

## Root lesion nematode, *Pratylenchus penetrans*, in 'Fire King' lilies: attack and control with aldicarb

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### Abstract

In field trials on fumigated sandy soil planted with stock of 'Fire King' lilies lightly infested with *Pratylenchus penetrans*, nematode control with aldicarb did not influence growth and yield of the lilies in the first growing season, perhaps because of the low initial number of nematodes. In the second season, however, a clear relation appeared between yield and nematode control by aldicarb.

In such a biennial crop, yields after aldicarb treatment at planting were almost as good as after treatment in both years, 3 kg aldicarb a.i./ha (1.6 mmol. m<sup>-2</sup>) being optimum.

### Introduction

Lilies, as well as many other crops, may suffer considerable damage from attack by the root lesion nematode, *Pratylenchus penetrans*, occurring mainly in light soils. In the Netherlands, this infestation has long been known in *Lilium speciosum* (Slootweg, 1956), and in *L. regale* 'Fire King', and in the United States in *L. longiflorum* (Jensen, 1966; Maggenti et al., 1970). *P. penetrans*, which penetrates entirely the roots and lays eggs in them, initially causes small necrotic specks on the roots. This infection increases the susceptibility of the plant to facultative pathogens. Particularly the fungus *Nectria radicola* stat. con. *Cylindrocarpon destructans* is often found in this association. Infested plants turn yellow and die early due to root rot, that may aggravate during storage of the bulbs.

Attempts to control root lesion nematodes should be directed not only to nematodes in the soil but also to those in the planting stock. The presence of these nematodes is not always clearly visible by symptoms on the roots of the bulbs.

In the soil, the nematodes can be effectively controlled by soil fumigation with a nematicide (d'Herde et al., 1960). In a biennial crop of lightly infested planting stock, soil fumigation alone is insufficient to prevent damage. This was demonstrated in a biennial trial with 'Fire King' in previously fumigated sandy soil at the experimental garden Ens in 1973 and 1974. In the second year, the growth of lilies was about four times as good where aldicarb at 0.8 mmol.m<sup>-2</sup> was applied in the row at emergence annually as without aldicarb (Fig. 1). In the roots of plants on untreated plots about twenty times as many root lesion nematodes (3500 per 10 g) were found as in roots of plants on treated plots (Brinkman, 1975). To re-examine this second-year effect and to establish optimal aldicarb treatments, similar trials were laid out at Ens in 1975 and 1976.

Fig. 1. Difference in growth in 'Fire King' lilies caused by the root lesion nematode, *Pratylenchus penetrans*, in the second growing season. Left treated with aldicarb at  $0.8 \text{ mmol.m}^{-2}$ ; right untreated.



Fig. 1. Groeiverschillen bij 'Fire King' lelies veroorzaakt door het wortellesieaaltje, *Pratylenchus penetrans* in het tweede groeiseizoen. Links behandeld met aldicarb ( $0,8 \text{ mmol.m}^{-2}$ ); rechts onbehandeld.

## Materials and methods

Aldicarb was applied at doses of 0, 0.4, 0.8, 1.2, 1.6, 2.0, 2.4, and  $2.8 \text{ mmol.m}^{-2}$  in three trials with planting stock of 'Fire King' lightly infested by root lesion nematodes. From 'Fire King' planting stock classed as 'good', 15 *P. penetrans* were extracted per bulb whereas 9 were extracted per bulb from planting stock classed as 'infested' (Fig. 2). The trials were performed on sandy soil and fumigated with dichloropropene-dichloropropane the previous autumn. In each trial were four replicates of 200 bulbs in 5 m of ridges on plots of  $3.6 \text{ m}^2$ . The planting stock was disinfected in a fungicide solution of 2% captafol ( $27.5 \text{ mmol.dm}^{-3}$ ) and 1% trichlorephenol ( $11 \text{ mmol.dm}^{-3}$ ). It was planted in March or early April. In Trial 1 aldicarb was applied in the planting furrow at planting or lightly mixed with the soil by a handowing machine on the ridge just before emergence in April in the first year. Trial 1 was harvested in October of the first year. In Trial 2 aldicarb was applied on the ridge in April in the first year or in both years. In Trial 3 it was applied on the ridge in both years. Trials 2 and 3 were harvested in October of the second year.

