, but the distribution of N in the other organs was remarkably similar for all three rootstocks despite differences in mass. More than half the absorbed N was retained in the leaves and shoots while the bunches (marc plus juice) accumulated a much smaller fraction (11,5 - 16,1%). This is consistent with the result obtained for apples (Hill-Cottingham & Lloyd-Jones, 1975) where most of the ^{15}N applied to a soil medium in summer was found in the leaves and only a small fraction in the fruit. For apricots Weinbaum *et al.*, (1980) concluded that fertilizer N must be absorbed by the tree before leaf fall to reach the flowers during anthesis in the next season. The total quantity of fertilizer N absorbed by the vine was not affected and this shows that, under the conditions of this experiment, the relatively small mass of roots produced by 99R was just as effective in the absorption of N as the significantly larger masses of roots found for 101-14 Mgt and 140 Ruggeri.

From previous work with 99R as rootstock (Conradie, 1980), the total amount of N accumulated by the bunches during the investigation stage was calculated and compared with the actual amount of newly absorbed fertilizer N found in the bunches (Table 2). The newly absorbed N only accounted for about one quarter of the accumulated N, and it is clear, therefore, that the bunches depended heavily on the pool of previously assimilated N. The total nitrogen content of the whole vine (excluding bunches) amounted to 3 460, 5 280 and 5 040 mg respectively for vines on 99R, 101-14 Mgt and 140 Ruggeri. Although the vines on 99R contained much less nitrogen than those on the other two rootstocks (on account of its smaller size) this did not affect the ratio of newly absorbed/previously assimilated nitrogen in the bunches.

TABLE 2
Relative contribution of newly absorbed fertilizer nitrogen to the total amount of nitrogen accumulated from the end of rapid shoot growth to vèraison by Chenin blanc bunches.

Rootstock	Newly absorbed fertilizer nitrogen in bunches (mg/vine)	Total amount of nitrogen accumulated in bunches (mg/vine)	Newly absorbed nitrogen as a percentage of the total N accumulated in the bunches
99 R	73,7 a	273 a	27,0 a
101-14 Mgt	61,7 a	241 a	25,6 a
140 Ruggeri	88,5 a	371 a	23,8 a

CONCLUSIONS

It was calculated that about three quarters of the N needed by developing bunches during the four weeks preceding véraison came from the pool of previously assimilated N in the vine. The fact that this pool was smaller for 99R than for the other two rootstocks did not affect the translocation pattern, and it may be speculated that 99R is a more efficient user of nitrogen (yield/unit of nitrogen in the vine) than 101-14 Mgt or 140 Ruggeri. It should be mentioned, however, that the yield of the vines in this experiment was extremely low and the position may change with different shoot/bunch ratios, while the important stage from véraison to full ripeness may also change the performance rating of the rootstocks.

More research is needed for a better understanding of nitrogen assimilation and distribution in the vine, and in this context the ^{15}N isotope is indispensible.

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