In August or October, root lesion nematodes were counted in samples of soil from five plants per plot after extraction by the elutriator method (Oostenbrink, 1960) and from roots of the five plants by the mixer-cotton wool filter method (Stemerding, 1964).

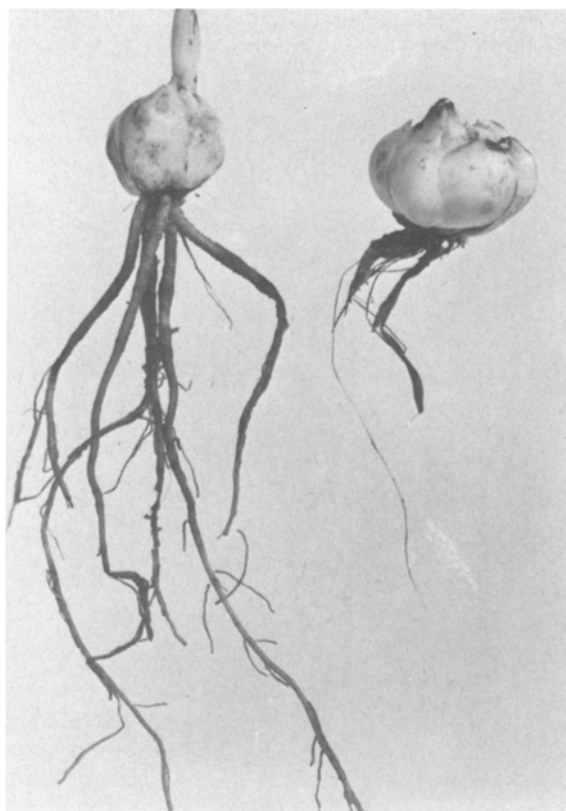


Fig. 2. Planting stock of 'Fire King' lilies lightly infested with root lesion nematode, *Pratylenchus penetrans*. Left visually healthy; right poorly rooted.

Fig. 2. Plantmateriaal van 'Fire King' lelies, licht besmet met het wortellesieaaltje, *Pratylenchus penetrans*. Links ogenschijnlijk gezond; rechts slecht beworteld.

At harvest in October 1976, the bulbs were weighed and visually graded for root quality on a scale from 1, very bad, to 10, excellent.

## Results

Numbers of lesion nematodes in root and soil samples taken during the biennial cultivation are presented in Fig. 3. In the plots without aldicarb in the first year, a clear increase in the nematode population was observed in the roots of the lilies and in the surrounding soil. In the second year only a slight further increase was observed.

In the plots with aldicarb the increase in nematode population was more inhibited the more aldicarb applied. The control of population increase by aldicarb was better in the first year than in the second (Fig. 4, Aug. '75). At the end of the second year, only the highest dose of aldicarb still gave nematode control (Fig. 4, Oct. 1976).

In all three trials, population increase of the nematodes was effectively limited in August of the first year (Table 1). This also holds for Trial 1 where aldicarb was applied in the planting furrow. At harvest of Trial 1 after one season however, no differences in yield of the bulbs were found between the plots with different amounts of aldicarb (Table 2). The somewhat lower yields from the plots with the two highest amounts of aldicarb may have been caused by some toxicity of this nematicide to the lilies.

Fig. 3. Numbers of *Pratylenchus penetrans* during two growing seasons with different doses of aldicarb (marked above lines) applied in both years (solid lines) or in the first year only (broken lines). A, Soil; B, Lily roots.

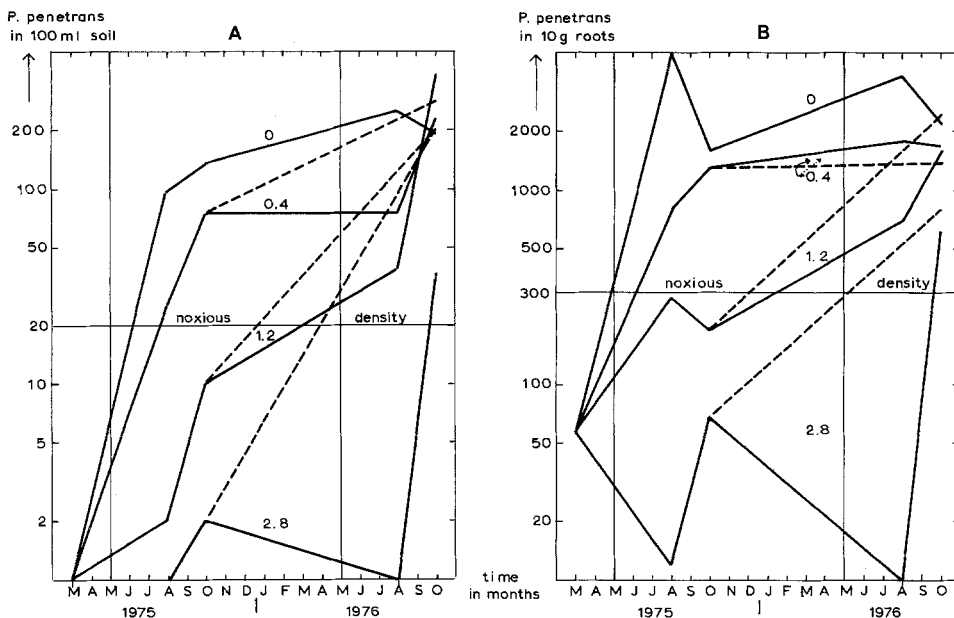


Fig. 3. Verloop van het aantal *Pratylenchus penetrans* gedurende twee groeiseizoenen bij verschillende doseringen aldicarb (aangegeven boven de lijnen) in beide jaren (getrokken lijnen) of alleen in het eerste jaar (gebroken lijnen) toegediend. A, Grond; B, Leliewortels.

At harvest of Trials 2 and 3 after two seasons, clearly increasing yields were found with increasing doses of aldicarb. In Trial 2 where aldicarb was applied in the first year only, yield was only slightly (6%) less than where it was applied in both years. In Trial 3 where poorly rooted planting stock was used, increase in mass of lily bulbs,

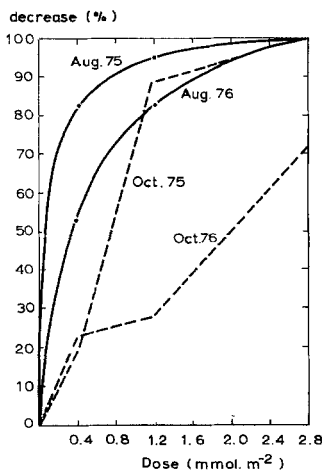


Fig. 4. Decrease in population of *Pratylenchus penetrans* relative to untreated controls in the roots of lilies at four sampling dates during two growing seasons after annual application of different amounts of aldicarb.

Fig. 4. Remming van de populatieopbouw van *Pratylenchus penetrans* in leliewortels op vier tijdstippen gedurende twee groeiseizoenen bij jaarlijkse toediening van verschillende doseringen aldicarb.

Table 1. Numbers of *P. penetrans* per plot in soil (per 100 ml) and in fresh roots (per 10 g) and survival relative to controls (%) in roots in August of the first year after different doses of aldicarb. Mean of 4 plots in each trial.

| Dose (mmol.m <sup>-2</sup> ) | Trial 1 |       |       |      | Trial 2 |     |       |       | Trial 3 |      |       |     | Average all trials |       |       |      |
|------------------------------|---------|-------|-------|------|---------|-----|-------|-------|---------|------|-------|-----|--------------------|-------|-------|------|
|                              | furrow  |       | ridge |      | furrow  |     | ridge |       | furrow  |      | ridge |     | furrow             |       | ridge |      |
|                              | soil    | roots | %     | soil | roots   | %   | soil  | roots | %       | soil | roots | %   | soil               | roots | %     | soil |
| 0                            | 35      | 912   | 100   | 110  | 2665    | 100 | 95    | 4770  | 100     | 442  | 2595  | 100 | 203                | 3051  | 100   | 203  |
| 0.4                          | —       | —     | —     | —    | —       | —   | 25    | 840   | 17      | 2    | 302   | 12  | 14                 | 553   | 18    | 14   |
| 1.2                          | 0       | 14    | 2     | 1    | 304     | 11  | 2     | 272   | 6       | 5    | 70    | 3   | 3                  | 167   | 5     | 3    |
| 2.8                          | 0       | 1     | 0     | 0    | 38      | 1   | 0     | 12    | 0       | 0    | 5     | 0   | 0                  | 12    | 0     | 0    |

Table 1. *Aantallen P. penetrans* per veldje in grond (per 100 ml) en in verse wortels (per 10 g) en overlevingspercentage (%) in de wortels in augustus van het eerste groeiseizoen bij verschillende doseringen. Gemiddelden van 4 veldjes in elke proef.

Table 2. Yields of lily bulbs per treatment (4 plots) absolute (kg) and relative (%) to the best yield after different doses of aldicarb. Trial 1 was harvested after 1 year and Trials 2 and 3 after 2 years. The last column gives the proportional increase in yield over the next lower dose.

| Dose<br>(mmol.<br>m <sup>2</sup> ) | Trial 1 |     | Trial 2 (well rooted) |     |             |    | Trial 3 (poorly rooted) |     |                  |     | Total (Trials 2 + 3) |     |                  |     | effect of<br>dose<br>increase |
|------------------------------------|---------|-----|-----------------------|-----|-------------|----|-------------------------|-----|------------------|-----|----------------------|-----|------------------|-----|-------------------------------|
|                                    | furrow  |     | ridge                 |     | 1° y. aldic |    | 1° + 2° y. aldic        |     | 1° + 2° y. aldic |     | 1° + 2° y. aldic     |     | 1° + 2° y. aldic |     |                               |
|                                    | kg      | %   | kg                    | %   | kg          | %  | kg                      | %   | kg               | %   | kg                   | %   | kg               | %   |                               |
| 0                                  | 25.39   | 95  | 24.98                 | 96  | 21.92       | 32 | 20.46                   | 29  | 22.07            | 31  | 64.45                | 31  | —                | —   |                               |
| 0.4                                | 26.66   | 100 | 24.48                 | 94  | 41.08       | 59 | 43.72                   | 62  | 43.47            | 60  | 128.27               | 63  | 118              | 118 |                               |
| 0.8                                | 25.77   | 97  | 24.97                 | 96  | 47.52       | 68 | 58.85                   | 84  | 53.74            | 75  | 160.11               | 78  | 25               | 25  |                               |
| 1.2                                | 24.06   | 90  | 23.96                 | 92  | 56.74       | 81 | 56.72                   | 81  | 57.79            | 80  | 171.25               | 84  | 7                | 7   |                               |
| 1.6                                | 25.99   | 97  | 26.04                 | 100 | 65.64       | 94 | 67.37                   | 96  | 72.09            | 100 | 205.10               | 100 | 20               | 20  |                               |
| 2.0                                | 25.70   | 96  | 25.15                 | 97  | 58.81       | 84 | 60.74                   | 87  | 67.80            | 94  | 187.35               | 91  | —9               | —9  |                               |
| 2.4                                | 24.87   | 93  | 24.06                 | 92  | 61.86       | 88 | 69.58                   | 100 | 68.45            | 95  | 199.89               | 97  | 7                | 7   |                               |
| 2.8                                | 23.91   | 90  | 23.47                 | 90  | 65.51       | 94 | 63.69                   | 91  | 70.63            | 98  | 199.83               | 97  | 0                | 0   |                               |
| Total yield<br>(m <sub>1</sub> )   | 202.35  |     | 197.11                |     | 419.08      |    | 441.13                  |     | 456.04           |     | 1316.25              |     |                  |     |                               |
| Mass planted<br>(m <sub>0</sub> )  | 116.48  |     | 116.48                |     | 58.24       |    | 58.24                   |     | 67.20            |     | 183.68               |     |                  |     |                               |
| m <sub>1</sub> /m <sub>0</sub>     | 1.7     |     | 1.7                   |     | 7.2         |    | 7.6                     |     | 6.8              |     | 7.2                  |     |                  |     |                               |

Table 2. *Opbrengst leliebollen per behandeling (4 veldjes) absoluut (kg) en relatief (%) van de beste opbrengst bij verschillende doseringen aldicarb. Proef 1 werd geoogst na 1 jaar en Proef 2 en 3 na 2 jaren. De laatste kolom geeft de relatieve meeropbrengst van de volgende dosis.*

Table 3. Root quality grade of lily bulbs after different doses of aldicarb in a biennial crop.

| Dose<br>(mmol.m <sup>-2</sup> ) | Trial 2 (well rooted) |                       | Trial 3 (poorly rooted) |
|---------------------------------|-----------------------|-----------------------|-------------------------|
|                                 | 1° year aldicarb      | 1° + 2° year aldicarb | 1° + 2° year aldicarb   |
| 0                               | 2                     | 2                     | 2                       |
| 0.4                             | 3                     | 5                     | 3                       |
| 0.8                             | 4                     | 6                     | 5                       |
| 1.2                             | 6                     | 7                     | 6                       |
| 1.6                             | 6                     | 8                     | 8                       |
| 2.0                             | 5                     | 7                     | 7                       |
| 2.4                             | 6.5                   | 8                     | 8                       |
| 2.8                             | 8                     | 9                     | 8.5                     |
| Total                           | 40.5                  | 52                    | 46                      |

Tabel 3. Bewortelingscijfers van leliebollen na verschillende doseringen aldicarb bij tweejarige teelt.

relative to initial planting was only slightly (11%) less than in Trial 2 planted with well rooted stock.

At harvest after two seasons, root quality of the bulbs scored higher with higher doses (Fig. 5). Where aldicarb was applied in the first year only, root quality was evidently poorer than where it was applied in both years (Table 3).

Fig. 5. Bulbs of 'Fire King' lilies infested by the root lesion nematode *Pratylenchus penetrans*. From left to right: treated with aldicarb at 2.8, 1.2, 0.4, and 0 mmol.m<sup>-2</sup>.

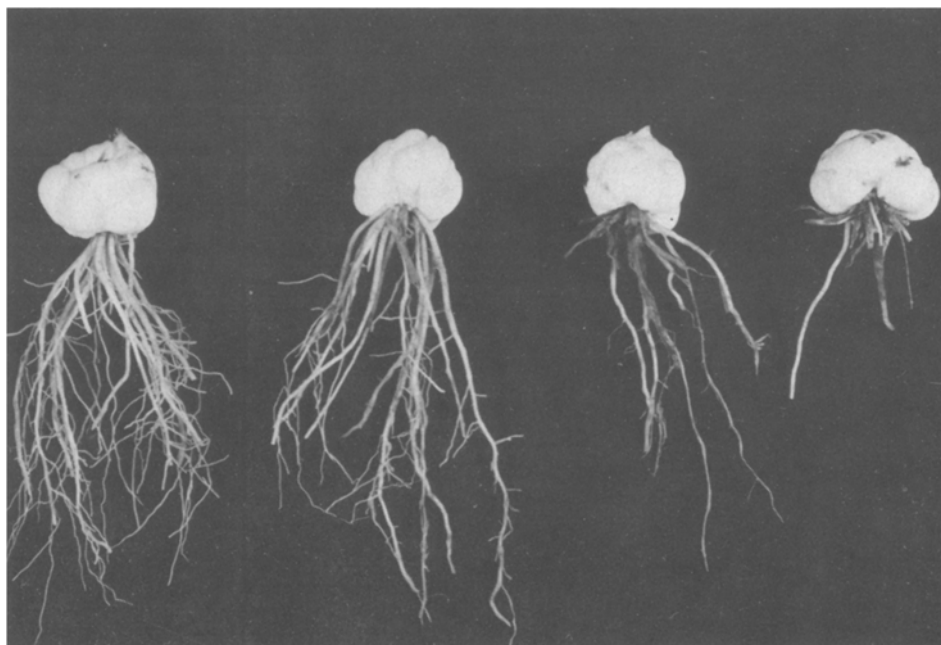


Fig. 5. 'Fire King' leliebollen aangetast door het wortellesieaaltje, *Pratylenchus penetrans*. Van links naar rechts: behandeld met aldicarb 2.8, 1.2, 0.4 en 0 mmol.m<sup>-2</sup>.

## Discussion

Effectively disinfected soil was infested by planting stock containing a few root lesion nematodes in the roots. This low initial population, increased during the first growing season. At harvest after the first season, no clear differences in yield were found between plots with higher and lower populations after application of different doses of aldicarb, perhaps because the population did not rise sufficiently before June to limit growth and yield during the first season. At the beginning of the second season, the population was high enough to limit growth and yield of the lilies, leading to clear differences between plots with different doses of aldicarb.

Although lily bulbs are graded by root quality, growth and bulb yield are mainly determined by the stemroots, as seen in yields from Trial 2 with well rooted planting stock and from Trial 3 with poorly rooted stock. Relative increase in bulb mass differed only slightly between the two trials (Table 2). The nematode population curves (Fig. 3) suggest that noticeable damage occurs with more than 300 *P. penetrans* per 10 g root and more than 20 *P. penetrans* per 100 ml soil in May, when stemroots would be developing. The numbers of nematodes remained below this limit in all plots of the first year. In the second year, numbers exceeded this limit in plots that received less than  $1.6 \text{ mmol.m}^{-2}$ .

The relation between dose and the relative yield (Table 2) shows that doses more than  $1.6 \text{ mmol.m}^{-2}$  are only slightly more effective and may even cause some decrease in growth of the lilies. As there was no difference in effect between application in the furrow at planting and on the ridge just before emergence (Table 1), application in the planting furrow is preferred for its easy procedure.

Application of aldicarb in both years caused only a slight increase in yield over application in the first year only (Table 2). Apparently the action of this nematicide is much more effective against the initially low population in the roots of the planting stock than when it is applied later to a much higher and more dispersed population at the beginning of the second year.

In this biennial crop, higher doses than  $1.6 \text{ mmol.m}^{-2}$  and application in both years still improved root quality of harvested bulbs (Table 3). The nematocidal action of aldicarb is limited to one or two months, so the nematodes may increase rapidly later and destroy root quality fast. To achieve a better root quality a much more efficient control of root lesion nematodes is necessary than to secure growth and yield.

As the bulb roots are of minor significance in growth and yield of these lilies (d'Herde et al., 1960), it seems to be unjustified to apply more than  $1.6 \text{ mmol.m}^{-2}$ .

## Samenvatting

*Het wortellesieaaltje, Pratylenchus penetrans, in de leliecultivar Fire King: aantasting en bestrijding met aldicarb*

Bij de bestrijding van wortellesieaaltjes moet niet alleen rekening worden gehouden met de in de grond aanwezige aaltjes maar ook met die in de wortels van het plantgoed. Aan de wortels van het plantgoed is de aanwezigheid van deze aaltjes niet altijd duidelijk te zien. In als 'goed' gekwalificeerd plantmateriaal van de leliecultivar 'Fire

King' werden gemiddeld 15 *Pratylenchus penetrans* per bol gevonden en in slecht plantgoed 9.

De aaltjes in de grond kunnen effectief worden bestreden door toepassing van grondontsmetting met een aaltjesdodend middel. In een tweejarige teelt van licht besmet plantmateriaal is dit echter onvoldoende om schade te voorkomen. Dit bleek uit een proef met 'Fire King' in vooraf ontsmette zandgrond op de proeftuin Ens. In het tweede jaar was de groei van de lelies na toepassing van aldicarb ongeveer drie maal beter dan zonder dit middel. In de wortels van de onbehandelde lelies werden ongeveer twintig keer zoveel wortellessieaaltjes gevonden als in die van de behandelde planten.

Om dit tweedejaarseffect nader te analyseren en de toepassing van aldicarb beter te preciseren werd het onderzoek op de proeftuin in 1975 en 1976 voortgezet, waarbij vooral aandacht werd besteed aan de dosering en de toedieningswijze van aldicarb in de vorm van Temik 10 G.

Uit het pouplatieverloop van de wortellessieaaltjes gedurende de tweejarige teelt (Fig. 3) kan worden afgeleid dat pas merkbare schade optreedt bij meer dan 300 *P. penetrans* per 10 g wortels en meer dan 20 *P. penetrans* per 100 ml grond in mei, wanneer de ontwikkeling van de stengelwortels plaats vindt. De gevonden besmettingen blijven in het eerste jaar in alle objecten beneden deze schade grens en komen in het tweede jaar daarboven in de objecten waar minder dan 3 kg aldicarb a.i./ha ( $1,6 \text{ mmol.m}^{-2}$ ) is toegediend in het eerste jaar. Dit is in overeenstemming met de opbrengstresultaten (Tabel 2).

Uit het verband tussen de toegediende hoeveelheid aldicarb en de relatieve opbrengst blijkt eveneens dat een hogere dosering dan  $1,6 \text{ mmol.m}^{-2}$  nog slechts weinig effectiever is en mogelijk zelfs groeiremmend kan werken. Het maakt daarbij weinig verschil of de toediening plaats vindt bij het planten in de vore of kort voor de opkomst van de lelies in de rug (Tabel 1). Uit praktische overwegingen moet de voorkeur worden gegeven aan de toediening in de plantvoor.

De toediening van aldicarb in beide jaren had slechts een geringe produktieverhogend effect boven toediening uitsluitend in het eerste jaar (Tabel 2). Blijkbaar is de effectiviteit van dit nematicide veel groter tegen de lichte aanvangsbesmetting met aaltjes in de wortels van het plantgoed dan wanneer het in de rug wordt toegediend aan de veel hogere, verspreide besmetting aan het begin van het tweede jaar.

Wat betreft de bewortelingskwaliteit van de bollen valt het op (Tabel 3) dat ook hogere doseringen dan  $1,6 \text{ mmol.m}^{-2}$  nog verbetering geven en dat toediening in beide jaren een betere bewortelingskwaliteit geeft dan wanneer alleen in het eerste jaar aldicarb wordt toegediend. Het nematicide aldicarb heeft slechts een werkingsduur van 1 à 2 maanden, zodat de aaltjes zich later in het seizoen weer sterk kunnen vermeerderen waardoor de kwaliteit van de wortels snel kan teruglopen. Om een betere bewortelingskwaliteit te bereiken wordt dan ook een veel effectievere bestrijding van de wortellessieaaltjes gevraagd dan voor het veiligstellen van de groei en de opbrengst van lelies.

Aangezien de bolwortels van ondergeschikte betekenis zijn voor de groei en de opbrengst van deze lelies lijkt het niet verantwoord hogere doseringen dan  $1,6 \text{ mmol.m}^{-2}$  toe te passen.

## Acknowledgments

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